Natural Resources as a Source of Latin American Income Inequality

World Development Report Memorandum

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June 13, 1999

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1 Issues

Arguments abound for the relatively poor economic performance of Latin America over the past 30 years. Many of these explanations attribute the region's troubles, including low growth and high income inequality, to a particular set of political choices made by governmental leaders. In this paper we take a different tack, revisiting the structuralist arguments with a new version of a familiar theoretical framework - the Heckscher-Ohlin model.

The model of international comparative advantage that has been internalized by most economists is the 2-good 2-factor Heckscher-Ohlin model which implies, among other things, factor price equalization. This 2 by 2 model is not an appropriate setting in which to discuss development generally or the effects of natural resource abundance on growth and inequality. More goods and more factors are needed. Leamer(1987) has shown using the three-factor multi-good model that countries rich in natural resources can have a path of development that is very unlike the paths taken by resource poor countries. Our goal here is to explore that idea as carefully as possible by developing five related hypotheses regarding the effect of natural resources on development:

1 ***Delays:*** *Natural resources absorb capital, delaying the emergence of manufacturing*

At the first stages of development when capital is very scarce, the best investment opportunities of resource rich countries are in extraction of resources and sowing of permanent crops,[1] and not in manufacturing. The absorption of scarce savings into natural resource sectors delays the emergence of manufacturing. Compared with countries that are poor in natural resources, these resource rich countries have higher per capita incomes because of earnings from the resources. But the resource-rich countries have greater income equality because manufacturing promotes equality by raising wages for unskilled workers and by increasing the demand for human capital which, by its nature, is more broadly owned than land or physical capital.

2 ***Great Leaps:*** *The manufacturing sectors that first emerge in resource-rich countries are relatively capital- and skill-intensive.*

When manufacturing does emerge in resource-rich countries, it concentrates on moderate to high capital intensive products. Such a development path is beneficial because it avoids the terms-of-trade deterioration that is likely to affect countries that compete directly with labor abundant countries such as China and India.

3 ***Human Capital Coordination Trap:*** *The giant step into relatively sophisticated manufacturing is not possible absent institutions that can coordinate the accumulation of the requisite specialized human capital.*

When investment opportunities in natural resource exploitation are exhausted, further growth requires a diversion of investment funds away from plantations and mines and towards the schools and homes where human capital is created. But human capital accumulation is impeded by coordination problems and credit market imperfections. The coordination problem is caused by the fact that a degree in accounting is not valuable unless someone else has an engineering degree. The coordination of physical capital investments can be accomplished internal to the firm. Internalization is a more limited option for human capital accumulation because, unlike machines and trees, human capital is usually owned by the operator and not by the firm. Resource poor countries may not face the same coordination problem since their first manufacturing sectors use mostly general skills like literacy. As these resource-poor countries

[1] By permanent agriculture we refer to crops requiring long gestation such as coffee, which does not bear fruit until several years after planting. We will use the term temporary agriculture to refer to crops which can be harvested in the same year that they are planted.

move from footwear to apparel to textiles to steel to machinery to chemicals, the demand for specialized human assets increases gradually and coordination problems may not be acute.

4 ***Human Capital Market Imperfection Trap:*** *The giant step into relatively sophisticated manufacturing is not possible absent institutions that can finance the accumulation of the requisite human capital.*

Human capital accumulation is also impeded by capital market imperfections. Unlike machines and trees, human capital cannot usually be used as collateral because ownership is not transferable. Formal and informal private capital markets that may be adequate to finance investments in equipment and trees may be incapable of channeling the earnings of a small, land-owning elite towards a peasant class requiring funds for education. The problem is particularly acute because the levels of skills needed for the first manufacturing sectors that emerge in resource-rich countries can be relatively high. Resource-poor countries, on the other hand, move from footwear to apparel to textiles to steel to machinery to chemicals, gradually increasing the required amounts of human capital. This gradualism may allow family "credit markets" to finance the accumulation of human capital necessary for development.

5 ***Capital Risk Trap****: Volatility in primary product prices can increase capital risk in resource rich countries, and thus deter investment and make it difficult for manufacturing to emerge.*

Global capital seeks high expected returns but also low risk. The price uncertainty of primary products is much greater than manufactures and is a source of uncertainty in the return to capital invested in manufacturing in resource-rich countries if primary product prices affect wages paid in manufacturing. Some economic structures allow land to absorb the effects of variation in price of primary products and leave the return on capital very predictable. But resource-rich communities with manufacturing concentrated at one level of capital intensity can have a very uncertain return to capital. As a result, liquid global capital avoids such communities and locates instead in land scarce regions where the return to capital is less volatile. Thus, by inhibiting industrialization, abundant resources can trap a country into primary product dependence.

The following document offers theory and evidence for these five hypotheses. As is characteristic of economics generally, we provide more theory than evidence.

2 Theory

In the standard multi-cone version of the Heckscher-Ohlin model zero profit conditions link the external prices of tradables with internal prices of factors. The logic of this mapping is pretty straightforward: with constant returns to scale and mobility of factors between sectors, a deterioration of the price of a tradable must be offset by a suitable reduction in some factor price in order to maintain the zero profit in the affected sector. This reduction in one factor price must be offset by increases in others in order to maintain zero profits in tradables sectors with stable product prices. And so on. If there are "enough" zero profit conditions in the tradables sectors, then factor prices are completely determined by these external competitiveness conditions. If not, the external competitiveness conditions determine some linear combinations of factor rewards (via the zero profit conditions) while local demand and supply conditions complete the system. In such a world, Asian countries producing apparel and footwear have one kind of mapping from tradables prices into wages and capital returns, while Latin American economies growing coffee and bananas have another.

2.1 Resources Delay the Emergence of Manufacturing and Hinder Human Capital Accumulation

Figure 2.1.1 is the type of triangular display suggested by Leamer (1987) for studying alternative paths of development. The corners of this triangle represent three factors of production: raw labor, natural resources (broadly defined) and capital (human and physical). Both the factor endowments of countries and also the input intensities of various productive sectors are depicted by points in this triangle. The most important feature to keep in mind is that increasing the amount of one factor, say capital, while holding fixed the supplies of the other two factors swings a country's endowment point directly toward the capital vertex. Thus on a line going through the capital vertex, the ratio of land to raw labor is constant. This allows one to put the three ratio scales on the edges of the triangle, land per labor on the left edge, capital per natural resources on the right edge and capital per worker on the bottom. You will have understood this point if you can see from the diagram that we are assuming the capital per worker in food processing is between the capital per worker in apparel and in machinery. We are also assuming that the land intensity of food processing is between the land intensity of peasant agriculture and primitive extraction.

The points representing activities are connected by lines to divide the figure into subtriangles labelled A, B, C, etc., which are often called "cones of diversification." Each of these subtriangles identifies a set of resource supplies all of which have the corresponding output mix. For example, labor abundant countries located in triangle A produce handicrafts, apparel and peasant farm products.

In each of these triangles three tradables are produced and the corresponding triple of zero-profit conditions can be used to solve for the three factor prices. Thus both the products and the factor prices are fixed within each of these triangles.

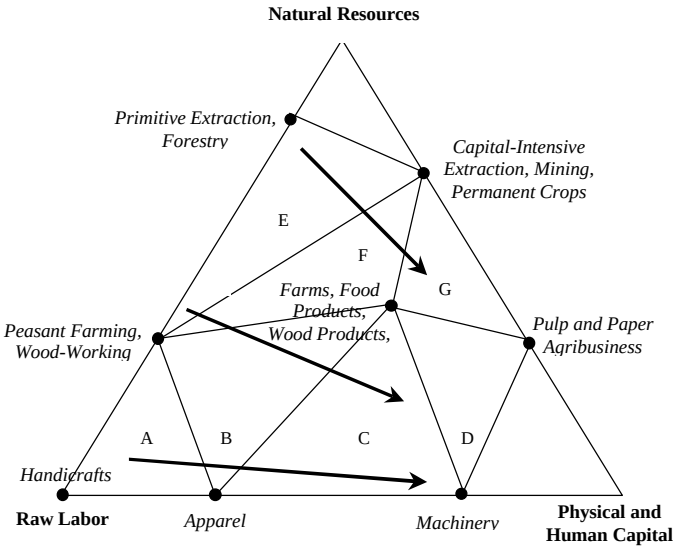
Another feature of Figure 2.1.1 to keep in mind is that the compensation of a factor stays the same or declines as one gets closer to the vertex representing the factor. Within a "cone of diversification" in which the product mix is fixed, changes in factor supplies have no effect on factor prices -- the so-called factor price equalization theorem, better called factor price insensitivity, meaning that factor prices are insensitive to factor supplies. However, a movement between cones in the direction of, for example, the capital vertex, is accompanied by a decline in the price of that factor. The three arrows in the figure represent three different development paths taken as countries accumulate capital holding fixed the relative supplies of land and labor. As capital accumulates and the endowment point shifts from cone A to cone B to cone C to cone D, the rate of return to capital declines and the wage rate of raw labor increases. That is the development path of a resource poor country.

Figure 2.1.1 can be used to contrast the development path A-B-C-D taken by resource poor countries with the development path E-F-G-D taken by resource rich countries. This figure has good news and bad news for land-abundant countries. The good news is that land-abundant countries have a preferred path of development that avoids the intense competition in the labor-intensive manufactures. The bad news is that the early stages of that preferred path might not prepare a land-abundant country for the human-capital needs at later stages, causing development to stall. The bad news is also that income inequality is likely to be very high until late in the development process.

The land scarce countries follow the path A-B-C-D. At the very first stage, these land scarce countries have some peasant agriculture but depend upon exports of handicrafts to pay for imports of simple consumer items like footwear and cloth as well as machinery and chemicals. As these countries develop, they begin to produce and to export labor-intensive manufactures such as footwear and apparel. This is accomplished not so much by moving workers off the peasant farms but primarily by transferring handicraft work to the formal manufacturing sector. When the handicraft work is completely eliminated the country moves from region A to B, experiencing an increase in wage rates and a fall in the rental price of capital and land. With further capital accumulation comes a consolidation of peasant farms and the emergence of capital-intensive farming as well as food processing. Once all the peasant farmers have been moved either into apparel or into capital-intensive farming/food processing, the country exits cone B and moves to cone C, experiencing a further increase in wages and a drop in land rents. Further capital accumulation supports a more capital-intensive mix of manufactures (cone C) and more-capital intensive

methods for exploiting the meager natural resources that are available (cone D). This process is accompanied by increasing wages for raw labor, a slowly elevating need for more educated workforce and a consequent natural rise in educational attainment. Per capita income rises and income becomes more equally distributed. The greater equality comes from both the rise in the compensation for unskilled labor and also the broadening of the ownership of the country's assets that is a result of the shift from land and capital into human capital as the most important form of wealth.

Figure 2.1.1: Natural Resource Development Paths



The resource-rich countries have a very different development path, E-F-G-D. The most undeveloped of the land abundant countries have peasant agriculture and primitive "harvesting" of natural resources including such things as cutting down trees, gathering natural crops and simple labor-intensive mining. Wage levels in these wealthy but primitive agrarian economies in cone E are "three cones" higher than wages in primitive resource-poor countries in cone A. Initial capital accumulation inside cone E supports a move out of primitive extraction, releasing both land and labor for use in both peasant farming and capital-intensive extraction and permanent crops. Once primitive extraction activities have disappeared, the country shifts from cone E to F, and further capital accumulation moves workers out of peasant agriculture, consolidating land into farms for growing crops- grains, fruits and vegetables. This shift toward permanent crops and away from peasant agriculture in natural resource-rich countries comes with increased land rents and correspondingly declining wages for raw labor power. With further capital accumulation comes more capital-intensive ways of utilizing the natural resources: pulp manufacturing, paper and agribusiness (cone G). Finally, when capital accumulation has been very substantial, the resource-rich countries produce sophisticated and capital-intensive manufactures such as machinery and chemicals (cone D).

This path has one very important appealing feature -- it never involves the production of apparel. The Asian success stories written by Japan, Taiwan and Korea are rapid A-B-C tales involving substantial exports of labor-intensive manufactures primarily to the United States, a market so huge that those exports could be absorbed with no terms of trade loss. But the greatly increased competition in apparel and other labor-intensive manufactures is causing new entrants like China, Indonesia, India and Bangladesh some considerable deterioration in their terms of trade. This makes it difficult for the emerging Asian countries to get from A to B, and C may now be completely unattainable and the exclusive domain of Japan, Korea and to a lesser extent Taiwan.

2.2 Resources Hinder Human Capital Accumulation: Coordination Problems and Capital Market Imperfections

Although the E-F-G-D development path may seem to offer a better future than A-B-C-D, there is a problem. In E and F it is capital and unskilled labor that create wealth. In G and D, skilled labor is essential. The A-B-C-D sequence gradually raises the skill requirements and we can expect and we do see land-scarce Asian countries gradually responding by increasing investments in human capital. But the early natural resource cones E and F do not require human capital and it is quite possible that countries get to the F-G border, with mines and food processing, but can't make the next step because the human capital that could support the movement into cones G and D does not exist. Thus, absent the book-learning and the know-how, the development of the natural resource-rich country comes to an end. This argument is a bit slippery because the development process stops at the very point at which the rate of return to human capital is very high, and, you may ask, why are the investments not forthcoming? There are two possible answers: coordination and capital market imperfections.

First consider the social coordination problem. An individual's education and know-how may not be valuable without equivalent investment by others, so that training must be coordinated or not done at all. It is easiest for the individual in a resource rich community not to worry about this coordination problem but just to go elsewhere where the complementary human inputs already reside.

This same coordination problem applies to machinery – a factory needs a fork-lift, and a drill and a lathe. In the case of equipment, the external coordination problem is solved by internalization- the same firm invests in all the distinct items of equipment. Firms generally do not make similar investments in different types of human capital – management, and engineering and accounting and so on. Instead firms rent the human capital from individuals suppliers – you and me.

One key difference between physical and human capital is that I can own the equipment that you are using but I cannot own the human capital you are using. Human capital is for rent, but not for sale. This is not a real distinction, you may be thinking, because there are rental markets for fork-lifts and drills and lathes. A firm that owns these distinct pieces of equipment is really renting them from itself, and could equally well accomplish the manufacturing with strictly rental equipment. Then there doesn't seem to be a coordination problem – the market is the coordinating mechanism; the rental market assures that just the right number of fork-lifts and drills and lathes are available. Indeed; but the question is then: which comes first, the firms or the rental markets? Absent the existence of manufacturing demand, who is going to set up a rental shop for fork-lifts recognizing that the forklifts won't be worth anything without the drills and the lathes. Absent the existence of manufacturing demand, who is going invest in human capital and offer to rent accounting services without the existence of similar rental firms offering management and engineering services? Thus, first come the firms which solve the coordination problem internally. When demand is adequate, a rental market emerges.[2] No such sequence is possible for human assets that cannot be owned by firms.

Another important difference between human and physical capital is the time to build: short for fork-lift, especially if the equipment is importable, long for an engineer. Obviously, coordination problems are more severe when the time to build is long.

Next consider the capital market imperfections. Wealth embodied in natural resources and the physical capital needed to process them can be and often is owned by a very few. Large amounts of human capital generally cannot be accumulated by a country unless wealth is broadly owned since human capital formation is typically self-financed or family-financed. Loans that might be used to finance human capital accumulation cannot be collateralized and indentured servitude is often an illegal and unenforceable contract. Moving from natural resource dependence to capital-intensive manufacturing

[2] Incidentally if imported equipment is exportable after use, then an implicit rental market exists externally. Countries may also be able to "rent" ex-patriot human capital by hiring consultants or by attracting multinationals.

requires a substantial upgrading of the human capital, but when most of the savings are generated by a few land-owners, it may be difficult for the financial system to transfer those savings into new human assets.

What about Canada and Sweden and Finland? How did they escape the trap of natural resources? It is possible that these countries for social reasons made early investments in education and once the educational capital and infrastructure was in place then came Northern Telecom, Ericson and Nokia. If this is somehow backed up with hard evidence, the policy advice is very clear: Governments in countries that are in cone F but close to cone G should be making major improvements in their educational systems, in particular eliminating the "dumbbell" educational systems that were economically efficient in cone F but inappropriate in cone G.

2.3 Resources Increase Capital Risk, Deterring Investment

Prices of primary products are much more uncertain than prices of manufactures. If primary price volatility increases the uncertainty of manufacturing profitability, it will deter manufacturing investment and impede development. There are of course many different models that link prices of primary products and manufacturing profitability. A key modeling choice is the specificity of the assets after announcement of the primary product price. A model with mobile labor but sector-specific capital links manufacturing profitability with primary prices though the labor market only. The Heckscher-Ohlin model and the Stolper-Samuelson Theorem is the basis for most of the discussion here. This model allows both labor and capital to be mobile between sectors within a country but immobile internationally. This model applies to a much longer interval of time and it links manufacturing profitability with primary prices through both the labor market and the capital market. The model has the very interesting implication that the risk borne by capital from primary price uncertainty depends on the product mix.

The Stolper-Samuelson mapping of goods prices into factor prices is built from a set of zero profit conditions that equate costs of production to product prices:

$$A'w = p$$

where A is the matrix of inputs per unit of output, w is the vector of factor rewards and p is the vector of product prices. If the number of factors equals the number of products, that is if A is square, and if there are no linear dependencies among the columns of A, then this system can be inverted to solve for the factor rewards as a function of product prices:

$$w = (A')^{-1} p$$

From these equations and from the mean $E(p)$ and covariance $Var(p)$, we may solve for the corresponding mean and covariance matrix of the factor returns:

$$E(w) = (A')^{-1} E(p)$$
$$Var(w) = (A')^{-1} Var(p)(A')^{-1}$$

From this system of equations we want to squeeze conditions under which the mean return to capital is high and the variance is low. The equation for solving for means and covariances is easy to write down, but not so easy to understand. A first step toward understanding comes from a careful examination of the two-dimensional case with the inputs being capital and labor. Then the vector of factor rewards as a function of product prices is:

$$\begin{bmatrix} w_K \\ w_L \end{bmatrix} = \begin{bmatrix} A_{K1} & A_{L1} \\ A_{K2} & A_{L2} \end{bmatrix}^{-1} \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} = (A_{K1}A_{L2} - A_{K2}A_{L1})^{-1} \begin{bmatrix} A_{L2} & -A_{L1} \\ -A_{K2} & A_{K1} \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \end{bmatrix}$$

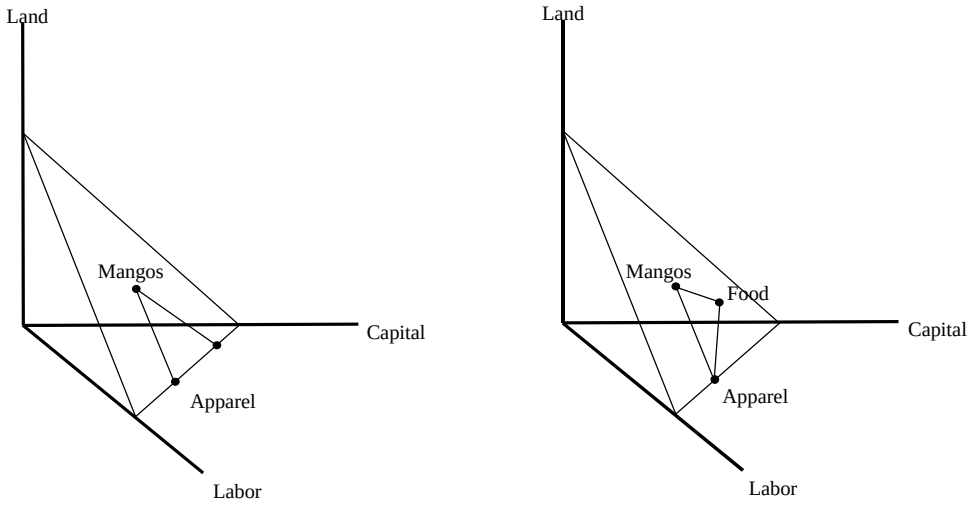
Since it is only relative prices that affect real rewards, we might as well normalize by the second price and solve for

$$Var(w_K / p_2) = (A_{K1}A_{L2} - A_{K2}A_{L1})^{-2} A_{L2}^2 Var(p_1 / p_2) = \left(\frac{1/A_{L1}}{\frac{A_{K1}}{A_{L1}} - \frac{A_{K2}}{A_{L2}}} \right)^2 Var(p_1 / p_2)$$

The message of this equation is conveyed by the denominator: diversity of capital intensities is a source of stability for capital returns. Countries that produce goods that are very similar in capital intensities have capital returns that are very sensitive to relative prices.[3]

The Stolper-Samuleson mapping is much more complex when there are more goods and more factors. Figures 2.3.1 and 2.3.2 help provide some intuition for how resource abundance affects capital risk by illustrating graphically the link between product price and factor reward uncertainty in an endowment triangle anchored by land, labor and capital.

Figure 2.3.1: The Affect of Price Risk on Rewards in a 3x*N* Model



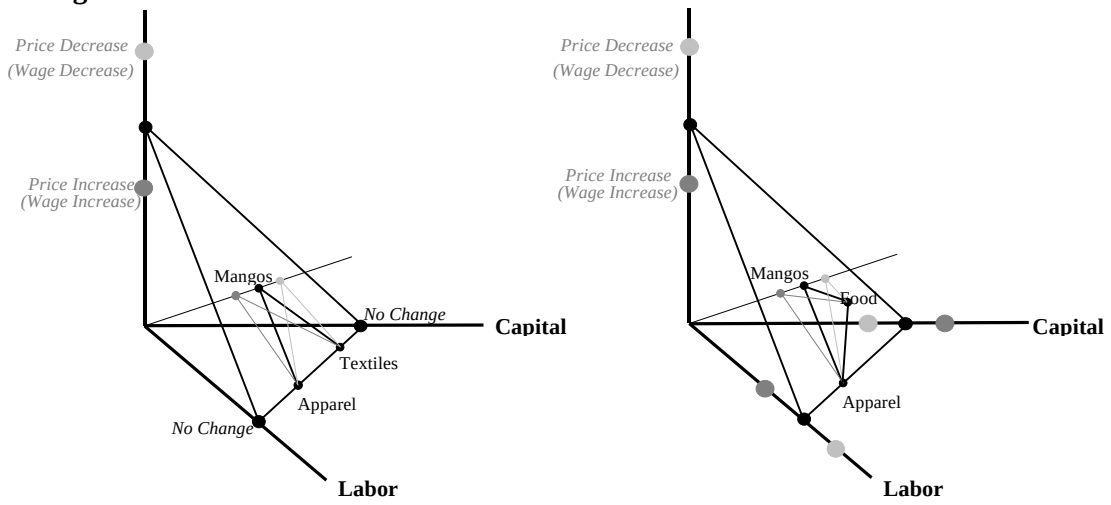
Panel 1 **Panel 2**

In the first panel of figure 2.3.1, the three sectors are mangos, apparel and textiles, while in the second panel they are mangos, processed food and textiles. These three unit value points determine a unit cost plane which has intersection with the three axes at the inverse of the corresponding factor price. This allows us to see what happens to factor prices if a product price changes. Suppose that the price of mangos varies but the prices of apparel and textiles remain constant. This price movement is represented graphically in figure 2.3.2 by sliding the Mangos industry input dot along a ray emanating from the origin. Movement toward the origin represents a price increase (i.e. fewer factors for the same dollar

[3] Although the labor-intensity of the first good enters the equation, that number and also the price variance depends on the units. It seems best to choose units of the products such that the labor input is one in both sectors.

output) and *vice versa*. What happens to factor rewards? As illustrated in the first panel, mango price movement stimulates fluctuations in the reward to land, which drops when the price of mangos falls (light gray circle) and increases when the price of mangos rises (dark gray circle), but the rewards to capital and labor do not change because the mangos-apparel-textiles cone of diversification merely pivots on the bottom edge of the simplex. Note that though this discussion has focused on the *nominal* rewards, this is equivalent here and below to focusing on *real* rewards if we normalize by the price of apparel, which is assumed to be constant.

Figure 2.3.2: Detail of the Affect of Price Risk on Factor Rewards in a 3x*N* Model



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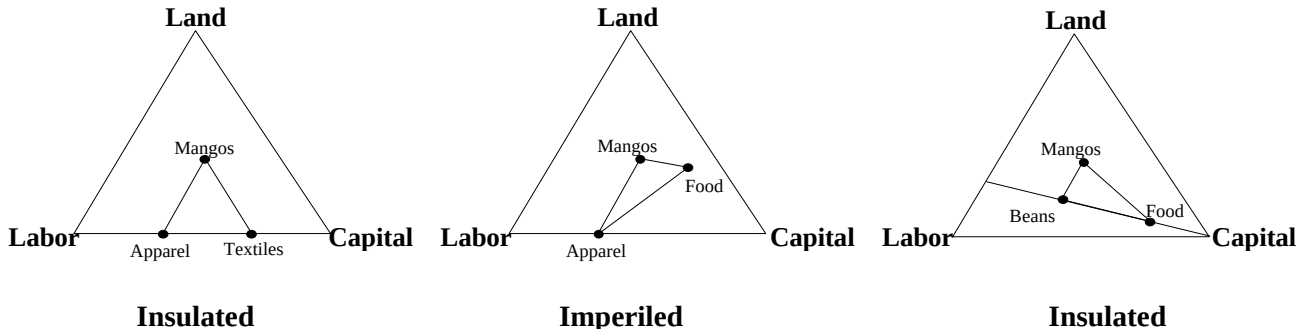
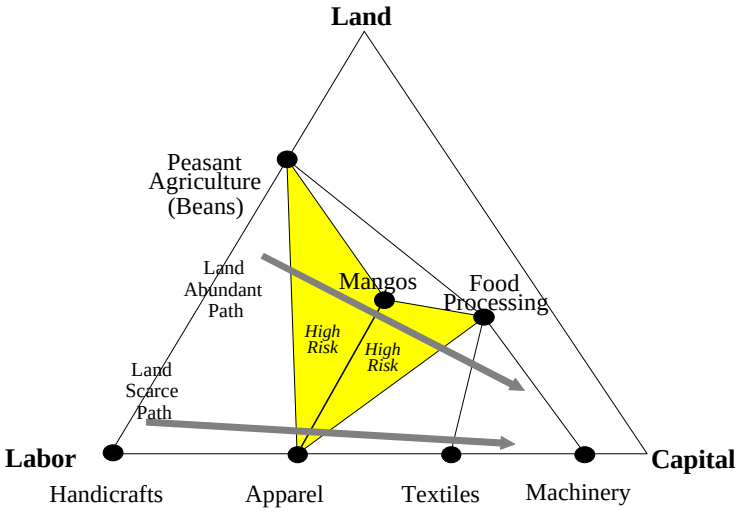
If a country's production is insufficiently diversified into land-independent manufacturing, as in the second panel of figure 2.3.2, the return to capital is "imperiled" by mango price volatility. Thus, as shown, fluctuations in the price of mangos tilt the high capital risk mangos-apparel-food processing cone of diversification in such a way as to shift the wages of all three factors. These shifts in factor rewards are indicated by the light and dark gray circles along each factor's vertex, where as above light gray means mango price decrease and dark gray means mango price increase. Indeed, as illustrated in figure 2.3.3, the reward to capital is insulated from product price variability so long as the sectors without volatility have identical land to labor input requirements. Geometrically, this is tantamount to lining up along a ray emanating from the capital vertex. This type of diversification occurs most intuitively in the first panel of figure 2.1.3, where manufactured goods all have zero land to labor requirements, but can occur with three natural resource commodities as well, as illustrated in the third panel. Of course, the insulation of capital in the third panel can be overturned if more than one commodity price is highly volatile.

Figure 2.3.3: Conditions Under Which Capital Returns are Insulated and Imperiled From Mango Price Volatility



What are the implications of high capital risk cones for development? Figure 2.3.4 plots possible development, or capital accumulation paths of two types of countries, land abundant and land scarce, in an *n*-good world. The upper arrow in the figure represents the land abundant development path, while the lower arrow traces out the land scarce path. Though both countries must pass through the two high risk cones, which are shaded in the figure, these cones comprise a much larger portion of the land abundant country's development path. To the extent that international investors avoid allocating capital to countries in high risk cones, land abundant countries may become "trapped" in the cones proceeding them. Land scarce countries, able to skirt through high risk cones relatively quickly by relying on domestic savings, on the other hand, may face no such obstacle to their development. As a result, whereas land scarce countries will move from handicrafts and apparel on to textiles and machinery, land abundant countries may remain undeveloped, producing handicrafts, apparel and beans indefinitely.

Figure 2.3.4: The Affect of High Risk Cones on Development



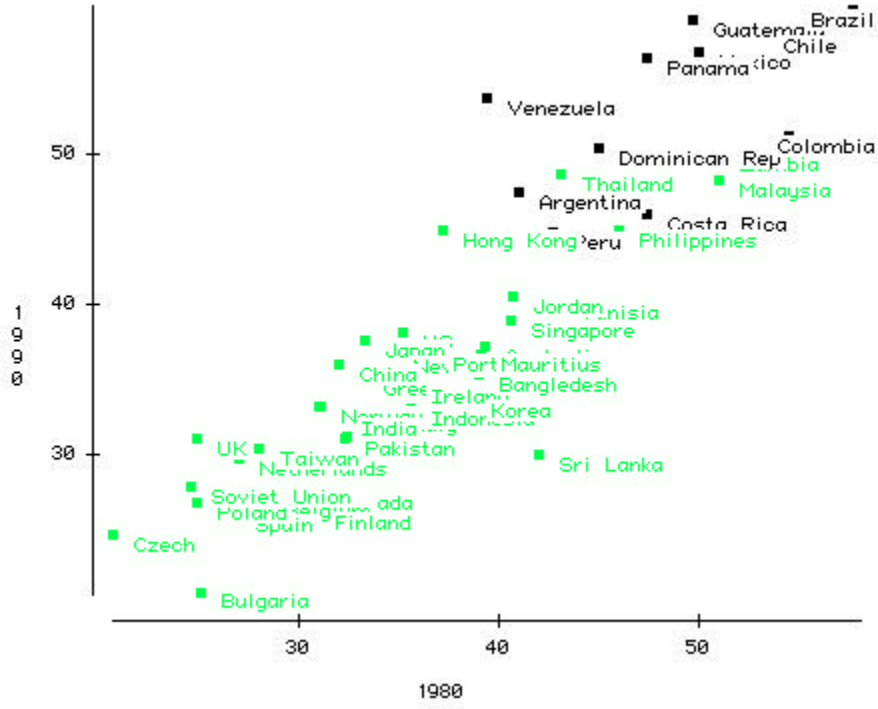
3 Evidence

This section accumulates evidence regarding the particular role endowments play in each of our hypotheses. Our data analysis is guided by the assumption that Gini is a function of economic structure, where economic structure can be characterized either in terms of fundamentals (e.g. endowments, climate, closeness to markets) or symptoms of these fundamentals (e.g. employment, investment, production and trade). The first part of this section focuses on data displays while the second concentrates on more formal econometric evidence.

3.1 Summary Data Displays

Figure 2.1.1 plots Gini coefficients for 1990 versus those for 1980. The figure indicates that measured income inequality is much higher in Latin American countries (in bold) and that it appears to be growing faster there than elsewhere. An interesting and suggestive feature of this figure is the presence of three of the more natural resource abundant countries of East Asia – Malaysia, the Philippines and Thailand – within the field of Latin American countries.

Figure 3.1: Gini Coefficients, 1990 vs 1980



Latin American economies are characterized by an abundance of land, natural resources and uneducated workers, and a scarcity of physical capital. This relative position is clear from table 3.1, which indicates which maps the median of the Latin American and Asian distributions for 1970 and 1990 into the corresponding percentile of the rest of world endowment distribution. This table reveals Latin America's capital scarcity by indicating that its median capital per worker ratio was at the 34th percentile of the rest of the world's distribution in 1970 and at the 37th percentile in 1990. Land abundance, on the other hand, is indicated by medians well into the right tail of the rest of world's distribution in both time periods. Note also that Latin America's experience with respect to capital contrasts sharply with that of Asia: during the same time period, its median per worker capital jumped from the 28th to the 52nd percentile.

With respect to education, table 3.1 reveals that Latin America has become both relatively more tertiary educated abundant *and* remained at the same level of no education abundance over time.[4] This combination suggests that only a small subset of Latin American workers is becoming more intensively educated over time. To be evocative, but to overstate the case, we will call this "dumbbell" education, meaning that it produces relatively large numbers of workers in the extreme educational groups, and relatively few between these extreme. This dumbbell distribution is consistent with the theory laid out above: because resource intense sectors absorb national savings but create few skilled jobs, resource rich countries may have little economic incentive to educate their citizens broadly until very late in the development process.[5]

Table 3.1: Percentile of Rest of World Endowment Distribution Occupied by Latin American and Asian Medians

	Latin America		East Asia	
	1970	**1990**	**1970**	**1990**
Capital/Worker	34	37	28	52
Cropland/Worker	75	69	17	21
Forestland/Worker	84	82	55	48
Proportion of Workers with No Education	54	54	54	52
Proportion of Workers Attaining Primary Education	69	80	54	58
Proportion of Workers Attaining Secondary Education	41	32	52	54
Proportion of Workers Attaining Tertiary Education	54	60	50	60

Note: Education categories do not sum to unity for a given country. Proportion of workers attaining primary education, for example, includes all those who have attained Secondary and Tertiary, as well.

Figure 3.2, which provides a breakdown of 1995 Latin American, Asian and OECD net exports, suggests a relatively simple world: Latin America exchanges natural resources and food for manufactures; Asia trades labor intensive products for capital intensive machinery and chemicals, and the OECD provides sophisticated manufactures and chemicals in exchange for materials, clothing and toys.

This figure breaks total net exports into 12 aggregates according to their propensity to be traded together (Leamer 1984). Countries that export apparel, for example, also export footwear and toys. These goods are combined into a single aggregate: labor intensive manufactures (LAB). The ten major categories, and indicative products contained within them, are summarized in table 2.3.1.

In both the figure and the table, tropical agriculture has been split into two sub-categories according to whether the underlying crop is permanent (e.g. fruit, coffee, rubber, nuts) or temporary (e.g. vegetables, grains). These special groups were constructed to help explore one of our central ideas – that permanent crops such as coffee and bananas embody large amounts of capital per worker because of the time needed to grow them from seeds to fruit-producing plants. For this reason, countries abundant in land suited to permanents can invest profitably in trees and plants, while countries not so endowed choose machinery instead. As a result, one might imagine that there are three different kinds of development paths -- one for countries that are resource poor, another for countries that are permanent cropland rich, and another for countries that are temporary cropland abundant. (A fourth path might apply to a country

[4] Primary education denotes up to six years of education, secondary up to twelve years, and tertiary greater than twelve.

[5] Of course, it may also be evidence that the uneducated are prevented from attaining education due to credit constraints or other distortions.

with a natural resource like oil that can be 'tapped' for a continuing flow of earnings without using much capital or labor.)

Figure 3.2: Net Exports By Region, 1995

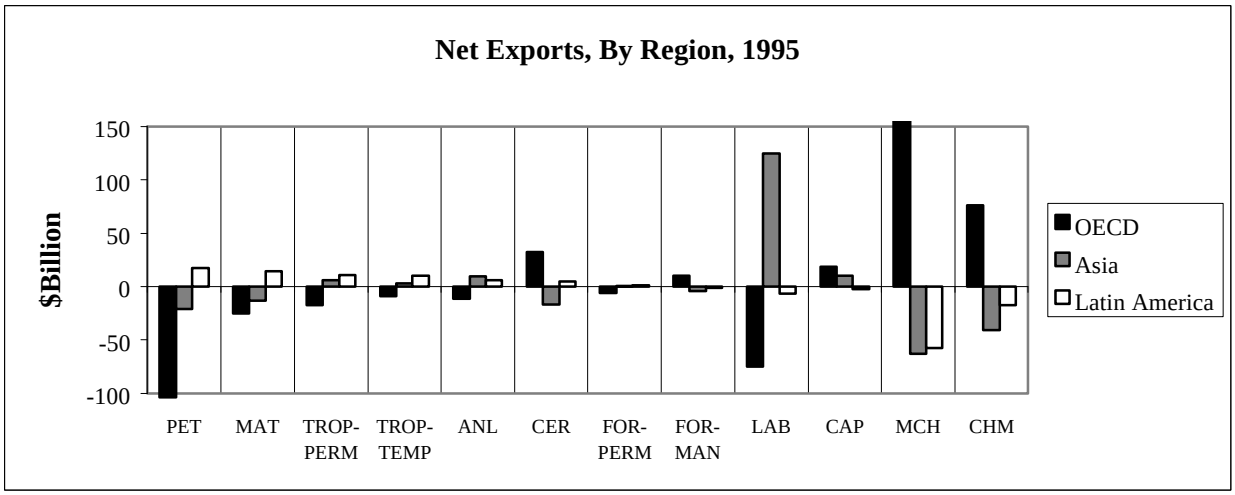


Table 3.2: Net Export Categories

Abreviation	Category	Representative Goods
PET	Petroleum Products	Oil
MAT	Raw Materials	Fertilizers, coal, natural gas, metals
TRP-PERM	Tropical Permanent	Fruit, sugar, coffee
TRP-ANNUAL	Tropical Annual	Vegetables, grains
ANL	Animal Products	Live animals, meat, dairy, eggs, fish, hides, fats
CER	Cereals and Grains	Cereals, feeding stuff, tobacco, oil seeds, fibers
FOR-PERM	Forest Permanent	Wood, lumber
FOR-MANUF	Forest Manufactures	Pulp, paper
LAB	Labor Intensive Manufactures	Furniture, clothing, footwear, coins
CAP	Capital Intensive Manufactures	Leather, rubber, textiles, iron, steel, fixtures
MCH	Machinery	Electrical machinery, tranportation, professional goods
CHM	Chemicals	Chemicals, pharmaceuticals, fertilizers, plastics

3.2 Formal Data Analysis

At its core, our story is that income inequality is connected to endowments via production: some endowments attract sectors that promote inequality while other endowments attract sectors that tend to combat inequality. Within our theoretical framework, we expect a world anchored by labor, land and capital, to have high income inequality in the land abundant region and low income inequality in the capital abundant region, with the labor abundant region somewhere in between. Three implications of this relationship are noteworthy. First, inequality always declines with rising capital intensity. Second, income inequality always rises with land intensity. Third, the effect of increased labor depends upon the land-capital ratio: for high ratios, more labor means lower inequality, and for low ratios, more labor means higher inequality.

In table 3.3 these implications are addressed formally by regressing Gini coefficients in 1980 and 1990 on per worker capital, cropland and the interaction of cropland and climate.[6] (Climate, from Jones and Hall (1997), is a variable between zero and unity which measures latitudinal distance from the equator, where zero means at the equator and unity means at either the North or South Pole.) As indicated in the table, Gini's fall with capital intensity and rise with land abundance in both time periods,

[6] Climate independently, forestland and its interaction with climate and capital interactions with economic distance are excluded from the regression due to their insignificance.

just as expected. The interactions with climate reveal that tropical cropland increases inequality in both periods, consistent with our story that more tropical agriculture soaks up capital and deters industrialization. 1990 results suggest, for example, that providing Panama (9^o latitude, 0.75 hectares cropland per worker) with Korea's (37^o latitude, 0.12 hectares cropland per worker) land and climate endowments would lower Panama's measured income inequality by 5.5 points, to 50, all else equal. Endowing Panama with Korea's capital ($8943 to $32,360 per worker), on the other hand, would reduce its Gini by 3.26 points.[7]

Table 3.3: Response of Gini to Fundamentals and Controls

Dependent Variable: 1980 Gini		
Independent Variable	**Coeff**	**t-Value**
Constant	38.8	24.39
Capital/Worker 1980	-0.3	-2.53
Cropland/Worker 1980	7.5	3.56
Cropland/Worker 1980 * Climate	-17.2	-3.16
Latin America Dummy	7.3	4.17
Adjusted R-squared	0.68	
Observations	44	

Dependent Variable: 1990 Gini		
Independent Variable	**Coeff**	**t-Value**
Constant	41.0	18.37
Capital/Worker 1990	-0.1	-2.09
Cropland/Worker 1990	7.4	1.69
Cropland/Worker 1990 * Climate	-17.5	-1.58
Latin America Dummy	8.9	3.15
Adjusted R-squared	0.49	
Observations	49	

Capital measured in $000; Land measured in hectares; Climate (between 0 and 1) measures latitudinal distance from the equator.

Regarding the effect of adding labor on Gini's, the third implication noted above, inspection of the estimated derivative of Gini with respect to labor indicates the effect is indeed positive for low levels of land and negative for high levels, as expected. Finally, note that the importance of the Latin American dummy variable in both time periods provides an indication both that our endowment measures are imperfect and that other forces, including government policy, culture and history are important influences.

We can complement this regression by examining simple and partial correlations between Gini coefficients and net export shares. The simple correlation between net export structure and Gini coefficient, GDP per worker, secondary education per worker and economic distance for 1980 and 1990 are presented in table 3.4. (Economic distance, from Leamer (1997), is a measure of a country's distance from global GDP, in miles.) Sectors are sorted by their correlation with income inequality, and shading represents statistical significance at the 95% level. Consistent with our theoretical framework, this table illustrates that Gini's are related negatively to manufacturing and positively to basic extraction and tropical agriculture. In addition, note that manufacturing categories utilizing greater levels of education (e.g. chemicals and machinery) have a larger effect on income inequality than manufacturing aggregates with lower demand for skill (e.g. labor and forest manufacturing). The relationship between per worker secondary education and net export shares reported in the third column of the table supports the view that manufacturing sectors are positively correlated with secondary education, though this effect is more pronounced in 1980 than in 1990. This difference may be due to changes in technology over time. In both periods, basic extraction and tropical agriculture are negatively correlated with secondary education. A similar pattern is found regarding GDP per worker.

[7] Regression coefficients are based on per worker capital measured in thousands of US dollars.

Table 3.4: Simple Correlations Between Net Export Shares and Various Measures, 1980-1990

1980	Gini Coefficient	GDP per Worker	Secondary Education Per Worker	Economic Distance
Machinery	-0.48	0.38	0.46	-0.30
Chemicals	-0.48	0.63	0.21	-0.56
Capital Intensive Manuf	-0.39	0.22	0.52	-0.18
Forest Manufacturing	-0.20	0.27	0.03	-0.13
Labor Intensive Manuf	-0.18	-0.24	0.26	0.30
Animal Products	-0.14	0.24	0.16	0.07
Cereals	0.11	0.22	-0.19	0.22
Petroleum	0.19	-0.05	-0.25	0.09
Forest Permanent	0.19	-0.07	-0.17	0.24
Tropical Temporary	0.24	-0.38	-0.10	0.18
Raw Materials	0.34	-0.17	-0.32	0.27
Tropical Permanent	0.54	-0.44	-0.22	0.24

1990	Gini Coefficient	GDP per Worker	Secondary Education Per Worker	Economic Distance
Machinery	-0.36	0.42	0.42	-0.18
Chemicals	-0.33	0.62	0.54	-0.46
Forest Manufacturing	-0.22	0.22	0.15	-0.07
Labor Intensive Manuf	-0.16	-0.31	-0.17	0.28
Animal Products	-0.08	0.16	0.10	0.02
Capital Intensive Manuf	-0.02	0.04	0.00	-0.05
Forest Permanent	0.02	-0.04	0.07	0.21
Petroleum	0.21	-0.01	-0.11	0.06
Cereals	0.22	0.05	0.07	0.21
Tropical Temporary	0.25	-0.43	-0.35	0.15
Raw Materials	0.34	-0.26	-0.13	0.33
Tropical Permanent	0.47	-0.39	-0.42	0.20

Note: Shading represents significance at the 95% level.

Correlations of net export shares with the economic distance indicator reveal that the closer to the global market an economy is, the more oriented toward capital intensive products it will be, a result that is likely due to transportation costs. For raw materials, tropical agriculture and labor intensive products the story is the opposite: the closer to the global market an economy is, the less it will produce these goods. This relationship suggests that global capital will reach out far to find natural resources but will not reach too far to find cheap raw labor (the US will prefer Mexico to China).

The main message from this table is that promoters of income equality include sectors with low land per worker, low natural resources per capital and middle to high capital per labor (i.e. capital intensive manufacturing, chemicals and machinery). Non-promoters of income equality are characterized by the intensive use of natural resources: tropical perennial crops, raw materials, tropical annual crops, raw forest production and petroleum extraction. Note that tropical perennial crops and raw forest products are both intensive users of waiting capital, the physical capital absorbed while perennials grow from seeds to fruit producing plants.

To rule out the possibility that these simple relationships are due to the link between Gini coefficients and stage of development, highlighted above, we now turn to the inspection of partial correlations. Table 3.5 shows the partial correlation of Gini coefficients and net exports, controlling for effects of per worker GDP. Here, too, sectors are sorted by their correlation with income inequality. As

indicated in the table, though the partial correlations are generally lower than the simple correlations, they nevertheless survive, albeit with some changes in ordering. The positive relationship between income inequality and cereals, for example, increases. This is because controlling for GDP removes the effect of high-income, low Gini cereal exporters like the US. In addition, controlling for GDP causes labor intensive manufacturing to join machinery as a strong promoter of income equality. This result is consistent with the story that movements into manufacturing improves inequality.

Table 3.5: Partial Correlation of Gini Coefficient and Net Export Shares, Controlling for GDP per Worker, 1980-1990 (Sectors are Sorted According to Partial Correlations)

1980			
	Partial Correlation	**Net Export t-Value**	**GDP t-Value**
Tropical Permanent	0.44	3.21	-2.77
Cereals	0.31	2.17	-4.78
Materials	0.30	2.10	-3.98
Forest Permanent	0.20	1.35	-4.01
Petroleum	0.19	1.31	-4.03
Tropical Temporary	0.08	0.51	-3.78
Animal	-0.03	-0.21	-3.94
Forest Manufacturing	-0.08	-0.54	-3.89
Chemicals	-0.20	-1.32	-2.24
Labor Intensive Manuf	-0.32	-2.23	-4.69
Machinery	-0.32	-2.25	-3.07
Capital Intensive Manuf	-0.34	-2.37	-3.94

1990			
	Partial Correlation	**Net Export t-Value**	**GDP t-Value**
Tropical Permanent	0.35	2.62	-2.94
Cereals	0.28	2.05	-4.27
Materials	0.26	1.90	-3.53
Petroleum	0.25	1.84	-4.14
Forest Permanent	0.02	0.15	-4.01
Tropical Temporary	-0.01	-0.06	-3.64
Chemicals	-0.03	-0.22	-3.09
Capital Intensive Manuf	-0.05	-0.33	-4.01
Animal	-0.08	-0.59	-3.95
Forest Manufacturing	-0.12	-0.82	-3.78
Machinery	-0.20	-1.43	-3.11
Labor Intensive Manuf	-0.29	-2.11	-4.54

4 Summary and directions for future research

We have presented five theoretical ideas that explain how abundance of natural resources can affect income inequality.

(1) Natural resources delay the emergence of manufacturing.
(2) When manufacturing does emerge, it leapfrogs over labor-intensive activities.
(3) The human capital formation needed to support this leap forward is impeded by coordination problems.
(4) The human capital formation needed to support this leap forward is impeded by capital market imperfections.
(5) Investments in manufacturing can also be impeded by the spillover of risks from primary product price uncertainty.

Evidence has been presented that offers substantial support for the hypotheses (1) and (2): the development paths of resource rich countries are very different from the development paths of resource poor countries. The data on educational attainments are supportive of hypotheses (3) and (4) regarding the impediments to the accumulation of human capital but much more is needed on this subject. No evidence is presented regarding hypothesis (5) having to do with impediments to the accumulation of physical capital.

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