Is globalization bad for the Environment? International trade and land degradation in developing countries: the case of small open economy

Bayou Demeke

May 2004

Department of Agricultural and Applied Economics

University of Wisconsin-Madison, 427 Lorch Street

Madison, WI 53706-1513

bedemeke@wisc.edu

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Denver, Colorado, July 1-4, 2004

Abstract

This paper uses a two-good specific factors model to derive a relationship between international trade and land degradation in a small open economy setting. Since, in general, developing countries have a comparative advantage in agriculture, more labor will move into agriculture and they will end up exporting agricultural goods. We show that international trade could lower steady state land quality under insecure property right regime. We derive condition under which the small open economy, with poor resource management policy, could suffer steady state welfare loss resulting from trade. We conclude that poor resource management largely undermines the conventional gains from globalization.

Key words: International trade; land degradation; specific factors, developing countries, small open economy

JEL classification: F10; Q24

I. Introduction

Trade liberalization in developing countries has been largely promoted by the World Bank and IMF since the beginning of 1980s. The main argument in favor of trade liberalization has been that it can lead to reallocation of resources between sectors to increase economic efficiency, and hence can benefit the nations. There has been a paramount debate on whether or not trade liberalization exacerbates land degradation in poor agrarian economies. Substantial debates have been observed on the impact of Structural Adjustment Program (SAP) on land degradation in Sub Saharan Africa; and also how NAFTA exacerbates deforestation in Mexico (e.g. Barbier, 2000; Deninger and Minten, 1999; Reardon and Barrett, 1999; Reardon et.al., 1999). Current estimates of the rate of deforestation in Mexico range from 0.4 to 1.5 million ha per year. A major cause of this deforestation has been an increase in land under rain fed agricultural production (Barbier, 2000). An economy making the move from autarky to international trade faces new prices based on valuations established in the world market rather than in the domestic economy alone. Engaging in trade thus results, in the typical case, in alterations in the allocation of resources to production and in the pattern of consumption (Coxhead and Jayasuriya, 2002).

Nearly all production processes—and many forms of consumption—generate environmental damage, whether this takes the form of emissions into air and water, or the depletion or degradation of natural resources. Thus virtually any pattern of economic change generated by a shift from autarky to trade—or more generally, by some change in a country's exposure to international markets—can be expected to have environmental consequences (Coxhead and Jayasuriya, 2002). There is substantial evidence that unintended environmental damage, including land degradation and forest conversion, can occur when economy-wide reforms in developing countries are undertaken while other policies, markets and institutional failures are ignored (Barbier, 2000). The questions are: Does trade liberalization worsen the environment in developing countries; could welfare deteriorate as a result of international trade? We believe that the claims of connection between land degradation and trade policies need a theoretically consistent analysis. To this end we propose a theoretical approach to answer the questions, taking fairly reasonable assumptions. The aim of this paper is therefore to build a simple theoretical dynamic model that shows the impact of trade liberalization on land degradation, and on welfare in a developing country context.

Several studies have raised the question of connection between international trade and management of renewable resources (e.g. Brander and Taylor, 1997; Brander and Taylor, 1998; Chichilnisky, 1994; Chichlinisky 1993; Coxhead and Jayasuriya, 1995). In a recent attempt towards this analysis, Coxhead and Jayasuriya (1995) consider the relationship between trade and land degradation. In that paper, they did not include dynamics of land quality and the effect of land quality on productivity, though the paper includes a non-traded good. Brander and Taylor (1997) used a dynamic Ricardian economy framework for open access renewable resource extraction, in which both renewable resource extraction sector and manufacturing sector use only labor as an input.

We take further step by employing a two-sector dynamic Specific Factors Model in which manufacturing sector uses labor and capital, while agricultural sector employs labor and land resources. We further incorporate the fact that land quality affects agricultural productivity, and that land quality has a dynamic structure. Lopez (1997) shows that land quality or biomass has an empirically significant contribution in the value of output. This work draws on traditional three factors model (see Jones, 1971; Mussa, 1974, Mayor, 1974). In our analysis we abstract from the welfare impact of pollution emitted by manufacturing sector, and the direct welfare implications of land degradation (for example amenity values of natural vegetations). The relationship between trade and pollution has been dealt in several recent studies, including Barrett (1994); Copeland (1994); Copeland and Taylor (1994); Copeland and Taylor (1995); and Antweiler, Copeland and Taylor (2001).

In many developing countries property rights are ill defined, and land tenure is insecure. Thus, most of the renewable resources are treated as open access resources. The assumption that there are no complete property rights in the south, or developing countries in our case, is shared in several recent studies (e.g. Brander and Taylor, 1997; Brander and Taylor, 1998; Chichilnisky, 1994; Chichlinisky 1993). Because land tenure is insecure, we assume that producers tend to maximize only current benefits (myopic). Even though this is an extreme situation, the model could be extended to the case where there is partial tenure security: for example, fixed period tenure systems.

The most important result of this paper is that trade indeed exacerbates land degradation in developing countries, when producers optimally ignore future costs of land degradation. Assuming most developing countries have a comparative advantage in agriculture, these countries will remain exporters of agricultural goods in the steady state. The welfare impact of trade is that, a small open economy will gain in the short run. But in the long run, due to land degradation, the benefit from trade will be eroded over time – leading to a possible loss from international trade. Depending on the magnitude of production parameter, taste parameters and relative prices, a small open economy could experience lower steady state welfare as compared to that of autarky steady state welfare. If it happens that the trading steady state welfare is lower than that of autarky steady state, with a reasonably low discount rate, the small open economy that export agricultural goods certainly loses from trade. Brander and Taylor (1997), in their theoretical analysis of trade and renewable resources, have reached to a similar conclusion. However, the results in Brander and Taylor (1997) depend on the specialization and diversification features of Ricardian economy. The specific factors model we have adopted, on the other hand, will not lead to specialization. Therefore our model is more general in terms relaxing restrictions on the production technologies.

In section II of this paper we set up a two sector general equilibrium model for a closed economy. Section III analyzes the impact of trade on welfare and on land degradation. We briefly discuss possible extensions of the model in section IV. In section V we present the summary and conclusions.

II. A Simple two-sector general equilibrium model

Before starting the equilibrium analysis, it is useful to define how land quality evolves over time. The stock of soil quality, S(t), that determines land productivity, evolves according to the following equation of motion. S(t) can be thought of as an index of different attributes of soil qualities; for example top soil depth, soil nutrient content, and soil organic matter content. We assume that the natural soil formation rate is constant i.e. natural growth is independent of the stock, S. Several authors share this formulation of resource dynamics (e.g. Barrett, 1991, Bulte, 2001; Lopez, 1997; McConnell, 1983). A stock-dependent growth function would clearly be more apt for biological resources (such as wildlife and fish stocks), but the current specification may be appropriate for renewable physical stock resources like in *situ* nutrient stocks or water (Bulte, 2001).We assume that evolution of soil quality is given as

$$dS / dt = r - D(t) \qquad (1)$$

where r is natural regeneration rate of land quality, and *D(t)* is land degradation in period t.

{figure1 here}

The dynamics of the renewable resource land quality are depicted in figure 1. If land degradation is above natural regeneration rate, r (e.g. at point (S", B)) land quality will decrease over time (i.e. $dS/dt < 0$), and leads to extinction. If land degradation is below the line r, (e.g. at point (S', A)), land quality will grow over time. If, however, land degradation rate is equal to natural regeneration rate, (e.g. point (S, r)) the stock of land quality will remain constant over time – i.e. the dynamics of land quality are at a steady state.

In our model we assume that land degradation depends on cultivation intensity, L_Q/T. Under the assumption of open access, labor use per acre of land can be used as a proxy for cultivation intensity. With ill-defined land tenure system, which is the case for most developing countries, open access will be a reasonable assumption to make. Under this assumption, intensity of cultivation will be associated with land degradation, through for example short fallow periods. Assume further that the functional relationship between labor and land degradation be represented as in equation (2).

$$D(t) = \frac{gL_Q(t)S(t)}{T} \qquad (2)$$

Equation (2) simply says that, when the stock of soil quality is high, land degradation increases with intensity of cultivation, where intensity in this is approximated by labor use in agriculture per land area. Because we assume that land area *(T)* is fixed in an economy, the change in the stock of land resource comes only through changes in soil quality, *S*. This can be generalized to allow for fallowing.

Production side equilibrium

Consider an economy comprising of two sectors, agriculture and numeraire sector which we call manufacturing. Assume that the economy is endowed with fixed amount of land (T), labor (L) and capital (K).

Assume that manufacturing sector employs labor and capital in production. Further we assume that manufacturing is characterized by constant returns to scale Cobb-Douglas technology as given in equation (3)

$$M = L_M{}^q K^{1-q}$$

(3) where M denotes manufactured good and L_M is labor used in producing M. On the other hand, agricultural sector employs land resource and labor in the production process. The production function for agriculture also exhibits CRS in land resource, *ST*, and labor.

$$Q = L_Q{}^q (ST)^{1-q} \qquad (4)$$

where Q is agricultural output; *ST* is the stock of land resource useful for agriculture; and L_Q is labor used in agriculture. *ST* can be thought of as the volume of soil stock available; where in this case *S* represents soil depth and soil organic matter content. Note that the model also explicitly assumes that land resource is specific to agricultural sector while capital is specific to manufacturing sector.

The production function in both sectors is made quite restrictive for the sake of analytical simplicity. If we allow for differences in parameters of the production functions, it becomes hard to get closed form analytical solutions. However, the general properties of the conclusions drawn from the model are not restricted to the functional form considered.

Normalize the price of M to 1 and let P denote the relative price of Q. Under competitive equilibrium, the wage rate is equal to the marginal value product of labor in the two sectors. Given the relative price P, the optimality condition requires that

$$PqL_Q{}^{q-1}(ST)^{1-q} = q\,(L_M)^{q-1}K^{1-q} \tag{5}$$

Equation 5 says that the equilibrium allocation of resources is found when the marginal value products of the two sectors are equalized. Full employment of labor implies that L_Q = $(L\text{-}L_M)$. After invoking the full employment condition for labor, the optimal labor allocation in both sectors can readily be solved from equation (6).

$$P\left[\frac{ST}{L_Q}\right]^{1-q} = \left[\frac{K}{L - L_Q}\right]^{1-q} \tag{6}$$

Solving equation (6), the labor demand in agriculture and manufacturing will be:

$$L_Q = \frac{L(TS/K)}{P^{1/(q-1)} + (TS/K)} \;\; and\; L_M = L - L_Q = \frac{LP^{1/(q-1)}}{P^{1/(q-1)} + (TS/K)} \tag{7}$$

It is straightforward to see that labor demand in agriculture increases with *P* and *TS* but decreases with *K* while in manufacturing sector the opposite holds; i.e. labor demand in M decreases with relative price and *TS* but increases with *K*.

Given the labor allocations in the two sectors, we can solve for the output supply functions of both manufacturing and agriculture as shown in (8).

$$Q = TS\left[\frac{L}{P^{1/(q-1)}K + TS}\right]^q \;\; \text{and} \;\; M = K\left[\frac{LP^{1/(q-1)}}{P^{1/(q-1)}K + TS}\right]^q \tag{8}$$

From the supply functions, the relative supply function can will be:

$$Q/M = P^{q/(1-q)}(TS/K) \quad (9)$$

This is an upward sloping relative supply function. Equation 9 demonstrates that relative supply depends on the endowment ratio. Note also that relative supply increases with the ratio of land stock to capital stock, *TS/K*.

By using log differentiation, we can easily see that a percentage rise in relative price (P) and a percentage rise in land resource stock (*ST*) raise relative supply; while a percentage rise in capital endowment reduces relative supply.

$$\hat{Q} - \hat{M} = \hat{TS} - \hat{K} + \frac{q}{1-q}\hat{P} \quad (10)$$

Using the output supply functions in (8) the revenue function of the economy, R = P Q* + M* , is given as:

$$R(P,TS,L,K) = PTS\left[\frac{L}{P^{1/(q-1)}K + TS}\right]^q + K\left[\frac{LP^{1/(q-1)}}{P^{1/(q-1)}K + TS}\right]^q = PL^q\left[P^{1/(q-1)}K + TS\right]^{1-q} \quad (11)$$

Consumption side equilibrium

Assume homothetic instantaneous utility function with constant budget share. The relevant welfare maximization problem for a representative consumer is:

$$\underset{q,m}{Max}[U = q^{a} m^{1-a}] \text{ Subject to } pq + m = R(P, L, TS, K/L \quad (12)$$

where q and m are per capita consumption of agricultural goods and manufacturing goods, respectively; α is a budget share allocated for consumption of agricultural good.

Solving the utility maximization problem and aggregating over all consumers, we have the following aggregate demand functions:

$M^d = (1\text{-}\alpha)R$ and $Q^d = \alpha R/P$ (13)

where $Q^d = q.L$ and $M^d = m.L$

From the demand functions given in (13), we solve for a relative demand function given by:

$$Q^d / M^d = \frac{a}{(1-a)}(1/P) \qquad (14)$$

It is straightforward to show that the relative demand equation in (14) represents a downward sloping relative demand curve.

Closed Economy General Equilibrium

Another way of depicting equilibrium of an economy is by using relative supply and relative demand curves (see figure 2). The equilibrium point of an economy is where the relative supply curve crosses the relative demand.

{figure 2 here}

Equating the relative supply in (9) to the relative demand given in equation (14), the equilibrium relative price is:

$$P = \left[\frac{(1-a)TS}{aK}\right]^{q-1} \qquad (15)$$

Autarky relative price reflects the relative scarcity of factors of production. It is decreasing in land resources and increasing in capital endowment. Also note that the relative price adjusts as the land quality changes over time; i.e. as land quality dwindles over time, relative price rises to reflect the rising cost of production.

Substituting the equilibrium relative price given in equation (15), the equilibrium allocation of labor in agricultural sector is

$$L_Q = \frac{L}{\frac{1-a}{a}+1} \text{ or } L_Q = aL \tag{16}$$

Equation (16) reveal that the fraction of labor that is allocated in agriculture is equal to the share of total income spent on agricultural good, a. Note that in autarky, labor allocation is independent of the endowment of the specific factors.

The economy's temporary autarkic equilibrium can be represented on a graph at a point where a production possibility frontier is tangent to an indifference curve. In Figure 3 the dynamics of the economy's autarkic equilibrium is depicted for an economy using a renewable resource as input. $\mathbf{PPF^0}$ stands for production possibility frontier at the initial land quality and $\mathbf{PPF^A}$ represents autarky steady-state production possibility frontier. We illustrate the dynamics for the situation where the economy starts from higher level of land quality i.e. $S^0 > S^A$. Point **O** in figure **3** represents the temporary equilibrium when land quality is at $\mathbf{S^0}$. Point ***A*** represents the autarky steady-state equilibrium of the economy, provided the economy remains closed. pl^A and pl^0 represent the equilibrium relative price lines at the autarky steady state, and at the initial land quality, respectively. Note that in a closed economy, even though land quality changes over time, the model predicts that the consumption of manufacturing remains constant over time. This is the direct consequence of the constancy of equilibrium labor demand (equation 16) in both sectors, irrespective of the endowment of the specific factors.

{figure 3 here}

<u>*Autarky steady state*</u>

Using equations (1) and (2), the land quality dynamics will be given as

$$dS / dt = r - \frac{g}{T} L_Q S \tag{17}$$

Steady state requires that *dS/dt*, in equation (17), be equal to zero. Substituting the optimal labor allocation and setting (17) to zero, the steady-state autarky land quality is given in equation (20).

$$S^A = \frac{rT}{agL} \tag{18}$$

Equation 18 reveals that the steady-state land quality increases with natural soil formation rate and land size; and decreases with land degradation parameter, budget share of agricultural good, and the economy's stock of labor. Substituting autarky steady state (S^A) into autarky equilibrium relative price given in equation (18), the steady-state autarky relative price will be given as

$$P^A = \left[\frac{(1-a)rT^2}{a^2 KgL} \right]^{q-1} \tag{19}$$

III. Trade: the small open economy case

Consider the case of small open economy, where the country under consideration faces exogenous fixed world prices. Assume further that the economy is at its autarky steady state before opening to trade. For any given P and S, labor demand is defined by equation (7). Substituting the labor demand into equation (1), the trading steady sate land quality will be the solution to equation (20)

$$dS/dt = r - \frac{gLS^2}{P^{1/(q-1)}K + TS} = 0 \;\; or \qquad (20)$$
$$rP^{1/(q-1)}K + rTS - gLS^2 = 0$$

For any P^T, ignoring the negative solution to the quadratic equation, the trading steady-state land quality is given in equation (21).

$$S^T = \frac{rT + \sqrt{(rT)^2 + 4gLrP^{T^{1/(q-1)}}K}}{2gL} \qquad (21)$$

Define $P^T = fP^A$ and substituting the steady state P^A, equation (21) will be:

$$S^T = \frac{arT + rT\sqrt{(rT)^2 + 4f^{1/(q-1)}(1-a)}}{2agL} \qquad (21')$$

Proposition 1: If the relative world price is greater than that of autarky relative price, then the small open economy will export agricultural good and will remain an exporter of agricultural good in the steady state. For the proof of proposition1, see appendix 1.

For $P^T > P^A$, when the economy opens to trade, labor will move into agricultural production and the economy will start exporting agricultural commodities, and imports manufactured goods. Figure 4 illustrates the temporary equilibrium with trade.

In figure 4, Q and M represent the optimal production in agricultural and manufacturing sectors, respectively. Q^c and M^c represent consumption of goods Q and M, respectively. If the economy opens to a higher world relative price as shown in figure 4, production of agricultural good will be greater than consumption, where the difference will be exported, and vice versa for manufacturing goods.

{Figure 4}

Trade and land degradation

Proposition 2: If world relative price is equal to autarky steady-state price, then steady-state land quality stock will be the same as that of autarky land quality. We provide the proof of this proposition in appendix 2.

Consider the case where the small open economy faces a higher relative price in the world market. The implication of this case for land degradation is given in proposition 3.

Proposition 3: If the world relative price (P^T) is higher than autarky relative price (P^A), the steady-state land quality will be less than that of autarky steady-state land quality. See appendix 3 for the proof. We can also see the proof by examining the graph shown in figure 5

The trading land degradation curve is drawn by using the definition $D = \frac{gLS^2}{P^{1/(q-1)}K + TS}$, and remembering that world price (P^T) is assumed to be above P^A. It is clear from the definition of D that higher relative price rotates the curve upwards. If $P^T = P^A$, the trading land degradation curve will pass through point F so that autarky and trading steady-state land quality will remain the same (see proof of proposition 2). In figure 5, S^T represents the trading steady-state land quality while S^A depicts the autarky steady-state stock of land quality.

{figure 5 here}

Welfare in Autarky and Trade

Since the utility function is homothetic, the aggregate indirect utility function can be written as income times some function of prices.

$$V(P,R) = \frac{a^a(1-a)^{1-a}}{P^a} R \tag{22}$$

where V is the aggregate indirect utility function. Plugging the autarky equilibrium price and the revenue function into equation (22), welfare at a given point in time is given as:

$$V = a^a(1-a)^{1-a} L^q \left[\frac{(1-a)TS}{aK}\right]^{(1-a)(q-1)} \left[\frac{TS}{a}\right]^{1-q} \tag{23}$$

$$V = AL^q (TS)^{(1-q)-(1-a)(1-q)} K^{(1-a)(1-q)} \tag{23'}$$

where $A = a^{-(1-q)+1-a)(1-q)+a}(1-a)^{(1-a)-(1-a)(1-q)}$ and A is positive.

As can be seen from equation (23), *V* is increasing in TS, K and L and is linearly homogeneous in its arguments. Given that θ <1, the indirect utility function increases with L at a decreasing rate; implying that per capita utility decreases with L.

After substituting the autarky steady-state land quality in to the indirect utility function, the steady-state autarky welfare becomes

$$V = AL^{q}\left[\frac{rT}{agL}\right]^{(1-q)-(1-a)(1-q)} K^{(1-a)(1-q)} \quad \text{or}$$

$$V_A = AL^{2q-1+(1-a)(1-q)} . \left[\frac{r}{ag}\right]^{(1-q)-(1-a)(1-q)} K^{(1-a)(1-q)} \tag{24}$$

Next we analyze the welfare impact of international trade of the small open economy. In our setting, trade affects welfare in two ways. One is through terms of trade improvement; and the other is through productivity loss educed by land degradation. The small open economy will benefit from trade in the short run through terms of trade improvement, but in the long run the steady state welfare could be lower than autarky steady state utility. This is because, as land quality stock dwindles over time the improved terms of trade could be outweighed by the productivity loss.

Proposition 4: *Proposition*: The impact of trade on steady state utility could be negative or positive depending on the magnitudes of ϕ, α and θ.

$$Welfare = V(P, R) \quad dV = [V_P + V_R(R_P + R_S S_P)]dp \tag{25}$$

$$dV = V_R[\frac{V_P}{V_R} + R_P + R_S S_P]dp$$

Using Roy's identity and Shepard's lemma we have:

$$dV = V_R[X + R_S S_P]dp \qquad (25')$$

where X denote export. The first term in the bracket is the *terms of trade* effect, and the second term is land degradation effect. Evaluating at the total equation (25') at $P = P^A$, (i.e $f = 1$), dV will clearly be negative. At $P = P^A$ export X is zero, and $R_S S_P$ is negative. Therefore, for an infinitesimal rise in price, from autarky to trade, the small open economy will suffer a steady state welfare loss.

For a discrete and big rise in relative price, the small open economy could in fact gain from trade. Intuitively, if the relative price rises to a very big number (e.g. infinity), the worst that can happen to the small open economy is to divert all the labor force into agricultural sector. Nevertheless, the steady state land quality is still positive and can produce positive amount of agricultural good.

To show this formally, substitute the revenue function into the indirect utility function for any P. The welfare will be given as:

$$V(P; L, T, K) = a^a(1-a)^{1-a} P^{1-a} L^q [TS + P^{1/(q-1)}K]^{1-q} \qquad (26)$$

If trading steady state utility is lower than autarky steady state utility ($V^A > V^T$), the following must hold.

$$P^{A^{1-a}}[TS^A + P^{A^{1/(q-1)}}K]^{1-q} > P^{T^{1-a}}[TS^T + P^{T^{1/(q-1)}}K]^{1-q} \qquad (27)$$

We have defined that $P^T = fP^A$, where φ>1. Substituting the steady state S and P for both autarky and trade, we have,

$$\left[\frac{rT^2}{agL}+\frac{(1-a)rT^2K}{a^2KgL}\right] > f^{(1-a)/(1-q)}\left[\frac{arT^2+rT^2\sqrt{a^2+4f^{1/(q-1)}(1-a)}}{2agL}+f^{1/(q-1)}\frac{(1-a)rT^2K}{a^2KgL}\right]$$

(28)

Further simplifying (28),

$$\left[\frac{1}{a}\right] > f^{(1-a)/(1-q)}\left[\frac{a+\sqrt{a^2+4f^{1/(q-1)}(1-a)}}{2}+f^{1/(q-1)}\frac{(1-a)}{a}\right] \quad (29)$$

$$\left[\frac{f^{(a-1)/(1-q)}-f^{1/(q-1)}(1-a)}{a}\right] > \left[\frac{a+\sqrt{a^2+4f^{1/(q-1)}(1-a)}}{2}\right] \quad (29')$$

The expression in (29') could be true or false depending on the choice of the parameters. We did simulations to sketch the welfare implications of trade liberalization as depicted in figure 6. We make use of some arbitrary values for the parameters, as shown in table 1.

{table 1 here}

{figure 6 here}

Figure 6 demonstrates that the small open economy could gain or lose from trade depending on the values of the relative price change and production parameter. The most interesting observations that follow from the simulation exercises are the following. If f rises above 1, the small open economy loses from trade for some range f and then gains for higher levels of f. For small values of increase in relative price, the long run productivity loss due to land degradation outweighs the terms of trade gain due to international trade. Another important component that influences the extent of loss or gain from trade is the share of land resources (1-θ) in the value of agricultural production. If (1-θ) is very small (i.e. θ is big) the loss from trade will be smaller since land resources are not very important in production. These results indicate that, without efficient resource management policy in place, the small open economy must be concerned about trade liberalization.

V. Conclusions

The concern that international trade increases land degradation seems more appealing, from the results of the general equilibrium analysis we have presented. For developing countries that do not use secure land tenure policy, we have shown that international trade unambiguously increases land degradation as long as the relative price of agricultural good is higher than that of autarky relative price. However, the direction of welfare change resulting from trade liberalization is ambiguous; since it largely depends on relative prices, taste parameters, and production parameters. It is possible that the conventional gains from trade to be eroded over time if the management of land quality is myopic. In particular, the welfare loss from trade liberalization will be substantially large when the impact of land quality on productivity is large. In addition, if world price is not "significantly" higher than autarky price, welfare loss from trade is more likely.

The result has very important and clear policy implications. The conventional gains from trade could only be assured if the domestic environmental externalities are removed before opening to trade or if losses from the externalities are negligible.

Removal of the intergenerational externality - for example using well-defined property rights or imposing Pigouvian tax on the resource user - will enhance the benefit from international trade. However, in many instances, first-best instruments to remove the externalities are not available, or they are extremely expensive to implement. In such cases, trade restricting instruments like import tariff, quotas or export taxes are the only options that can reduce the externality. Without these corrections, the small open economy could potentially lose from globalization. Our analysis points out that the benefit from trade would be maximized under a well-defined property rights or under any other efficient resource management schemes that takes future costs of land degradation into account. In conclusion, poor resource management that arises from poorly defined property rights largely undermines the conventional gains from globalization.

References

Antweiler, W. B. Copeland, and M. S. Taylor. 2001. Is Free Trade Good for the Environment? (forthcoming in the *American Economic Review*).

Barbier, E. B. 2000. Links between economic liberalization and rural resource degradation in developing countries. *Agricultural Economics. 23. pp. 299-310.*

Barrett, S., 1994. Strategic environmental policy and international trade. *Journal of Public Economics.* vol. 54, pp. 325-338.

Barrett, S., 1991. Optimal Soil conservation and the reform of agricultural pricing policies, *Journal of Development Economics* 36, 167-187.

Bulte, E.H, and D.P. van Soest. 2001. Environmental degradation in developing countries: households and the (reverse) Environmental Kuznets Curve. *Journal of Development Economics* vol. 65 pp 225-235.

Brander, J.A. and M.S. Taylor. 1998. Open access renewable resources: Trade and trade policy in a two-country model. *Journal of International Economics* Vol 44. No. 2 pp 181-210.

Brander, J.A. and M.S. Taylor. 1997. International trade and open access renewable resources: the small open economy case, *Canadian Journal of Economics.* Vol. 30 No. 3 pp 526-552.

Chichilnisky, G, 1994. North-South Trade and Global Environment. *American Economic Review*. Vol. 8. No. 4 pp. 851-874.

Chichilnisky, G, 1993. North-South trade and the dynamics of Renewable Resources. *Structural Change and Economic Dynamics.* Vo. 4 No. 2. pp. 219-248.

Copeland, B. R. 1994. "International trade and the environment: policy reform in a polluted small open economy", *Journal of Environmental Economics and Management* 26, pp.44-65.

Copeland, B.R. and M.S. Taylor 1994. "North-South trade and the global environment", *Quarterly Journal of Economics* 109, pp.755-787.

Copeland, B.R. and M.S. Taylor 1995Trade and trans-boundary *American Economic Review.* 85, pp.716-737

Coxhead, I. and S. Jayasuriya. 2002. *The Open Economy and the Environment: Trade, Policy and Resource Degradation in Asian Developing Countries* Forthcoming, July 2002 (Edward Elgar).

Coxhead, I. and S. Jayasuriya. 1995. Trade and tax policy reform and the environment: The Economics of soil erosion in developing countries. *American Journal of Agricultural Economics.* Vol. 77 No. 3 pp. 633-644.

Deacon, R.T, 1995. Assessing the relationship between government policy and deforestation. *Journal of Environmental Economics and Management.* Vol. 28. No. 1. pp.1-18.

Deninger, K.W and B. Miniten 1999. Poverty, policies and deforestation: the case of Mexico. *Economic Development and Cultural Change.* 47 (2), 313-344.

Jones, R. W. 1971. A three factor model in theory, trade and history", in *Trade, Balance of Payments and Growth: Essays in Honor of C.P. Kindleberger,* pp 3-21.

Mayer, W. 1974. Short run and long run equilibrium for a small open economy. *Journal of Political Economy.* Vol. 82. pp 955-968.

Mussa, M. 1974. Tariffs and the distribution of income: the importance of factor specificity, substitutability, and intensity in the short and long run. *Journal of Political Economy.* Vol. 82. pp 1191-1203.

Lopez, R. 1997. Environmental Externalities in traditional agriculture and the impact of trade liberalization: the case of Ghana. *Journal of Development Economics.* Vol. 53. No. 1. pp. 17-39.

McConnell, E. K. 1983. An economic model of soil conservation, *American Journal of Agricultural Economics*, pp 83-89.

Reardon, T., C.B Barrett, V. Kelly, K. Savadogo. 1999. Policy reforms and sustainable agricultural intensification in Africa. *Development Policy Review*. *1*7(4), pp. 375-395.

Reardon, T., C.B Barrett, 1999. The ambiguous effects of policy reforms on sustainable agricultural intensification in Africa: renewed threats to fragile margins? In: Angelsen, A., and D.,Kaimowitz. (Eds.). *Agricultural Technologies and Tropical Deforestation*. CABI, Wallingford, UK.

Appendix 1*:* Proof of proposition 1

It is sufficient to prove that the small open economy exports agricultural good in the trading steady state. In the trading steady state the country will be an exporter of agricultural goods if $Q > Q^d$ Using the demand and the supply functions of agricultural good, for any S and P^T, the following must hold for an exporting economy.

$$TS\left[\frac{L}{P^{T\,1(q-1)}K+TS}\right] > a\left[\frac{L}{P^{T\,1(q-1)}K+TS}\right](P^{T\,1(q-1)}K+TS) \qquad \text{(A1)}$$

Simplifying equation (A1), we have

$$TS(1-a)/a > P^{T\,1/(q-1)}K \qquad \text{(A2)}$$

Substituting the trading steady state S and rearranging (A2) we get

$$P^{T^{1/(1-q)}} T\left[\frac{rT+\sqrt{(rT)^2+4gLrP^{T^{1/(q-1)}}K}}{2gLK}\right]>\left(\frac{a}{(1-a)}\right) \tag{A3}$$

We have assumed that $P^T > P^A$, $P^T = fP^A$ and ϕ>1. Rewrite equation (A3) and use the expression of P^A given in (19) to find:

$$f^{1/(1-q)}\frac{a^2KgL}{(1-a)rT^2}T\left[\frac{rT+\sqrt{(rT)^2+\frac{4gLr(1-a)rT^2f^{1/(q-1)}K}{a^2KgL}}}{2gLK}\right]>\left(\frac{a}{(1-a)}\right) \tag{A4}$$

$$f^{1/(1-q)}\frac{a^2KgL}{(1-a)rT^2}T\left[\frac{arT+rT\sqrt{a^2+4(1-a)f^{1/(q-1)}}}{2agLK}\right]>\left(\frac{a}{(1-a)}\right) \tag{A5}$$

Further simplifying (A5), the following inequality must hold.

$$a+\sqrt{a^2+4f^{1/(q-1)}-4f^{1/(q-1)}a}>2f^{1/(q-1)}=a+\sqrt{a^2+4f^{2/(q-1)}-4f^{1/(q-1)}a} \quad \text{A6)}$$

As long as ϕ>1 and θ<1, the expression in (A6) is true since $f^{1/(q-1)} > f^{2/(q-1)}$ _

Appendix 2: Proof of proposition 2

Proof: Substitute the autarky steady-state price given in equation (19) in to the trading steady-state stock of land quality to get the expression in equation (A7).

$$S^T=\frac{rT+\sqrt{(rT)^2+4\left(\frac{(1-a)r^2T^2}{a^2}\right)}}{2gL} \tag{A7}$$

Simplifying this we have

$$S^T = \frac{arT + rT\sqrt{(2-a)^2}}{2agL} = \frac{arT - arT + 2rT}{2agL} = \frac{rT}{agL} \tag{A8}$$

The expression in (A8) is the same as the expression given in equation (18) _

Appendix 3: Proof of proposition 3

We have defined $P^T = \phi P^A$, where $\phi > 1$. Rewrite the trading steady-state land quality given in equation (21) as:

$$S^T = \frac{rT + \sqrt{(rT)^2 + 4gLr(fP^A)^{1/(q-1)}K}}{2gL} \tag{A9}$$

We substitute the autarky steady-state P given in equation (19) into equation (A9) and rearranging:

$$S^T = \frac{rTa + rT\sqrt{a^2 + 4(f)^{1/(q-1)}(1-a)}}{2agL} \tag{A10}$$

It follows that the following inequality must hold.

$$S^T = \frac{rTa + rT\sqrt{a^2 + (f)^{1/(q-1)}(4-4a)}}{2agL} < \frac{rTa + rT\sqrt{a^2 + 4 - 4a}}{2agL} = S^A \tag{A11}$$

The inequality in (33) holds since $\phi > 1$, and $\theta < 1$ _

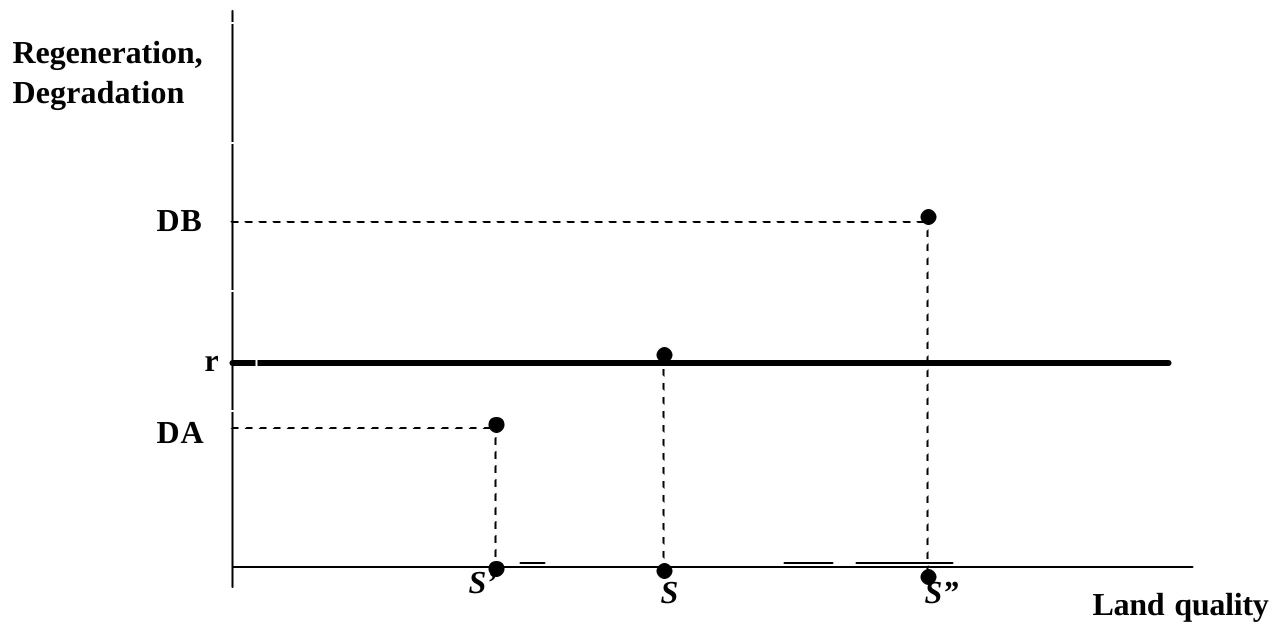

Fig. 1: Dynamics of Land quality

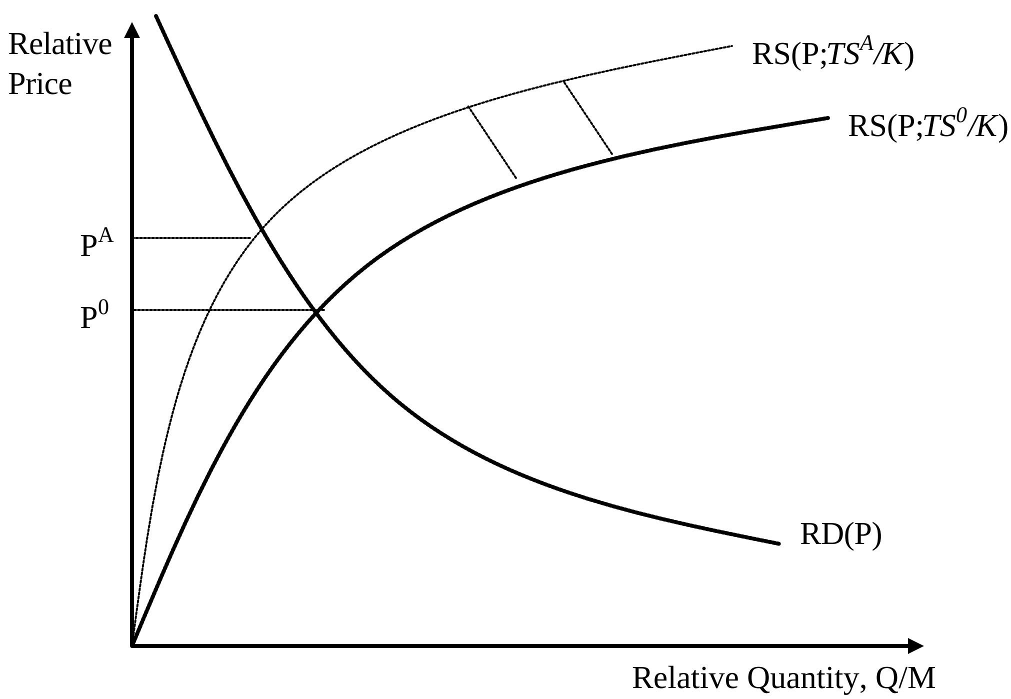

Fig. 2. Relative supply, relative demand and dynamics of equilibrium in Autarky

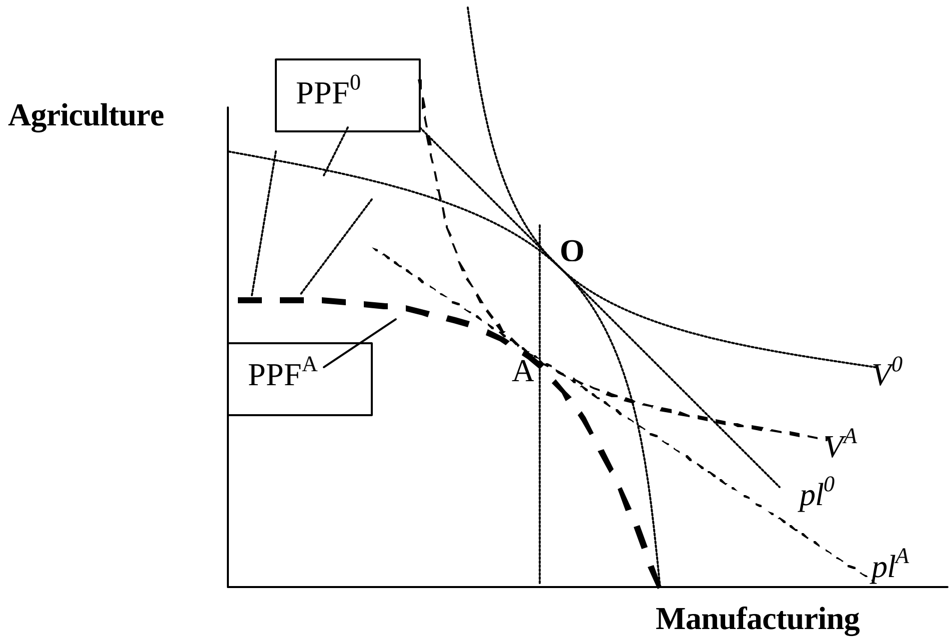

Fig. 3: Dynamics of Closed Economy General Equilibrium

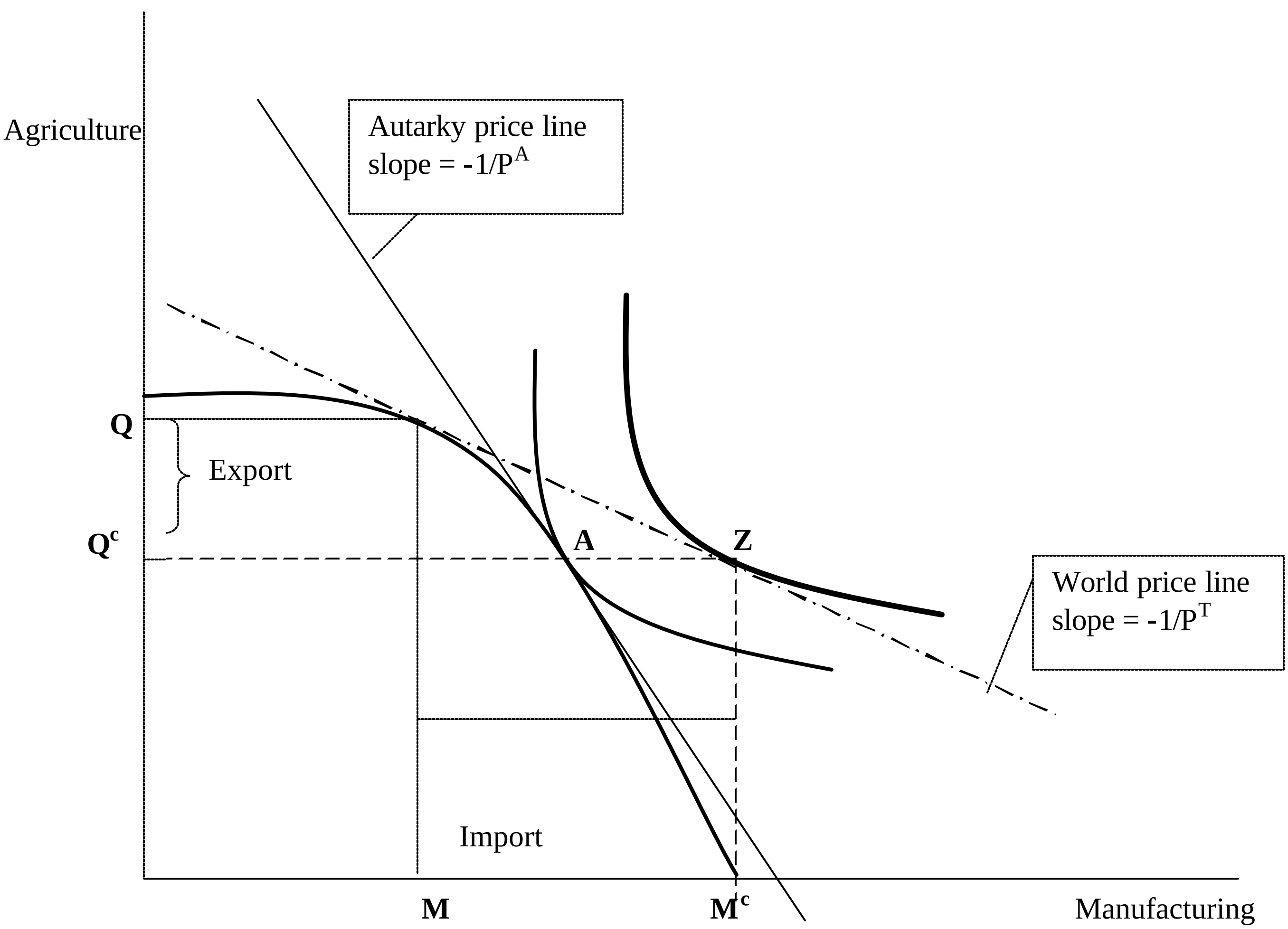

Fig 4: Temporary production and consumption equilibrium with trade

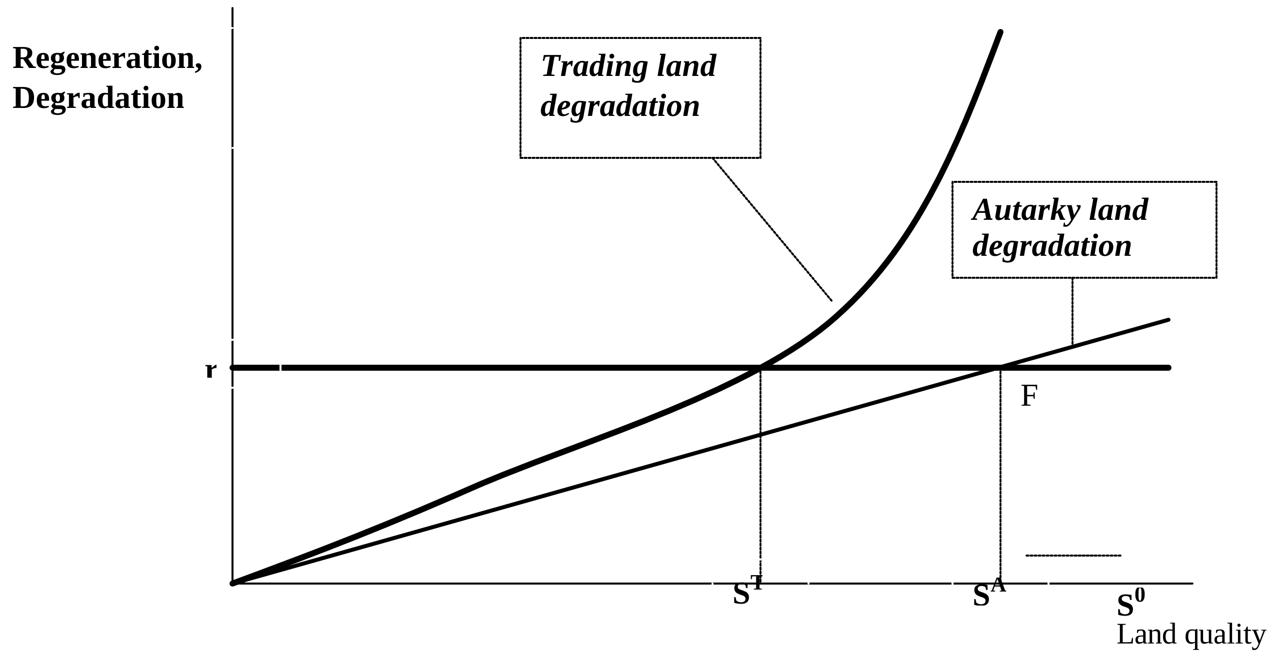

Fig. 5. Dynamics of Land quality (Autarky and Trade)

Table 1:

Land	Labor	Capital	r	γ
5000	3000	6000	10	1

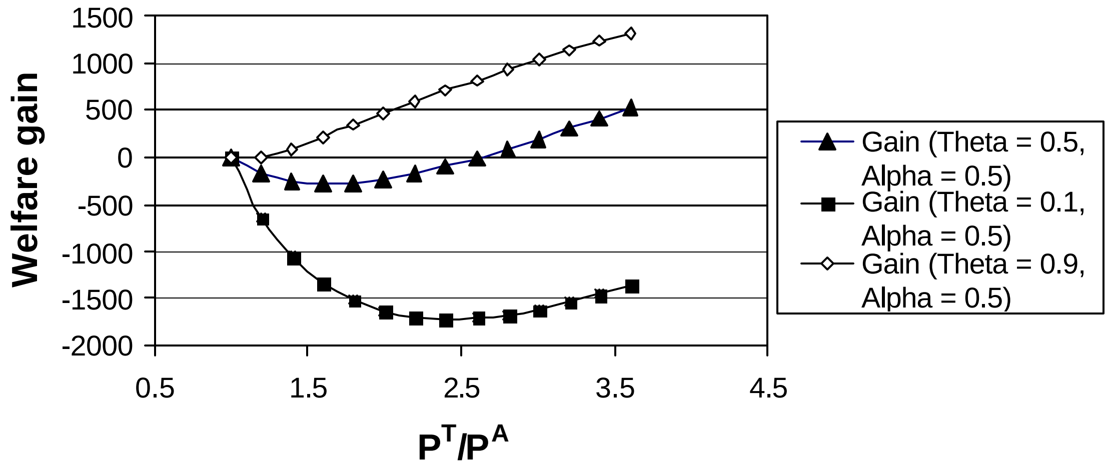

Figure 6: Welfare impact of trade