The Evolution of Inequality after Trade Liberalization

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October 31, 2000

[1]The original version of this paper was written at the University of Virginia and during visits at CIEPLAN and at the Departamento de Ingeniería Industrial, U. de Chile. F. Ruge-Murcia was an excellent research assistant and J. José Saénz helped collect the data. Please send comments to rfischer@dii.uchile.cl.

Abstract

The paper presents a general framework for the analysis of the evolution of personal income distribution following trade liberalization. The model allows many factors of production and the possibility of capital gains. In this framework, the short run evolution of inequality depends on the wage to wealth ratio, while changes in the interest rate determine the changes in long run inequality. The general frame-work is applied to the dynamic specific factors model of Eaton (1987). In this model the land-labor ratio determines whether a country exports the land-using or the capital-using good in the long run. The type of the export good determines the effects of liberalization on inequality. In land (labor) abundant countries, inequalities increase (decrease) along the dynamic path. The model provides an explanation for the differences between Latin American and Asian countries in their response to trade liberalization. Econometric analysis provide mixed results for these predictions, with the correct signs but non-significant coefficients for the coefficient on the interaction between openness and the land-labor ratio.

1 Introduction

This paper describes a framework for the analysis of the dynamic effects of trade liberalization on personal income distribution. It uses this framework to derive the effects of trade on inequality in a dynamic specific factors trade model. The paper also reports the results of preliminary econometric testing of the model's prediction that the effects of trade on inequality depend on whether the country is land (or natural resource) abundant.

While the changes in the functional income distribution due to trade have been studied in static models since Ricardo, there has been little work on the dynamic effects of trade policy on personal income distribution. The full effects of trade liberalization when land or natural resources are factors of production involve dynamic aspects that cannot be examined in static factor endowments models. In particular, liberalization provides large capital gains or losses to the owners of these factors. Furthermore, the evolution of inequality should be studied in a dynamic context in order to study the interaction between changes in income distribution and changes in the ownership of assets.

The first part of the paper develops a framework to study the effects of trade liberalization on income distribution. This framework is a generalization of one used in Fischer (1992a), which studied the effects of liberalization on personal inequality in a dynamic 2x2 factor abundance model. In the present paper, agents own many different assets. Liberalization leads to capital gains or losses, which in turn affect inequality.

An agent's income has two components: wages, which are equal for all agents and wealth, which is unequally distributed.[1] Wealth corresponds to the value of assets, which can include holdings of capital, human capital, land, natural resources or any other factors of production. Agents in a cohort receive unequal bequests from their parents. A reduction in cohort inequality leads to a reduction in the inequality of bequests to descendants. In this way, changes in inequality are transmitted over time. An increase in wages relative to wealth reduces inequality by increasing the importance of the component of income that is equitably distributed. In effect, the framework maps the functional distribution results of trade models into the personal distribution space by distributing the factors of production unequally among individuals, so that increases in wealth imply greater inequality.

A major result of the paper is that it shows that in the long run, increases in the wage to wealth ratio are captured by reductions in the interest rate.[2] Hence, a fall in the long run interest rate leads to less inequality in the steady state. An intuitive explanation is that in equilibrium all non-labor factors must receive the same return including capital gains. In a steady-state equilibrium, there can be no capital gains. Hence, in the long run, all sources of wealth must provide the same return as physical capital. If the steady state interest

[1] Wealth holdings are part of income because agents live a single period. In our model, wages are the reward to unskilled labor. In developing countries wage inequality is important, but this a consequence of the high return to human capital.

[2] This result depends on a no-arbitrage condition that is unlikely to be satisfied by investments in human capital due to rationing constraints. As a result, if human capital provides a higher return than alternative investments, the inclusion of human capital has important effects.

rate declines, the return to all non-labor sources of income falls, while wages rise. It follows that the steady state income distribution improves.[3]

Analytical complexities loom larger when we study the distributional effects of liberalization along the path to the new steady state. The general framework must be embedded in a particular trade model in order to trace the ratio of wages to wealth along the dynamic path. Consider the instantaneous effect of trade on a model with capital, labor and land. Immediately after liberalization, the capital stock remains unchanged, but both land prices and real wages increase. These price movements alter the income distribution. If these changes lead to less inequality, the bequests received by the next generation are less unequal. The evolution of inequality after the initial instant will depend on future changes in the stock of capital, the price of land and wages.

In the next section of the paper this general income distribution framework is embedded in a dynamic specific factors model described in (Eaton, 1987). Consider the case of two small countries, I and II, with the same level of protection, identical preferences and technology and equal stocks of land, which face the same relative prices when trading with a large world. Suppose country I has a labor-land ratio that is higher than the world ratio, whereas in country II this ratio is lower than in the world. If protection is not excessive, in the initial steady state country I will be capital abundant while country II will be land abundant. In this case, country I exports the capital using good while country II exports the land using good. The long run effect of trade liberalization is to reduce interest rates (by increasing capital stocks) in country I and to reduce capital stocks, thus increasing interest rates in country II. Hence long run inequality falls in country I and increases in country II.[4]

In the short run, wages and wealth will both be changing and owners of land will suffer capital gains or losses. Under appropriate parameter restrictions, trade liberalization lowers inequality along the whole dynamic path in the labor abundant country. In a land abundant country the results are reversed: inequalities increase in the short and medium run. This implies that land abundant countries face a tradeoff between equality under protection or the efficiency benefits of trade liberalization. Fortunately, this tradeoff can be avoided. If free trade is combined with capital mobility, it can be shown that inequality falls in the land abundant country. The explanation for this result is that capital mobility reduces interest rates in the land abundant country, hence lowering inequality. By the same token, capital mobility coupled to free trade raises inequality in labor abundant countries.

The main conclusion from the analysis of the Specific Factors Model is that the effects of trade on inequality depends on whether the countries are rich or poor in natural resources. Consider Table 1, which examines the effects of trade liberalization on income distribution in two countries distinguished by the difference in their endowments of land and natural resources. The data cannot be compared directly, because

[3]The relevant interest rate is the one facing small firms, and should include all costs of loans.

[4]All of these results hinge on the labor share of income in the capital using sector being larger than in the land using sector, a condition that is satisfied by the data, see Table 2.

Table 1: Income Distribution in Taiwan and Chile (Quintiles)*

	Year	1	2	3	4	5	GINI
Taiwan	1953	3.0	8.3	8.1	18.2	61.4	.558
	1970	8.4	13.3	17.1	22.5	38.7	.321
	1985	8.4	13.6	17.5	22.9	37.6	.317
Chile	1968	4.4	9.0	13.8	21.4	51.4	.426
	1978	4.6	9.6	14.1	19.9	51.9	.448
	1988	4.2	7.5	10.8	16.9	60.5	.525

(*) Family income as a proportion of total income.

Taiwan: Bourguignon and Morrisson (1989).

Chile: Van de Walle, D. *"Poverty and Inequality in Latin America..."* Human Resources Division, Technical Department, The World Bank, August 1989. Instituto Nacional de Estadísticas, Conferencia de Prensa, septiembre 1989.

the methods for estimating inequality are different, but the direction of change can be contrasted. In 1953, Taiwan traded very little. It started to liberalize its economy at the end of the 1950s. The table shows the large decline in inequality that followed. The Chilean economy was liberalized during the mid 1970s, with the opposite outcome.[5] This paper explains the difference in the distributional effects of trade liberalization in Latin America as compared to Asia.

The theoretical results of the paper are independent of the specific pattern of land and natural resource holdings. While it is true that the property of land is more concentrated in Latin America than in Asia, it does not affect our concern, which is to examine the changes in inequality due to liberalization. The predictions of the model depend only on the relative abundance of factors and the fact that there is some inequality in wealth holdings. Note that the 2x2 factor abundance model used in Fischer (1992a) is unable to explain Table 1 because the evolution of inequality should have been the same in both capital poor countries. This shows the advantage of the dynamic specific factors model.

Bourguignon and Morrisson (1990) found that income distribution in Less Developed Countries (LDCs) depends on the level of protection, on the distribution of endowments and on the abundance of resources. Bourguignon and Morrisson determine that in countries where land and natural resources are abundant,

[5] At approximately the same time that it liberalized its economy, Taiwan had a successful agrarian reform. Chile also had an agrarian reform, partially reverted during the 1970s. Thus Table 1 may also represent the difference between a successful and a partially successful agrarian reform. For a detailed analysis of the liberalization process in Taiwan, see Bourguignon and Morrisson (1989), who also discuss the influence of the distribution of land ownership on income distribution.

inequalities are higher. These authors also show that protection has an inequalizing effect. Their explanation is that LDCs are labor abundant so trade leads to increased exports of labor abundant goods, raising real wages while reducing inequality.

This paper contains preliminary results on the estimation of this model. The procedure consists of looking for the presence of an interaction effect between a measure of openness and the factor abundance variables. I use data on openness, capital stocks, agricultural land, Gini coefficients of inequality and the Sachs-Warner openness index for a large set of countries. A restricted fixed effects model (a Hausman test rejects the random effects model) show that openness by itself increases inequality, but that as predicted, this effect is moderated by an interaction effect with capital stocks and amplified by the interaction with land abundance. Hence in countries that are well endowed in land or natural resources so they are both capital and labor poor, liberalization increases exports of natural resources and raises the return to their ownership. Since these factors are not held equitatively, inequality increases. Casual observation indicates that in Latin American there has been an increase in inequality following trade liberalization. In East Asian countries, the opposite seems to be the case. Latin American countries are known to be land and resource abundant, while Asian countries are abundant in labor. Unfortunately, these results do not survive the introduction of all possible interaction cross-terms or of an education variable corresponding to human capital.

Edwards (1997) presents evidence suggesting that there is no relationship between openness and inequality. These results do not consider the possibility that different countries are affected differentially due to their different relative factor endowments and hence are not incompatible with the predictions of this paper. In a recent study, Spilimbergo *et al.* (1999) examines the links between factor endowments, trade and personal income distribution using panel data in an approach that is similar to the one used in this paper.[6] They obtain a result showing that openness by itself causes increased inequality (as in this paper), keeping constant the factor endowments. Contrary both to the predictions of the theoretical model and to the empirical results in this paper, the sign of the coefficient on the interaction between openness and land is negative, implying that opening the economy reduces inequality in countries with a higher land-labor ratio.

The next section presents the general income distribution framework. The following section applies this framework to the Heckscher-Ohlin model and to the dynamic specific factors model. The third section examines the available empirical evidence. The next section describes possible extensions and concludes.

2 A Model of the Evolution of Income Distribution

This section describes a framework in which to analyze the dynamic effects of various economic shocks on arbitrary initial income distributions when there are many factors of production. The results of this framework can be applied to dynamic trade models once production is specified.

[6] Another paper that examines the relation between natural resources and inequality is Leamer *et al.* (1999).

2.1 Agents

Agents live a single period. During this period they supply labor inelastically in exchange for the market wage w_t.[7] At the end of their life, agents provide a bequest to their sole descendant. Hence, agents are endowed with wealth at birth. This endowment, plus the income from wages, represents the total wealth (or income, since agents live a single period) of the agent. Each agent divides her wealth between the fraction that is used for consumption and the fraction saved for the bequest. There is a continuum of agents in each generation, indexed by $z \in [0, L]$. Agents have different propensities for consumption and receive different inheritances from their progenitors.

There are n goods in the economy. The consumption of agent z in period t is a vector $c_t(z) \equiv (c_{1t}(z), c_{2t}(z), \ldots, c_{nt}(z))$, where the first subscript represents a particular good. Agents receive sub-utility $V(c_t(z))$ from consumption. This sub-utility function is homothetic and satisfies the usual smoothness and concavity assumptions. Defining commodity 1 as the numeraire, the relative price of good j in period t is p_{jt}, $j = 1 \ldots n$. The vector of prices is denoted p_t.

Each agent is born with a propensity to consume given by the realization of a random variable $\alpha_{zt} \in [0, 1]$. These random variables are independent and identically distributed (iid) for all z and t. The propensity to consume reflects the agent's preference for consumption relative to the utility derived from the bequest. Let $y_t(z)$ be the income of the agent and $s_t(z)$ denote the savings for her bequest. The value of the bequest received by the descendant is $b_{t+1} = (1 + r_{t+1})s_t(z)$, where r_t is the interest rate in period t. The problem facing agent z, living in period t is:

$$\begin{aligned} \max_{\{c_t, b_{t+1}\}} \quad & U(c_t, b_{t+1}; z_t, \alpha_{zt}) = \quad V(c_t(z))^{\alpha_{tz}} b_{t+1}^{(1-\alpha_{tz})} \\ s.t. \quad & p_t c_t(z) + s_t(z) = \quad y_t(z) \end{aligned} \tag{1}$$

It is important to note that agents receive utility from the bequest and not from the utility of the descendants. This formulation of utility has the virtue of simplifying the analysis of personal income distribution. It has been used to study the evolution of income distribution in Banerjee and Newman (1991) and in Fischer (1992b). An alternative specification is commonly used in macroeconomics (see Barro (1974)), where agents receive utility from the utility of their descendants, effectively making them infinitely lived individuals. Galor and Zeira (1989) study the evolution of income distribution in a model of growth through the accumulation of human capital and show that the two specifications of utility give rise to similar results.

There are two reasons to introduce randomness into the model. First, randomness in the propensity to consume has an attractive interpretation: some agents are spendthrifts while others are frugal, and this characteristic does not depend on wealth. A thrifty, wealthy agent may have a descendant that spends all

[7] We assume labor homogeneity. When labor is non-homogenous, there exists an additional factor such as human capital, and observed wages include the return to human capital.

of her inheritance and leaves little to her own successor. Families, indexed by z, may become relatively wealthier or poorer, independently of the behavior of the economy at large. Since the value of α_{tz} is known to an agent at birth, the allocation of income between consumption and savings is non-random. The second reason for randomness is that without randomness the limiting distribution of incomes is degenerate, if it exists.[8]

Agents save by purchasing stocks of the m factors of production. The first factor is named capital and is identified with the first commodity, so its price is the numeraire price. Each factor provides a total return equal to a per-period return plus a capital gain. In an equilibrium, the total return to a dollar invested in any asset (here, a factor of production) is the same. Let $q_{it}, i = 1, \ldots, m$ denote the price of the i-th factor and let π_{it} be its return in period t. The *no-arbitrage* condition is:

Condition 1

$$1 + r_{t+1} = (q_{it+1} + \pi_{it+1})/q_{it}, \ \ i = 2, ..., m \tag{2}$$

where r_t is the return to capital. If condition 1 is satisfied, agents are indifferent as to how they allocate savings among the different assets. In the long run, the distribution of income is independent of the initial distribution of assets, so the long run distributional results hold even if agents hold assets in different proportions. This proves to be a problem for the short run analysis, because unanticipated shocks can have different effects on equally wealthy agents. The following assumption deals with this problem.[9]

Condition 2 *All agents divide their savings among the various assets in the same proportion by value.*

Let $m_{it+1}(z)$ denote the quantity of factor i bought by agent z in period t. The value of the bequest received by agent z living in period $t+1$ is:

$$b_{t+1}(z) = \sum_i q_{it+1} m_{it+1}(z) \tag{3}$$

The sources of income of agent z living in period t are his salary and the value of the bequest received, b_{tz}. This income is to be divided between consumption expenditure and savings for own bequest. The no-arbitrage condition implies that:

$$y_t(z) = w_t + b_t(z) = C_t(z) + b_{t+1}(z)/(1 + r_{t+1}) \tag{4}$$

where $C_t(z) = \sum_i p_{it} c_{ti}(z)$ is the consumption expenditure of agent z. Utility maximization requires that

[8] This motive for the introduction of randomness appears first in Karni and Zilcha (1989).

[9] This is a strong assumption, but on the other hand, the no-arbitrage condition implies that agents' decisions are not distorted by this assumption.

$$C_t(z) = \alpha_{zt} y_t(z) = \alpha_{zt}(w_t + b_t(z)) \tag{5}$$

$$S_t(z) = (1 - \alpha_{tz}) y_t(z) = (1 - \alpha_{zt})(w_t + b_t(z)) \tag{6}$$

3 Income Distribution

The *Lorenz Curve* is the appropriate instrument for the study of income distribution in this economy. The Lorenz curve is defined as the curve that assigns to the x% poorest agents in the economy the percentage of total income received by this group. Since our interest lies in the changes in the concentration of income and not in the effects of trade on welfare, the use of the Lorenz curve to compare distributions with different mean incomes is appropriate. The Lorenz distribution induces a partial ordering in the set of income distributions. A distribution X is said to be *Lorenz preferred* to Y if the Lorenz curve for X lies everywhere above the Lorenz curve for Y.[10]

Assume that in period $t-1$, there is a shock to the economy, such as an unexpected liberalization of trade. The physical allocations of assets for bequests have been made and cannot be changed. The value of the bequests changes in the new circumstances. Consider the income of agent z with and without the shock (primes denote variables that have changed):

$$\begin{aligned} w_t + b_t(z) &= y_t(z) \\ w'_t + b'_t(z) &= y'_t(z), \quad \forall z \in [0, L] \end{aligned} \tag{7}$$

Since all agents invest their wealth in the different assets in the same proportions, a change in the price of any asset will affect all bequests in the same proportion. Denoting by B_t the aggregate value of bequests:

$$B_t = \int_0^L b_t(z) dz \tag{8}$$

Denote the ratio of aggregate wealth with the shock to aggregate wealth without the shock by

$$v'_t = B'_t / B_t.$$

If there is no shock, $v_t = B_t / B_t = 1$. Then (6) can be written

[10]The analysis that follows is formally similar to the one in Fischer (1992a)). Note, however, that wealth includes many assets and the possibility of capital gains or losses.

$$\begin{aligned} w_t + b_t(z)\nu_t &= y_t(z) \\ w'_t + b_t(z)\nu'_t &= y'_t(z), \quad \forall z \in [0, L] \end{aligned} \tag{9}$$

which means that the original stocks of assets are scaled by the percentage change in aggregate wealth change. The second distribution is Lorenz preferred (see appendix) if:

$$w_t/\nu_t < w'_t/\nu'_t \tag{10}$$

For any variable z, let $\hat{z} \equiv dz/z$ denote the percentage change in z and let a bar over a variable denote its steady state value. It follows from (8) that the effects of a shock on the distribution of income depend on $\text{Sign}(\widehat{w_t/\nu_t})$, where $\text{Sign}(\widehat{w_t/\nu_t}) = \text{Sign}(\widehat{w_t/B_t})$. We have shown:

Proposition 1 *Any shock that leads to an increase (fall) in the ratio of inherited to total wealth raises (lowers) inequality, given the distribution of bequests.*

The intuition behind this result is that wages are the only source of income that is evenly distributed among agents. When their relative importance declines, inequality increases. In the case of comparisons between steady states, proposition 1 can be simplified considerably. Let α^* be the expected value of the propensity to consume be, i.e., $E(\alpha_{tz}) \equiv \alpha^*, \forall t, z$. Suppose our framework is applied to a dynamic economic model which has a steady state (the conditions for existence of a steady state depend on the particular model). The following lemma describes the aggregate stock of wealth in steady state:

Lemma 1 *Suppose a steady state exists. The steady state value of aggregate bequests is*

$$\bar{B} = \frac{(1-\alpha^*)wL(1+r)}{(1-(1-\alpha^*)(1+r))} \tag{11}$$

Proof: Total savings are

$$S_t = \int_0^L (1-\alpha_{tz})(w_t + b_t(z))dz.$$

Since the random variables α_{tz} are iid and $b_t(z)$ is predetermined at t, it is possible to write:[11]

$$S_t = (1-\alpha^*)\int_0^L (w_t + b_t(z))dz = (1-\alpha^*)(w_t L + B_t)$$

[11]The argument requires that the Law of Large Numbers hold for a continuum of random variables. Judd (1985) and Feldman and Gilles (1985) show that the Law of Large Numbers does not always hold in this setting.

Hence, by the no-arbitrage condition

$$B_{t+1} = (1 + r_{t+1})(1 - \alpha^*)(w_t L + B_t).$$

The lemma now follows from the fact that in a stationary state, $B_t = B_{t+1} = \bar{B}$, $r_t = r_{t+1} = \bar{r}$ and $w_t = \bar{w}$. ■

Proposition 1 is apparently not applicable to comparisons between steady states, since it was derived under the assumption that bequests are the same with and without the shock. The next lemma shows that the steady state distribution of income is independent of initial bequests, which implies that proposition 1 is applicable to comparisons between steady states.

Lemma 2 *If there exists $T \in N$ and $\epsilon > 0$ such that*

$$(1 - \alpha^*)(1 + r_t) < 1 - \epsilon, \ \forall t > T \quad (12)$$

$$E(1 - \alpha_{tz})^2 (1 + r_t)^2 < 1 - \epsilon, \ \forall t > T \quad (13)$$

then there exists a limit income distribution associated to each steady state that is independent of initial bequests. This distribution depends on the steady state interest rate and on the distribution of the propensity to consume α_{tz}.

Proof: See Appendix. ■

The conditions in the Lemma ensure that the amount of mixing due to the random nature of the savings rate α counteracts the tendency of inequality to increase if wealth receives a high reward.

Assume that the conditions for lemmas 1 and 2 hold. Then steady state income distributions can be Lorenz-ranked by the changes in the steady state interest rate, since $\text{Sign}(\widehat{\bar{w}/\bar{B}}) = -\text{Sign}(\hat{\bar{r}})$. This proves one of the main results of the paper:

Proposition 2 *Considering only steady states, trade liberalization reduces (increases) long run inequality if it lowers (raises) the steady state interest rate.*

Proposition 2 shows that it is simple to study the long run effects of a shock on income distribution. On the other hand, an analysis of the dynamic effects of a shock requires knowing the path of the wage to wealth ratio.[12]

In order to determine the effects of trade on income distribution, it is necessary to specify a particular trade model in which to set our framework. The present framework can be easily applied to embed a dynamic

[12] As mentioned before, the appropriate interest rate is the one that applies to small firms.

Heckscher-Ohlin trade model (see Fischer (1992a)). To restate the conclusions for the dynamic Heckscher-Ohlin model, trade improves (worsens) the distribution of income of all generations in the labor (capital) abundant country if the investment goods sector is capital intensive. These results are inconsistent with the notion that trade liberalization affects LDCs differentially, as shown in Table 1. The dynamic Specific Factors Model of Eaton (1987), as we show below, provides a better explanation for Table 1.

4 Trade Liberalization and Income Distribution

In this section we apply the previous results to the dynamic specific factors model of Eaton (1987).

4.1 The Dynamic Specific Factors Model

Consider a small country with two specific factors: Land and Capital; and a mobile factor, Labor. The amount of land is normalized to 1. Let $m_t(z)$ and $k_t(z)$ be the individual holdings of land and capital respectively, then:

$$K_t = \int_0^L k_t(z)dz; \qquad T \equiv 1 = \int_0^L m_t(z)dz \tag{14}$$

Production is described by:

$$Q_1 = F(K, L_1), \quad Q_2 = G(T, L_2) \tag{15}$$

where L_1 and L_2 are the allocations of labor to the two sectors of the economy, i.e. $L_1 + L_2 = L$. The functions F and G are convex, twice differentiable, linearly homogenous and satisfy the Uzawa conditions. The technology and preferences over goods are identical to those in the world. The linear homogeneity of production and the small country assumption imply that an increase in land size is equivalent to a decrease in the labor supply and a compensating change in capital stocks in terms of its effects on agents.

Let p^* be the world price and p be the domestic price of the agricultural good relative to the capital using good, a price that may include a tariff. Trade is balanced each period. In order to simplify the analysis, we assume tariff revenues are not returned to agents. The qualitative results are not altered if we assume that tariff revenues are returned to agents without redistribution.

Wages and rents from capital are derived from the zero-profit conditions of production. Land rents are the residue of the product of land after workers have been paid. Let the price of land be q_t. Savings not used for the purchase of land are accumulated as capital (in terms of quantities of good 1 that are not consumed):

$$K_{t+1} = [B_t/(1 + r_t) - q_t] \tag{16}$$

Capital does not depreciate. The total wealth of the economy in period t is $B_t = q_t + K_t$. The value of land in any period can be derived from the no-arbitrage condition (2), which becomes:

$$(q_{t+1} + \pi_{t+1})/q_t = (1 + r_{t+1}) \tag{17}$$

In the steady state, there is no land appreciation, so the price of land satisfies:

$$\bar{q} = \frac{\bar{\pi}}{\bar{r}} \tag{18}$$

and steady state capital stocks are:

$$\bar{K} = \left[\bar{B}/(1 + \bar{r}) - \bar{q}\right] \tag{19}$$

Eaton establishes conditions for the existence of a steady state in capital and land prices and describes the steady-state responses of endogenous variables to changes in the exogenous variables p and L.[13] The results E1—E5 that follow can be derived from those of Eaton (1987) (See appendix for details).

Let $\theta_{Li} \equiv F_L L_i/Q_i$ be the labor share in market i and $\theta_{K1} = 1 - \theta_{L1}, \theta_{T2} = 1 - \theta_{L2}$ be the capital and land shares, respectively. Let $\sigma_2 \equiv G_L G_T / G G_{TL}$ be the elasticity of substitution between labor and land and $\lambda_{Li} \equiv L_i/L$ be the fraction of labor in sector i. Consider the following parameter restrictions:

Condition 3

C1. $\theta_{L1} - \theta_{L2} > 0$.

C2. $(\theta_{L1}/\theta_{K1}) - (\theta_{L2}/\theta_{T2})\sigma_2 > 0$

C3. $\theta_{K1}/\theta_{L1} < (1 - \alpha^*)\bar{r}/((1 - (1 - \alpha^*)(1 + \bar{r}))$

Then

E1. If C1, an increase (fall) in the amount of land raises (lowers) the steady state interest rate.

E2. If C2, an increase (fall) in the price of the agricultural good raises (lowers) the steady state interest rate. Moreover, the steady state stock of capital falls (increases).

E3. If C3, then a fall (increase) in the price of the agricultural good leads to a decrease (increase) in the steady state price of land.

E4. If C1, an unanticipated shock to an exogenous variable leads to initial overshooting of the land price.

[13] There are minor differences with Eaton's model because we use a specific utility function and agents live a single period. These changes are reflected in weaker conditions for stability.

E5. If C3 and C1, an increase in the labor force leads to an increase in steady state capital stock.

How likely is it that condition $C1$ holds? Table 2 presents data on the labor share in the agricultural and manufacturing sector in various countries. A test of means shows that the means of the labor shares in the two sectors are significantly different (at 1%) and that the labor share is smaller in the farming sector, as required by $C1$.[14] Condition C2 has no obvious intuitive interpretation, but note that C2 reduces to C1 for Cobb-Douglas production functions. Finally, $C3$ is quite reasonable. For developed countries, $\theta_{K1}/\theta_{L1} \approx 1/2$ (Table 2). Assuming an average savings rate of .15 and a generation life of 25 years, $C3$ requires a yearly interest rate higher than $r = .043$. If the savings rate is .1, the yearly interest rate should be higher than $r = .057$. Moreover, this condition on interest rates can be relaxed substantially at a cost in the complexity of the condition. The following analysis assumes that conditions $C1 - C3$ hold. To proceed we need a link between the factor abundances and the direction of trade in steady state. We need the following definitions:

Definition 1

- *A country is* capital (land)-abundant *if its capital-labor (land-labor) ratio is higher than the world ratio, while the land-labor (capital-labor) ratio is lower than that of the world.*
- *A country is* labor-abundant (poor) *if its labor-land ratio is higher (lower) than that of the world.*[15]
- *A country is said to* liberalize trade *if the difference between world and domestic prices falls.*

Proposition 3 *If the country is capital-abundant (land-abundant), it exports the capital-using (land-using) commodity.*

Proof: Under free trade, a capital-abundant country with constant returns technology produces more than the world's per-capita amounts of the capital-using good. The homotheticity of the utility function implies that these goods are exported).

■

Corollary 1 *In steady state under free trade, countries can only be capital or land abundant.*

Proof: In steady state, the capital stock is an endogenous variable. Result E5 implies that if we compare two countries, one of which has the average labor to land ratio and the other has a higher ratio, i.e., it is labor-abundant, in the steady state it has more capital and a higher labor to land ratio. This means it is capital abundant in the steady state. Conversely, if a country is labor-poor, it is land abundant in steady state.
■

Proposition 4 describes the long run effects of trade on steady state income distribution. It shows that

[14] In some African countries farmers work land they own, so the figures for the labor shares are likely to be biased. If we exclude African countries from the sample, the difference between the labor shares remains significant at 1%.

[15] Observe that this is a strict definition, so at a point in time, countries are either labor abundant or not. In the long run, however, countries are either capital or land abundant, as we show below.

for moderate amounts of initial protection, the effects of liberalization on income distribution depend only on the relative labor abundance of the country.

Proposition 4 *Assume conditions $C1-C3$ hold. There exists $\bar{p}$ such that for all $p \in [p^*, \bar{p}]$, trade liberalization reduces steady state inequality in labor-abundant countries. There exists $\underline{p}$ such that for all $p \in [\underline{p}, p^*]$, trade liberalization raises steady state inequality in labor-poor countries.*

Proof: Consider a labor-abundant country. By corollary 1 the country is capital-abundant in steady state under free trade. By E2, a tariff (that leads to an increase in the domestic price of the agricultural good) reduces the steady state stock of capital. Let p^* be the world price facing the country and let $\bar{p}$ be the maximum domestic price such that the country remains capital-abundant. Then for any domestic price $p \in [p^*, \bar{p}]$, the country exports the capital using product. Using $E2$ again, a reduction in protection, i.e., a fall in p, leads to a corresponding fall in the steady state interest rate. By Theorem 1, this implies a reduction in steady state inequality in the case of labor-abundant countries. An analogous proof applies to the case of labor poor countries. ■

The dynamic analysis of inequality requires the path of the wage-wealth ratio w_t/B_t. Consider an initial steady state and examine what happens at the moment of unanticipated trade liberalization, which is assumed to take place after bequests have been decided. Bequests received in the initial period are the same with and without liberalization, though their value changes. There is an instantaneous change in the price of land, while the adjustment in the capital stock will take time. In fact, the capital stock remains constant in the initial period. All the initial adjustments in wages are a consequence of the changes in land prices. Figure 1 shows the case of liberalization in a labor abundant country under the conditions of the next proposition, which describes the path of inequality associated to the path of wealth shown in Figure 1.

Proposition 5 *Assume that in the initial steady state $K/q > \theta_{K1}\theta_{T2}L_1/L_2$. If liberalization lowers (raises) the price of the agricultural good, in each succeeding period the distribution of income is less (more) unequal than in the initial steady state. In the steady state inequality is lower (higher).*

Proof: See proposition 7 in the appendix of the working paper version.[16]

The factor intensity condition is needed to ensure that in the first period (while capital stocks have not begun to adjust), the fall in wages is compensated by a larger fall in land prices, so the ratio of wages to wealth increases. This reduces first period inequality and, hence, second period agents receive less differentiated bequests. Moreover, the second period wage-wealth ratio increases. These two effects reduce second period inequality compared to the situation before liberalization. By the same token, third period bequests are less unequal, and so on.

[16] Since $C1$ implies that $q/L_2 > K/L_1$, the condition in the proposition defines a range for the capital intensity as a fraction of the land intensity: $K/L_1 \in [q/L_2, \theta_{K1}\theta_{T2}q/L_2]$. The proof in the appendix requires the weaker but less intuitive condition: $K/L_1 > \theta_{K1}\theta_{T2}(q+K)/L$.

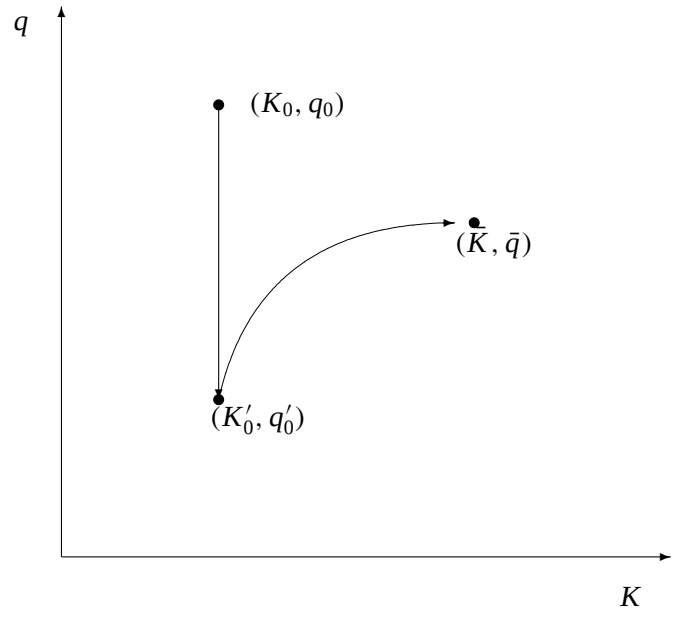

Figure 1: Adjustment path in Eaton's model

Proposition 5 implies that trade liberalization has regressive effects in land-abundant countries. If trade liberalization is accompanied by liberalization of international capital flows, the results are significantly different. In the specific factors model, free capital movements and free trade imply factor price equalization. The reason is that free capital movements imply that interest rates are equalized. Thus, free trade ensures equalization of the price of the capital-using good, hence wages must be identical with those of the rest of the world. Free trade in the agricultural good and equal wages ensures that land rents are the same. The implications of Factor Price Equalization are strong:

Proposition 6 *Under free trade and capital mobility, in steady state a land-abundant country has a distribution of income that is better than before trade liberalization.*

If a land-abundant country liberalizes its capital flows, there is an immediate inflow of capital that lowers interest rates. The rewards of all factors are the same as those in the rest of the world. The lower interest rate in the world implies that there is less inequality in the world than in the country. After liberalization inequality decreases and tends over time to converge to the level of inequality of the world. Hence, a simple way of counteracting the negative effects of trade liberalization in land-abundant countries is to simultaneously liberalize capital flows[17]. By allowing capital mobility, land abundant countries obtain the welfare gains

stemming from trade liberalization without the adverse distributional impact. In a labor abundant country, free capital flows imply the long run income distribution is worse than if these flows had not been allowed.

It is important to realize, as mentioned previously, that the relevant interest rate is not the one charged to large firms which can obtain loans abroad, but the one used in small commercial loans. This rate includes the spread charged by banks, which depends on factors such as the legal environment, the bankruptcy laws, competition in banking, etc. An additional issue is the fact that there usually is credit rationing for human capital investments, so that our assumption of equal rates of return on all assets might not hold for human capital, which has important implications for our empirical results, as shown below.

5 Labor inflexibility

The analysis so far has dealt with labor that shifts instantaneously from one sector to the other. In the short run, however, there may be a period of adjustment in which labor is unemployed, perhaps because of the existence of a minimum wage, as in Brecher (1974). In order to be able to say anything meaningful about personal income distribution, we make the assumption that it is the agents with least wealth that are unemployed. The following analysis is qualitative, since embedding the short term out-of-equilibrium approach within Eaton's dynamic model goes beyond the scope of the article.[18] Consider the effects of liberalization in a labor abundant country initially in a steady state, thus an importer of the land-using good. The immediate effect is a lowering of the price of land and unemployment of labor in agriculture. As compared to the case of instantaneous labor adjustment examined before, inequality does not decrease as much, as the poorest workers loose their salaries until they are absorbed by the expanding capital using sector, all of this occurring before the capital stock is allowed to change. The evolution of inequality in the typical case is shown in Figure 2, where $t = 0^+$ is the moment after liberalization, and before the labor market reaches equilibrium. The effect of unemployment tempers the reduction in inequality caused by trade liberalization.[19] In the figure, t_1 is the point at which labor is again fully employed, but capital has not yet begun to accumulate. The other interesting situation occurs in the case of liberalization in a land abundant country, where initial unemployment in the capital using sector amplifies the rise in inequality due to the rise of the price of land.

[17] In the long run, capital mobility is fundamental. Neither the trade regime nor the population density will have any effect on the long run income distribution, which is determined solely by the interest rate of the world.

[18] The formal analysis of the short term can be carried out using the restricted revenue function of Neary (1985), as used by Edwards (1989) in a two period specific factors model.

[19] I have not eliminated the possibility that the initial effect is to increase inequality if the effects of unemployment swamp those of the change in the value of land, though this seems unlikely.

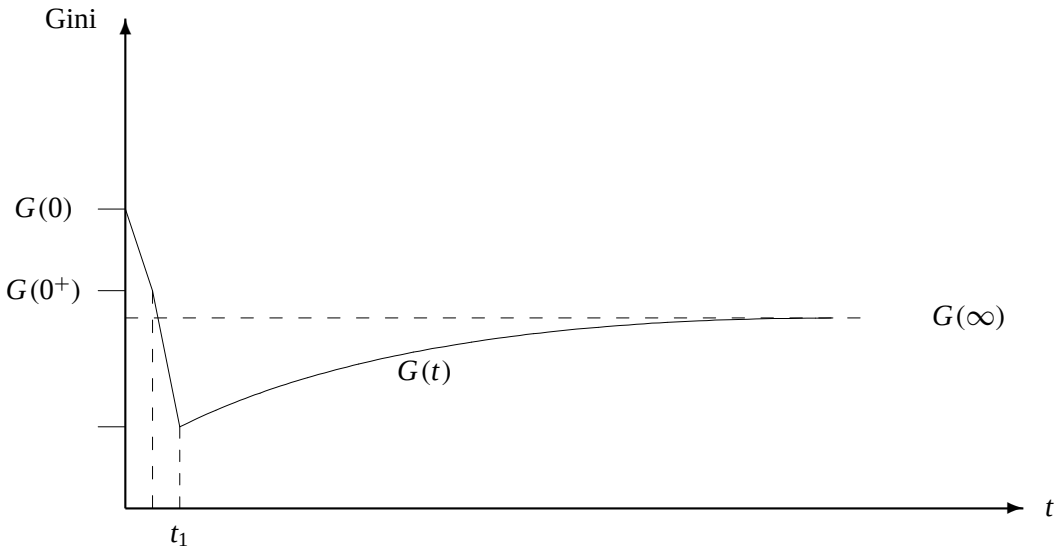

Figure 2: Evolution of inequality with labor inflexibility.

6 Empirical Evidence

In recent years there has been an increase in the number of empirical studies that focus on the relation between trade, factor endowments and income distribution. Bourguignon and Morrisson (1990), henceforth BM, have studied the effects of protection, the distribution of factor ownership and the endowments of factors on personal income distribution. BM examine a cross section of developing countries and obtain suggestive results. Unfortunately, the data available at the time gave rise to problems so severe that the results of BM can only be considered tentative.

First, the authors find that higher levels of secondary school enrollment or better distribution of farm land leads to lower inequality (we reproduce these results). Conversely, high ratios of exports of agricultural or mineral products to GDP lead to more inequality. Moreover, according to BM, protection leads to more inequality in LDC's, a result that we cannot confirm. This is attributed to the fact that protection lowers the rewards to unskilled labor, which is evenly distributed. The question is to determine whether this is still true for Latin American countries, which are characterized by low ratios of labor to land and natural resources. Moreover, BM do not test the issue examined in this paper: whether the response of inequality to liberalization depends on the factors abundant in the country.

Spilimbergo *et al.* (1999) have done a very careful test of the hypothesis that there is a negative interac-

tion effect between natural resource abundance and trade and have obtained the conclusion that, contrary to expectations, the interaction effect has the opposite sign: openness reduces inequality in resource abundant countries. On the other hand, they find that inequality is positively correlated with the interaction effect between openness and human capital.

In this section I perform a preliminary empirical analysis of the theoretical results using panel data on income distribution which satisfies minimal requirements of consistency and quality.[20] I use data on agricultural land as a proxy for natural resources. We construct a capital-labor ratio and a agricultural land-labor ratio.[21] Finally, the index of openness is taken from Sachs and Warner (1995).[22] The variables are five year averages of the underlying variables (in the case of Sachs-Warner, we use the number of years the country is classified as open in the previous 5 years). We use centered variables for factor resources.

Suppose there is a functional relation between inequality and the explanatory variables: the *degree of relative openness* A, the *relative capital-labor ratio* k and the *relative land-labor ratio* t. Since the Lorenz ordering is partial, we use the *Gini Coefficient G* as the dependent variable, because it provides the same ordering as the associated Lorenz distributions when these can be ordered.[23] Under those assumptions, suppose there is a functional relation between inequality, protection and the capital-labor and land-labor ratios:

$$G = H(k, t, A) + \epsilon_l, \quad \epsilon_l \text{ i.i.d.} \tag{20}$$

Using a second order Taylor expansion, we obtain:

$$G \approx H_0 + kH_1 + tH_2 + AH_3 + k^2H_{11} + t^2H_{22} + A^2H_{33} + tkH_{12} + kAH_{13} + AtH_{23} + \epsilon_l \tag{21}$$

where the subscripts indicate partial derivatives and $H_0 \equiv H(0, 0, 0)$. The simplest way to model how land abundance influences the distributional effects of trade is to test that H_{23} is positive. This implies the existence of an interaction between the degree openness and the land-labor ratio. We would also like the effect of capital to be to reduce inequality when an economy liberalizes: $H_{13} < 0$. We begin by considering a simplified model in which all other second order terms are zero, in order to provide at least a chance of success to the model. Below we lift this restriction.

$$G = H_0 + kH_1 + tH_2 + AH_3 + kAH_{13} + AtH_{23} + \epsilon_l \tag{22}$$

[20] For data sources, see appendix.

[21] An important problem may arise from the lack of data on mineral resources. This might be important for andean countries, which are mineral-rich and not so well provided with agricultural land.

[22] Rodríguez and Rodrik (1999) have strong criticisms of Sachs and Warner's and as well as other indexes of openness. Since the present study is preliminary, we use the index for convenience while noting its weaknesses.

[23] This presupposes, of course, that the associated Lorenz curves do not cross. This is a limitation of the analysis.

The results of this regression is favorable to the model, see Table A. These show the results of fixed and random effects regressions in the panel of countries (with unbalanced observations).[24] We note that all variables are significant and that the direct effects of factor abundances are: increased inequality are associated to higher capital-labor ratios and that higher-land labor ratios are negatively related to inequality. As in Spilimbergo *et al.* (1999) the interaction coefficients have the opposite sign of the direct effect.[25] Moreover openness leads to more inequality by itself. How important are these effects? Going from a totally closed to an open economy would raise the Gini directly by about 0.03, everything else equal. The effect can be much larger if coupled to large land-labor ratios: in that case, the additional increase in the Gini is 0.13. On the other hand, the maximum effect of the capital-labor interaction effect is at most 0.03. It is important to note, however, that we are assuming that the other terms in the second order expansion are zero. If we consider the full equation (22), the desired effects remain in the random effects regression but disappear in the fixed effects model. Unfortunately, the random effects model is again rejected in a Hausman test. Hence, the evidence is not conclusive as to whether the theoretical model is verified by the data.

When human capital is introduced as an additional variable the results change considerably, see Table A: openness and the land-labor ratios cease to be significant.[26] Spilimbergo *et al.* (1999) examine this result and find that it has been observed before in the literature on wage inequality. There are two potential explanations:

- Rationing in credit markets for human capital imply that the returns to human capital investment may be higher than the interest rate and this effect could be amplified by opening to trade.
- The non-inclusion of mineral and other forms of wealth.

7 Conclusions and Extensions

Free trade is well known to have positive effects on welfare, at least when we consider representative agents. When agents are differentiated, gainers from free trade can potentially compensate losers so that everybody is better off. These compensations are not common, so we may expect a skewed distribution of the gains from trade. A natural question to ask is whether the personal income distribution improves or worsens under free trade. The paper presents a general framework that can be used to analyze this issue. The first conclusion is that the long run evolution of inequality depends only on the effect of trade liberalization on interest rates. In the short run it is necessary to examine the dynamics of the wage-wealth ratio and to keep track of the distribution of bequests between cohorts.

This general framework is applied to the dynamic specific factors model of trade of Eaton (1987). The two main results from this section are: first, in the specific factors model, trade leads to more (less) inequality

[24] A Hausman test rejects the use of a random effects model.

[25] This could also be a sign of a problem with the functional form of the right hand side.

[26] Human capital from Barro and Lee, average years of schooling.

in land abundant (capital-abundant) countries; and second, that capital mobility reverses the effects of trade on inequality in the long run. Thus it seems that free trade should encounter opposition in land-abundant countries if it is not accompanied by a liberalization of capital flows.

The specific factor model explains the stylized observation that land abundant Latin American countries have experienced increases in inequality following liberalization. This conclusion is reversed in the case of labor abundant countries, such as those in Southeast Asia. Preliminary econometric testing provides mixed results. Potential explanations include the lack of an overall measure of natural resources and problems with the indexes of openness. There are several potential extensions to the empirical part of the paper that would be worthwhile pursuing.

First, there are difficulties with the protection indexes used in the paper. Rodriguez and Rodrick (1999) have criticized most of the indexes used in the literature. An alternative would be to use Leamer (1989) proposal for an index of protection.[27] This consists of using the residuals from a regression of total trade (Exports + Imports) on factor endowments as an index of protection. Intuitively, the farther a country's relative endowment of factors differs from the worlds, the more it should trade. Any differences between the expected trade of a country (the regression prediction) and the observed trade are assumed to be due to protection. Since Leamer's index for a country is the residuals of a regression, it includes an error term. Hence, using the index as an explanatory variable in an OLS regression leads to inconsistent estimates. The solution is to use Maximum Likelihood to estimate simultaneously Leamers index and equation (22). The parameters are identified in the covariance matrix of the system.[28]

There are two further predictions of the model that might be tested: first, the existence of a positive relation between the local interest rate and the level of inequality. Second, it might be of interest to test the link from free capital flows to a reduction in inequality in land abundant countries and, conversely, to an increase in inequality in labor abundant countries.

[27] Spilimbergo *et al.* (1999) uses this approach.

[28] A suggestion of Jim Hamilton.

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A Appendix

Results (a3)-(a6) are derived in Eaton (1987). We will also assume the conditions for non-oscillatory convergence to the steady state derived in that paper.

$$\begin{aligned}
\theta_{K1} &= F_K K_t/Q_{1t} & \theta_{L1} &= 1-\theta_{K1}\\
\theta_{T2} &= G_T T/Q_{2t} & \theta_{L2} &= 1-\theta_{T2}\\
\sigma_1 &= F_K F_L/FF_{KL} > 0 & \sigma_2 &= G_T G_L/GG_{TL} > 0\\
\lambda_{Li} &= L_{it}/L & \theta &= \theta_{L1}-\theta_{L2}\\
\phi &= (\theta_{T2}\lambda_{L1}\sigma_1+\theta_{K1}\lambda_{L2}\sigma_2)^{-1}\\
\eta &= \eta_r-\eta_w\theta_{K1}/\theta_{L1} & \eta_z &= s_z z/s,\ z=w,r.\\
\Delta &= \frac{K}{K+q}+\lambda_{L1}\phi\left(\theta_{L1}\theta_{L2}\eta+\frac{q\theta}{q+K}\right)
\end{aligned}$$

Let $\hat{z}_t = dz_t/z_t \to \hat{z} = d\bar{z}/z,\ z = w, q, p, r$.[29] Then

$$\hat{w}_t = \left[\theta_{K1}\lambda_{L2}\sigma_2\hat{p}_t - \theta_{K1}\theta_{T2}(\hat{L}-\lambda_{L1}\hat{K}_t)\right]\phi \tag{23}$$

$$\hat{r}_t = \left[-\theta_{L1}\lambda_{L2}\sigma_2\hat{p}_t + \theta_{L1}\theta_{T2}(\hat{L}-\lambda_{L1}\hat{K}_t)\right]\phi \tag{24}$$

In terms of the exogenous variables L and p, between steady states

$$\hat{K} = \left\{\left(1+\theta_{L1}\theta_{T2}\phi\eta+\frac{q}{q+K}\phi\theta\right)\hat{L}+\left(\eta_p-\theta_{L1}\lambda_{L2}\sigma_2\phi\eta-\frac{q}{(q+K)\theta_{T2}}(1+\lambda_{L2}\sigma_2\phi\theta)\right)\hat{p}\right\}\Delta^{-1} \tag{25}$$

$$\hat{r} = \left\{\theta_{T2}\left(\frac{K}{K+q}-\lambda_{L1}\right)\hat{L}+\left[\lambda_{L1}\left(\frac{q}{K+q}-\theta_{T2}\eta_p\right)-\frac{K}{K+q}\lambda_{L2}\sigma_2\right]\hat{p}\right\}\theta_{L1}\phi\Delta^{-1} \tag{26}$$

$$\hat{w} = -\theta_{K1}\hat{r}/\theta_{L1} \tag{27}$$

$$\hat{q} = \frac{\left(\theta_{L1}\hat{p}-\theta\hat{r}\right)}{\theta_{L1}\theta_{T2}} \tag{28}$$

Assume that C1-C3 hold and that L remains constant. In the present model $\eta_p = 0$. Moreover, $\eta > 0$

[29] The proportional change between the initial steady state and the period t value of the variable is denoted $\hat{z}_t$. The proportional change $\hat{z}$ measures the change between steady states, so $\hat{z}_t \to \hat{z}$.

by C3. To see this, note that $\eta > 0 \Leftrightarrow \theta_{L1}\eta_r - \theta_{K1}\eta_w > 0$, where η_z is the elasticity of savings with respect to the variable z = w,r. Note also that $\theta > (<)0 \Rightarrow \lambda_{L1} > (<)K/(q+K)$. To see this, observe that $wL_1/rK > (<)wL_2/\pi \Leftrightarrow q/K > (<)L_2/L_1$. Using (6) and (11) for an agent with average wealth in steady state, we get $\eta_w = 1$ and $\eta_r = (1-\alpha^*)\bar{r}/(1-(1-\alpha^*)(1+\bar{r}))$. Then condition C3 is sufficient for $\eta > 0$. The following lemma derives E1-E5 from C1-C3. The lemma is used in the proof of proposition 4.

Lemma 3 *If conditions C1-C3 are satisfied,*

E1. A fall in the price p of the agricultural good lowers the steady state interest rate and raises (lowers) the steady state stock of capital.

E2. A fall in the price p of the agricultural good raises the capital stock in all periods. After an initial instantaneous jump in the interest rate, it falls in succeeding periods.

E3. A fall (increase) in the price p of the agricultural good lowers (raises) the steady state price of land.

E4. The initial change in the value of land overshoots its long run value.

E5. An increase in the amount of labor increases the steady state capital-labor ratio.

Proof: Note that since $\sigma_2 > 0$, $\theta > 0$ and $\eta_p = 0$, (25) shows that the steady state stock of capital increases in the steady state. As in (Eaton, 1987), (26) implies that when C2 holds, the fall in the price of p lowers the steady state interest rate. Hence from some period t onwards the LHS of (24) is negative. Since the first term in the RHS is positive, the last term, which corresponds to the change in the change in period t capital with respect to the original stock, must be negative. Since we have assumed non-oscillatory convergence, the capital stock is higher than initially and increasing in each period. Consider the initial effect of the change in the price of the agricultural good. The stock of capital cannot change instantaneously, so, by (24), there is an initial jump in the interest rates. As capital accumulates and the price of the agricultural good does not change any further, the interest rate falls, eventually falling to a level that is lower than the original value (since the steady state value is lower).

In order to study the changes in the price of land, note that since $\eta_p = 0$, (26) becomes

$$\hat{r} = \frac{\hat{p}\,(\lambda_{L1}q - K\lambda_{L2}\sigma_2)\,\theta_{L1}\phi}{K + \lambda_{L1}\phi\,\{\theta_{L1}\theta_{L2}\eta(K+q) + q\theta\}}$$

Thus, from (28)

$$\hat{q} = \frac{\hat{p}}{\theta_{T2}}\left\{1 - \frac{\theta\phi\,(\lambda_{L1}q - K\lambda_{L2}\sigma_2)}{K + \lambda_{L1}\phi\,(\theta_{L1}\theta_{L2}\eta(K+q) + q\theta)}\right\} \tag{29}$$

We need to show that the term between braces in (29) is positive (recall that $\theta > 0$ by C1 and that $\eta > 0$). If $\lambda_{L1}q - K\lambda_{L2}\sigma_2 < 0$, the result follows. Otherwise, if $\lambda_{L1}q - K\lambda_{L2}\sigma_2 > 0$, then it follows that

$$\theta\phi(\lambda_{L1}q - K\lambda_{L2}\sigma_2)[K + \lambda_{L1}\phi(\theta_{L1}\theta_{L2}\eta(K+q) + q\theta)]^{-1} < [\theta\phi(\lambda_{L1}q - K\lambda_{L2}\sigma_2)]/(q\theta\lambda_{L1}\phi) \quad (30)$$

$$= 1 - K\lambda_{L2}\sigma_2/(q\lambda_{L1}) < 1$$

Thus, in all cases, $sgn(\hat{q}) = sgn(\hat{p})$.

For (a4) we follow (Eaton, 1987) section 6.1. In the initial period after the fall in the price of the agricultural good, the interest rate goes up (there is no instantaneous adjustment in capital stocks) and the price of land falls. In succeeding periods, as the interest rate falls, the price of land rises to its long run value when $\theta > 0$ (which is lower than the original steady state in this case).

Finally, for (a5), note that from (25), when $\theta > 0$, a change in the quantity of labor leads to a more than proportional increase in the steady state stock of capital.

■

Corollary 2 *We have the stronger result:*

$$\hat{q} < (>)\ (K\lambda_{L2}\sigma_2/(q\lambda_{L1}))\ \hat{p}/\theta_{T2} \text{ if } \hat{p} < (>)0 \quad (31)$$

(a7)

Proof: In the case $(\lambda_{L1}q - K\Lambda_{L2}\sigma_2) > 0$ this is clear from (29) since the term in braces is larger than 1. When $(\lambda_{L1}q - K\Lambda_{L2}\sigma_2) < 0$, note that the term in braces in (29) is larger than $(K\lambda_{L2}\sigma_2/q\lambda_{L1})$.

■

Proposition 7 *Suppose in the initial steady state $\theta_{K1}\theta_{T2}\lambda_{L1}\phi < K/(K+q)$. Then, if liberalization lowers (raises) the price of the agricultural good, there is an instantaneous decrease (increase) in inequality. Moreover, in the new steady state, the distribution of income is less unequal than in the initial steady state. Along the path to the new steady state, inequality is always lower than before the drop in agricultural prices.*

Proof: Consider the path of land prices in response to a fall in the price of the agricultural good (the case in which the price rises is completely analogous). By lemma 3 the short run fall in price of land overshoots the long run fall in land prices in response to a fall in p. Along the path towards the new steady state the price of land increases.

Assume liberalization occurs before cohort 0 becomes active. Consider any period *after* liberalization. Each period (except for period 0) there is a higher K and a lower q compared to the initial steady state, because of our assumption of no oscillation. There are no further changes in p. Using (23), we can write $\widehat{w_t/B_t} = \hat{w} - \widehat{K+q}$ as

$$\begin{aligned}\hat{w}_t - q\hat{q}_t/(q+K) - K\hat{K}_t/(q+K) &> \hat{w}_t - q\hat{q}/(q+K) - K\hat{K}_t/(q+K) \\ &= \left\{\theta_{K1}\theta_{T2}\phi\lambda_{L2} - \frac{K}{K+q}\right\}\hat{K}_t - \frac{q\hat{q}}{K+q} + \theta_{K1}\lambda_{L1}\phi\sigma_2\hat{p} \quad (32)\end{aligned}$$

(a8)

where we have used the fact that $0 > \hat{q} > \hat{q}_t$ due to overshooting of the price of land. As $t \to \infty$, the two sides of the inequality converge. Moreover, they converge to a positive number, since we know that long run inequality decreases when p falls (because $\hat{r}$ falls). The only term that is changing in the RHS of the inequality (32) is $\hat{K}_t$ and it is increasing over time. Using Corollary 2, we have:

$$\begin{aligned}-\frac{q\hat{q}}{K+q} + \theta_{K1}\lambda_{L1}\phi\sigma_2\hat{p} &> \hat{q}\left\{-\frac{q}{K+q} + \frac{\theta_{K1}\lambda_{L2}\sigma_2 q\phi\lambda_{L1}\theta_{T2}}{K\lambda_{L2}\sigma_2}\right\} \\ &= \hat{q}\left\{-\frac{q}{K+q} + \frac{\theta_{K1}\lambda_{L1}\theta_{T2}q\phi}{K\lambda_{L2}\sigma_2}\right\} \\ &= \frac{\hat{q}}{K}\left\{-\frac{K}{K+q} + \theta_{K1}\lambda_{L1}\theta_{T2}\phi\right\}\end{aligned}$$

which implies that:

$$\hat{w}_t - q\hat{q}_t/(q+K) - K\hat{K}_t/(q+K) > \left\{\hat{K}_t + \frac{\hat{q}}{K}\right\}\left\{\theta_{K1}\theta_{T2}\phi\lambda_{L2} - \frac{K}{K+q}\right\} \quad (33)$$

When the term in brackets in the RHS is negative, the RHS is initially positive because (because $\hat{q} < 0$ and $\hat{K}_0 = 0$). Hence the labor income to wealth ratios is always better than before the fall in the price of the agricultural good.

Consider the impact effect of trade liberalization on bequests. We assume that the fall in prices occurs before cohort zero starts producing, but after the bequest decisions of parents have been made. Therefore the bequest distribution has not changed, but since the value of wages increases relative to wealth, cohort zero members receive a less unequal distribution of income, i.e., the impact effect of lower agricultural prices is to improve the distribution of income. In the following periods, the capital stock increases (but it is better distributed) towards its new steady state value. Since in the new steady state the distribution of income is better than before the fall in agricultural prices and initially the distribution of income improves, the fact that the approach to the new steady state is non-oscillatory implies that the wage income wealth ratio is always better than before the drop in agricultural prices. Since cohort zero has less inequality, their bequests are also less unequal. Hence, period 1 members receive bequests that are less unequal and face labor income to wealth ratios that are better than before the price drop. Hence, the distribution of income of that generation is also better than the original income distribution. This is true for all following generations. Hence the

distribution of income is better than before the fall in prices along the whole path to the new steady state.

We need to show that the distribution of bequests is at least as good as before trade liberalization in order to prove the claim that inequality is reduced each period. Consider the impact effect of trade liberalization, which we assume occurs before cohort zero starts producing, but after the bequests decisions of parents have been made. Therefore the bequest distribution has not changed. In period 0, K is fixed, since it depends on the previous period's decisions. The remainder of the proof shows that there is an initial decrease in inequality, which implies that period 1 bequests are less unequal, and so forth.

■

Note that the condition on the ratio of wealth in capital to total wealth is a sufficient condition that can be relaxed at the price of expressions that are difficult to interpret. This condition requires that the initial capital stock not be too small a proportion of total wealth.

We need to prove lemma 2:

Lemma 4 *If there exists a* $T \in N$ *and* $\epsilon > 0$ *such that*

E1. $(1-\alpha^*)(1+r_t) < 1-\epsilon,\ \forall t > T$

E2. $E(1-\alpha_{tz})^2(1+r_t)^2 < 1-\epsilon,\ \forall t > T.$

(a9)

then there exists a limit income distribution associated to each steady state that is independent of initial bequests. The limiting distribution depends on the interest rate and on the distribution of the α_{tz}.

Proof: (Following a suggestion of W. Epps). We show that for any $z \in [0, l]$, $y_t(z)$ converges in square mean when $t \to \infty$, independent of initial endowments $b_0(z)$. Now

$$y_t(z) = w_t + b_t(z) = w_t + (1-\alpha_{(t-1)z})(w_{t-1} + b_{t-1}(z))(1+r_t)$$

$$= w_t + (1-\alpha_{(t-1)z})[(1+r_t)w_{t-1} + (1-\alpha_{(t-2)z})(w_{t-2} + b_{t-2}(z))(1+r_{t-1})]$$

$$y_t(z) = w_t + \sum_{j=1}^{t} w_{t-j} \prod_{i=1}^{j}(1+r_{t-i})(1-\alpha_{(t-i)z}) + b_0(z)\prod_{j=1}^{t}(1+r_{t-j})(1-\alpha_{(t-j)z})$$

As $\{w_t\}$ is bounded, let $\bar{w}_t = \max_{j=1\ldots t}\{w_j\} < \infty$. Then we may study the convergence of

$$x_t(z) = \bar{w}_t\left[1 + \sum_{j=1}^{t} w_{t-j} \prod_{i=1}^{j}(1+r_{t-i})(1-\alpha_{(t-i)z})\right] + b_0(z)\prod_{j=1}^{t}(1+r_{t-j})(1-\alpha_{(t-j)z}) \qquad (34)$$

(a9)
because $0 < y_t(z) \leq x_t(z), \forall z,\ t$. Let

$$P_j = \prod_{i=1}^{j}(1-\alpha_{(t-i)z})(1+r_{t-i}), \quad P_0 = 1$$

$$x_t(z) = \bar{w}_t \sum_{1=0}^{t} P_j + P_t b_0(z)$$

Let

$$Y_i = (1-\alpha_{(t-i)z})(1+r_i) \tag{35}$$

$$S_t = \sum_{j=1}^{t} P_j$$

$$E(P_j) = (1-\alpha^*)^j \prod_{i=1}^{j}(1+r_i)$$

$$E(P_j^2) = \left\{E(1-\alpha_{tz})^2\right\}^j \prod_{i=1}^{j}(1+r_i)^2$$

$$ES_n^2 = E(\sum_i \sum_j P_i P_j) = \sum_{j=1}^{n} E(P_j^2) + 2\sum_{i<j} E(P_i P_j)$$

The first term in the RHS of (a9) converges if there exists $T \in N$ and $\epsilon > 0$ such that $E(1-\alpha_z)^2(1+r_j)^2 < 1-\epsilon, \forall j\ >\ t$.
By independence of the α_{tz}

$$\sum_{i<j} E(P_i P_j) = \sum_{i<j} E(Y_1^2 Y_2^2 \cdots Y_i^2 Y_{i+1} \cdots Y_j) = \sum_{i<j} E(Y_1^2)\cdots E(Y_i^2)E(Y_{i+1})\cdots E(Y_j)$$

Since $EY_j = (1-\alpha^*)(1+r_j)$, we have that this term converges if, in addition to the previous condition, there exists $T' \in N$ and $\epsilon' > 0$ such that

$$(1-\alpha^*)(1+r_j) < 1-\epsilon',\ \forall j > T'$$

Note also that these conditions ensure that

$$b_0(z)\prod_{j=1}^{t}(1+r_{t-j})(1-\alpha_{(t-j)z}) \to_t 0$$

Thus $x_t(z)$ and therefore $y_t(z)$ converge in square mean and $y_t(z)$ does not depend on the initial distribution of endowments.

■

Finally, we need to show that a shock reduces inequality if $w_t/v_t < w'_t/v'_t$, where a prime on a variable denotes the value after a shock (a similar proof appears in Fischer 1992). The Lorenz curve is defined implicitly by

$$\Phi(t) = \frac{1}{\bar{Y}}\int_0^{z_1} y(z)dz; \quad T = \int_0^{z_1} dz; \quad Y = \int_0^{L} y(z)dz, \quad \forall z \in [0, L],$$

where $y = w_t + v_t b_t$ and $y' = w'_t + v'_t b_t$. Lorenz dominance means that $\Phi'(T) - \Phi(T) > 0 \forall T \in [0, 1]$.[30] Suppose we order agents so that $b_t(z_1) \leq b_t(z_2)$ if $z_1 < z_2$. Then

Lemma 5 *The distribution of y'_t dominates the distribution of y_t if and only if $w_t/v_t < w'_t/v'_t$.*

Proof: Elementary simplifications lead to

$$sgn\left(\Phi'(T) - \Phi(T)\right) = sgn(w'_t/v'_t - w_t/v_t)\left(B_t\int_0^{z_1} dz - L\int_0^{z_1} b_t(z)dz\right)$$

Since $b_t(z)$ is positive and increasing,

$$\int_0^{z_1}\left[\frac{B_t}{L} - b_t(z)\right]dz > 0.$$

Hence $sgn(\Phi'(T) - \Phi(T)) = sgn(w'_t/v'_t - w_t/v_t), \forall z_1 \in [0, L]$

■

[30] A prime denotes the variable in a liberalization equilibrium.

Table 2: LABOR SHARES IN PRODUCT

Farming	Manufacturing	Mining	Country
0.203	0.561	0.306	Australia(88)
0.272	0.659	0.370	Canada(86)
0.391	0.375	0.377	Chile
0.417	0.368	0.250	Colombia
0.216	0.684	0.122	Denmark(88)
0.146	0.249	0.042	Ecuador
0.216	0.464	0.024	Egypt(80)
0.159	0.683	0.654	France(84)
0.344	0.349	0.028	Iraq
0.463	0.432	0.430	Jamaica
0.256	0.506	0.289	Japan(88)
0.269	0.266	0.383	Jordan(83)
0.107	0.446	0.557	Kenya
0.114	0.387	0.577	Korea
0.042	0.642	0.600	Lesotho
0.281	0.335	0.019	Libya(80)
0.208	0.290	0.076	Malaysia(83)
0.124	0.627	0.714	Malta
0.187	0.585	0.069	Netherlands(88)
0.068	0.388	0.248	New Guinea(83)
0.142	0.684	0.175	Norway(88)
0.204	0.284	0.145	Peru
0.134	0.148	0.321	Sierra Leone
0.391	0.474	0.318	Sri Lanka(83)
0.245	0.700	0.720	Sweden(88)
0.283	0.298	0.647	Sudan
0.236	0.470	0.694	Swaziland
0.123	0.279	0.155	Thailand
0.557	0.813	0.071	Trinidad Tobago
0.232	0.198	0.033	United Arab Emirates
0.305	0.685	0.224	UK(87)

Table 2: LABOR SHARES IN PRODUCT (Continued)

Farming	Manufacturing	Mining	Country
0.220	0.706	0.302	US(85)
0.240	0.362	0.078	Venezuela(84)
0.117	0.323	0.246	Yemen
0.371	0.579	0.825	Zimbabwe
$\bar{\theta} = 0.237$	$\bar{\theta} = 0.466$	$\bar{\theta}$ =0.317	
σ = 0.115	σ = 0.175	σ = 0.240	

Notes:

1) Factor shares of labor: Compensation to employees/value added. Value added = Compensation to employees+capital consumption+net operating surplus+indirect taxes-subsidies. The values for some African countries with high ratios of ownership of land may not correct for implicit wages.

2) Source: United Nations National Accounts Statistics, Main Aggregates and Related Tables 1988. Published 1990. Data are for 1982, unless specified.

B Data

There are 66 countries with observations each 5 years beginning in 1965. The data form an unbalanced panel due to missing observations.

1. Capital stocks: From Nehru, V.; Dhareshwar, A. (1993). "A New Database on Physical Capital Stock: Sources, Methodology and Results", Revista de Análisis Económico v. 8 N1 (Junio): 37-59, from the World Bank CD-Roms.

   The data was adjusted from 1987 to the price level of the Penn World Tables (1985) by setting: $K = (K_{wb}/Y_{wb})Y_{pwt}$. I use the World Bank values of K and Y of (1985) and the Penn World Tables values for Y in that year. The rest of the series uses this baseline by considering the growth rates of capital stock in the World Bank series.

2. Labor: From the FAO website.

3. Land: From the FAO website, agricultural land.

4. Gini: Data from Barro and Lee.

5. Human capital: From the Barro and Lee dataset.

6. Openness: From Sachs and Warner (1995), in each 5-year period, number of years for which the country is classified as open.

Table 3: Fixed and random effects estimation of the model

Variables	Fixed effects	Random effects	Fixed effects	Random effects	Fixed Effects	Random Effects
C		0.382646*		0.401853		0.406159*
		0.016088		0.018249		0.016725
Open	0.011116*	0.005867*	0.018008	0.020359	0.006545	0.003110
	0.003608	0.002856	0.009271	0.008848	0.003403	0.003182
K/L	2.49E-06	1.32E-06	3.89E-06	2.01E-06	3.88E-06*	3.70E-06*
	1.38E-06	1.15E-06	1.39E-06	1.15E-06	1.41E-06	1.24E-06
T/L	-0.022333*	-0.013247*	-0.016398	-0.01011	-0.012682	-0.002901
	0.006535	0.005440	0.006871	0.00581	0.007392	0.005819
Educ					-0.020932*	-0.026827*
					0.005323	0.005045
Open*K/L	-5.69E-07*	-5.40E-07 *	-4.45E-07	-8.22E-07*	-9.06E-07*	-9.71E-07*
	2.72E-07	2.42E-07	3.04E-07	2.95E-07	2.84E-07	2.62E-07
Open*T/L	0.002688*	0.002254*	0.002148	0.004357	0.000849	0.000381
	0.001269	0.001123	0.001642	0.001569	0.001441	0.001197
Open*Educ					0.003175*	0.003051*
					0.000952	0.001082
K/L*T/L			8.58E-07*	1.60E-08		
			3.93E-07	1.44E-07		
$(T/L)^2$			0.000101	-0.000398*		
			0.000184	0.000157		
OPN^2			-0.001555	-0.002615		
			0.001959	0.001857		
$(K/L)^2$			-3.21E-11	-4.34E-12		
			2.01E-11	2.48E-11		

Note: A Hausman test indicates that the random effects model is more appropriate in regressions 1 and 2. Standard errors under coefficient values.