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Trade Liberalization and the Relative Wages for More-Skilled Workers in Costa Rica

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Abstract

A prominent argument regarding the effects of trade liberalization on the dispersion of wages in LDCs is that trade liberalization should lower the relative demand for more-skilled workers by inducing between-sector shifts towards sectors intensive in unskilled labor. Based on a disaggregating, nonparametric approach that imposes little structure on the data, the paper presents evidence that trade liberalization in Costa Rica led to an increase in relative demand. Other findings are consistent with the "skill-enhancing-trade hypothesis," whereby trade liberalization induces an acceleration of physical capital imports, which raises relative demand through capital–skill complimentarily.

1. Introduction

A prominent analysis of the effects of trade liberalization is presented clearly by Krueger (1990), who argues that trade liberalization in developing countries will generally compress the wage gap between more- and less-skilled labor. This reasoning builds from the Hecksher–Ohlin and Stolper–Samuelson theorems. In these models, free trade substitutes for factor mobility, and trade liberalization leads to growth in sectors where countries have comparative advantages, causing factor prices to converge internationally. We will refer to this as the "extended Hecksher–Ohlin–Samuelson" hypothesis, or "HOS-X." It argues that for less developed countries (LDCs) comparative advantage generally lies in their stocks of unskilled labor, while protectionism distorts prices in favor of capital. Because capital and skill are compliments, protectionism raises the demand for skilled versus unskilled labor. Therefore, moving from protectionism to trade liberalism should shift the composition of output and employment towards sectors intensive in unskilled labor, raising the relative demand for unskilled labor, versus skilled labor, and increasing the wages of unskilled workers relative to the wages of skilled workers.

In this paper, using a disaggregated, nonparametric approach that imposes little structure on the data, we measure the changes in the relative wages, relative supply and relative demand for more-skilled workers in Costa Rica before and after trade liberalization. We find evidence that, contrary to the predictions of HOS-X, relative wages for skilled workers increased after trade liberalization in Costa Rica. We further find that this increase in the relative wages cannot be explained by changes in relative supply, and must have therefore been due to changes in the relative demand for more-skilled workers. Building on the disaggregated results, we measure changes in the relative demand for more-skilled workers, finding an increase coincident with trade

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liberalization. In section 5 we regress the time-series of imputed demand shifts on to trade flows and imported capital stock to GDP ratios, and GDP growth rates, finding that manufactured exports appear to raise relative demand, and changes in imported capital stock have large, statistically significant and positive affects upon relative demand.

Our results indicate that the extended Hecksher–Ohlin–Samuelson hypothesis did not hold in Costa Rica. The results are consistent with the argument made by the "New" trade theorists (Stokey, 1994). In their view, trade liberalization leads to larger markets, which in turn induces greater Research and Development (R&D), increases the stock of technological knowledge, and reallocates employment towards innovative activities requiring more education. Through these interrelated channels, they advance the hypothesis that trade liberalization in LDCs raises the return to human capital, driving up the wage gap between skilled and unskilled workers.

Recent work by Robbins (1995a) analyzing changes in the dispersion of wages in Chile after its major trade liberalization reforms provides evidence in favor of the "New" trade theorist arguments and against the HOS-X hypothesis. Robbins showed that trade liberalization in Chile led to an increase in the wages of more-skilled relative to less-skilled workers. He further argued that relative wages rose because trade liberalization in Chile led to an increase in the demand for more skilled workers, causing both between- and within-industry demand shifts favoring more-skilled workers. Similar results were found for Colombia and Argentina, where rising manufactured export shares and rising ratio of imported machinery to GDP were closely associated with skill-biased demand shifts (Robbins, 1995b,c). For ease of comparison with recent related studies, the present study employs the same methodology used in Robbins (1995a).

2. Costa Rican Experience with Trade Liberalization: History and Previous Research

History and Trade Outcomes

In 1984, Costa Rica initiated a comprehensive structural adjustment program. An important part of this program was a comprehensive trade liberalization: the reduction of tariffs, the reduction of the variance between tariffs, and the replacement of quantitative import limitations with tariffs.[1] Table 1 summarizes the trade reform measures implemented between 1984 and 1992. A new Central American Common Market tariff regime, agreed to in 1985, simplified the tariff system somewhat, though tariff reductions began only in October 1987. Trade liberalization was implemented by Costa Rican policymakers in an explicitly gradual manner (Lizano, 1990). Vargas-Alfaro (1993, p. 18) characterizes the 1987–92 period of reform as one of "gradual reduction in nominal and effective protection." The tariff reductions begun in 1987, for example, were allowed to adjust over a period of up to five years. In Costa Rica, trade liberalization was accompanied by a gradually depreciating real exchange rate (Conejo, 1992). From 1984 to the present, coincident with trade liberalization, the Central Bank of Costa Rica has engaged in a policy of frequent "mini-devaluations" leading to gradual depreciation of the real exchange rate (Conejo, 1992). As Table 2 shows, trade liberalization and devaluation were followed by a steady increase in exports. After 1987, exports grew steadily, and nontraditional exports became an increasing proportion of total exports.

Table 1. Trade Liberalization in Costa Rica, 1984–93

Date	*Measure*
1984	Approval of the Law for Financial Equilibrium in the Public Sector, consolidated regulations to promote exports such as (a) free-trade zones (b) export contracts and reformed the export tax regime: (a) creation of the National Investment Council (b) simplified export permit paperwork.
1985	Approval of a new CACM tariff regime, including tariffs of 35–100% for final goods.
1986	First Structural Adjustment Program signed, which *called for* (a) a gradual reduction in tariffs on final goods and the elimination of all quantity restrictions on imports; (b) maximum tariff of 40% on final goods by 1990.
1987	Tariff reduction of 10% on consumer goods whose tariff was more than 40%.
1988	Begin twice-yearly tariff reduction. Tariffs are to be reduced by between one-sixth and one-tenth twice a year on all final goods until 1992.
1989	"Depositos previos" for imports reduced from 50% to 10%.
1990	Incorporation into the GATT. Reductions in tariffs and import quantity restrictions in accordance with the second "Structural Adjustment" loan agreement with the World Bank.
1992	Elimination of the "depositos previos" for all imports. Exchange rate liberalization. Tariffs on final goods reduced by 4% and 6.5%. Elimination of quantity restrictions on imports within Central America.

Source: Vargas-Alfaro (1993).

Previous Literature on Trade Liberalization and Distribution in Costa Rica

Previous literature on Costa Rican distribution and trade divides into two groups. The first group decomposes distributional measures, while the second group focuses upon the determinants of wage structure. Examples of the first type of study include Bourguignon and Morrison (1989) and Morley and Alvarez (1992), which examine the impact of trade liberalization on the distribution of earnings in Costa Rica by disaggregating inequality and poverty measures. Examples of supply and demand analyses include Funkhouser (1993, 1994), which is similar to our present study in that it examines the impact of changes in the relative supply and demand on relative wages for more educated workers in Costa Rica from 1976 to 1992, using the same national household surveys we use in this paper. Funkhouser (1993) employs a supply–demand framework of the type developed in Freeman (1980) to construct time series of returns to schooling, relative supply shifts, and relative demand shifts. Estimated returns to schooling from earnings functions linear in schooling and estimated by OLS are his relative wage measures. He constructs two measures of relative supply: the average years of formal schooling for workers, and the ratio of counts of workers with less than or primary education to workers with more than primary education (relative supply shifts are measured as the difference in the rate changes of these two groups). Relative demand is measured using Freeman's fixed-coefficient manpower approach. This

Table 2. Selected Macroeconomic Indicators, 1970–93

Year	*Growth rate of GDP (%)*	*Terms of trade*[a]	*Inflation rate*[b]	*Export earnings (millions US dollars)*	*Nontraditional exports*[c] *(millions of US dollars)*
1975	2.1	79.6	12.4	494	149
1976	5.5	91.1	3.5	593	201
1977	8.9	110.4	4.2	828	288
1978	6.1	99.4	6.0	865	280
1979	4.8	91.7	9.2	945	310
1980	0.7	91.9	18.1	1,002	420
1981	–2.3	78.6	37.7	1,008	409
1982	–7.6	79.2	90.1	878	325
1983	2.8	71.6	32.6	873	400
1984	7.7	84.4	12.0	1,006	402
1985	0.7	87.3	15.1	946	375
1986	5.5	109.8	11.8	1,121	420
1987	4.8	90.6	16.9	1,158	514
1988	3.4	92.0	20.8	1,246	638
1989	5.7	90.6	16.5	1,415	776
1990	3.6	81.8	19.0	1,448	813
1991	2.3	79.3	28.7	1,598	859
1992	7.3	77.8	21.8	1,829	1,073
1993	6.1	80.1	9.8	na	na

[a] 1966 = 100.
[b] Percentage change in the consumer price index of low- and medium-income families in San Jose, calculated on the basis of the annual average price index.
[c] Nontraditional exports are exports which are not coffee, meat, bananas, sugar, cocoa, or fertilizers.
Sources: Gindling and Berry (1993); Central Bank of Costa Rica (BCCR); *Cuentas Nacionales de Costa Rica*, various years; Cepal (1994).

approach assumes that relative labor intensities within industries are constant over time, and projects demand shifts by examining changes in the level of output (in practice employment) across industries. Funkhouser regresses the rate of return to schooling on the demand and supply indexes, and on a combined demand and supply variable.

Funkhouser (1993) finds that estimated returns to education fell from 1976 to 1985, perhaps rising slightly over 1987 to 1992. The relative supply measure increased rapidly from 1976 to 1987, and then rose slowly, perhaps declining slightly from 1987 to 1992. Except for a decline during the 1980–82 recession, the fixed-input coefficient relative demand shift measure increased each year from 1976 to 1992, rising most rapidly between 1976 and 1980. He concluded that supply and demand shifts have large affects upon relative wages—he estimates that a 10% fall in relative demand would result in a 1.1–1.2% drop in returns to education.[2]

Several methodological issues arise in considering Funkhouser (1993). First, using coefficients from OLS earnings regressions as the measure of relative wages imposes restrictions on the structure of the relationship between wages and education. The second issue concerns the constructed supply variable. By simply counting workers

within two broad groups, the method employed implicitly assumes that all workers within the two subgroups—primary education or less and more than primary education—are homogeneous. This also ignores variations in hours worked across workers. Third, the division of workers into primary or less and more than primary education is subject to question. This division implicitly assumes that workers with secondary and university educations are nearly perfect substitutes, and that the share of workers with university educations is small enough so that they should be lumped together with workers with secondary educations. However, in Costa Rica, the share of the labor force with university educations was significant and rising, going from 6% to over 10% over 1976–93. This constituted a major change in the relative supply of university to primary, or university to primary and secondary education. Thus, supply shifts of university to other groups can also be very important. A fourth issue concerns the demand measures; the fixed-coefficient manpower assumption does not account for labor demand shifts across skill levels within firms.

Our paper compliments and extends Funkhouser (1993) by addressing methodological limitations and by explicitly measuring relative demand shifts. We also use a disaggregated, nonparametric approach, and a time-series approach building upon the disaggregated measures, that is responsive to many of the technical limitations of the previous literature.

3. Data

The data we use are from the Household Surveys of Employment and Unemployment conducted by the Statistics and Census Department of the Ministry of Labor and Social Security of the Costa Rican central government. The household surveys are conducted annually. We use the data from the July 1976 to July 1993 surveys, excluding 1984 and 1986 when there were no useable surveys. These countrywide surveys of approximately 1% of the population provide information on earnings, hours worked, workplace characteristics, education, age and other personal characteristics of individuals.[3]

The surveys for pre-1987 and post-1986 are not precisely comparable to one another. In 1987 a new survey design, based on the results of the 1984 census, and a new questionnaire were introduced. Although the samples and questionnaire were designed to be comparable between the pre-1987 period and the post-1986 period, the changes appear to have influenced the reported results in ways we do not fully understand (nor does the Department of Statistics and Census, according to our interviews).

In some cases it is possible to obtain information on variables reported in the household surveys from alternative sources. Comparing changes between 1985 and 1987 in variables from these alternative sources of data to changes in the household surveys suggests that the household surveys exaggerate some changes between 1985 and 1987. Based on what we can infer from these alternative data sources, we believe that there were no dramatic changes in the Costa Rican labor market between 1985 and 1987. We believe that any dramatic changes observed in the household surveys occur because of the changes in the survey. Examination of the household surveys yields very stable relative wage levels and wage structure between 1985 and 1987, while the distribution of the labor force does change. Thus, in our time-series work we regard the level shift in relative supply as spurious, and emphasize relative supply measures that adjust supply after 1987 upwards. The conclusions derived are, however, robust to this adjustment in relative supply.

4. Time Series Analysis of Relative Wages, Supply, and Demand

Forming the Time Series of Relative Wages

The approach used in this section analyzes the relative wages of more-skilled and less-skilled workers using detailed demographic cross-classifications of workers by sex, schooling, and experience, that imposes little parametric structure upon the data. This technique, which follows that described in Katz and Murphy (1992), calculates the change in the wages of workers at each skill level while holding the age/schooling-experience distribution of workers constant. First, we construct normalized relative wage and relative employment vectors for each year from the cross-sectional household survey data, where the elements of the vectors are demographic cells. We divide the data into 80 demographic cells—two sex, five education and eight experience cells—and calculate the average wage of workers in each cell.[4] Next, the wages of workers in each cell in each year are deflated using the employment-weighted wage index described below. Following Katz and Murphy (1992), we call the wage-index-deflated wages "relative wages." Finally, we use weighted averages of wages across demographic cells to calculate the relative wages for more aggregate demographic categories. For example, to calculate the relative wages of university-educated workers we first construct a vector of the over-all-years-average employment (as a proportion of all workers with a university education) in each sex–experience cell. The elements of this vector are then used as weights in calculating the index of relative wages of university-educated workers in each year.

The relative employment matrix is the distribution of total hours worked across cells, $n_{i,t}$. The average of the employment distributions over time, N, is used as a constant demographic weight when aggregating across cells. The relative wage matrix, W, is composed of relative wage vectors that are the mean wages per cell divided by a weighted annual average wage, where the weights are the vector N.

Thus, for year t we calculate the mean wages per cell and the total hours per cell divided by total annual hours:

$mw_{i,t} \equiv$ mean (or median) wage for ith cell in year t,
$n_{i,t} \equiv$ proportion employed (in hours or counts) in the ith cell in year t.

The vector of the average proportion employed in each cell for all years, N, is

$$N \equiv \sum_{t=1}^{T} n_t / T, \tag{1}$$

where T is the total number of years of household surveys.[5] Thus, the normalized wage vector w_t, for year t, is

$$w_t \equiv mw_t / (N' mw_t). \tag{2}$$

For comparisons of relative wages of subgroups of cells (for example, university graduates) we typically want comparable price indices unaffected by the changing distributions of workers across cells. To construct such indices, when aggregating wages across cells into larger categories, we use the constant demographic weights, N. For example, if "k" is university education, the fixed-demographic-weighted mean wage for university-educated workers, w_u, is

$$w_u \equiv \sum_{i \in u} w_i \cdot [N_{i,u} / N_u], \quad \{\text{or } w' N_i / N_u\} \tag{3}$$

where $N_u \equiv \Sigma_{i \in u} N_i$.

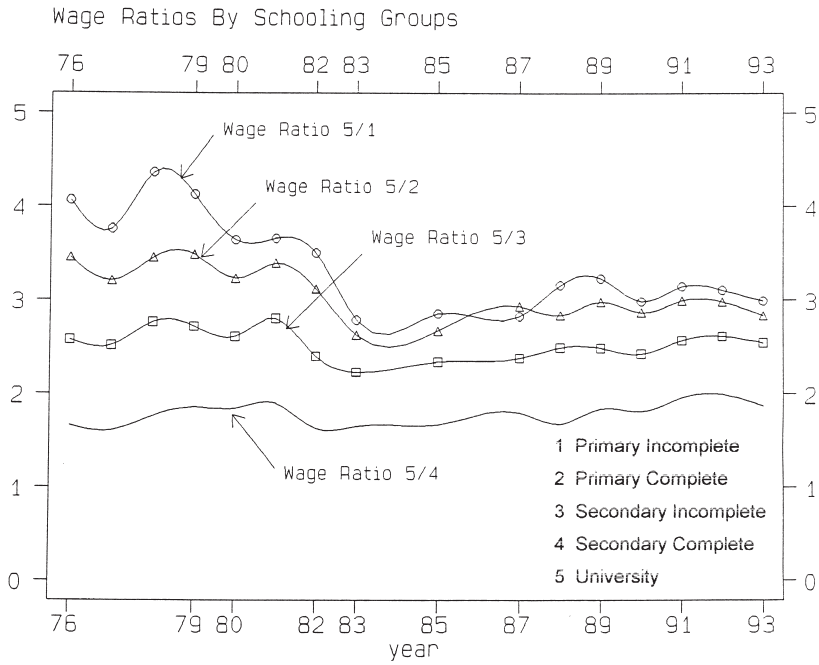

Figure 1. Relative Wages: University Versus Other Groups

Figure 1 plots the relative wages of university workers relative to workers at other education levels. This shows that the relative wages of university workers fell from 1976 to 1983, then rose from 1983 to 1993.

Forming the Time Series of Relative Supply

We next need to create a measure of the relative supply of university graduates to primary school graduates. Because not all workers fall into one of these two categories (for example, some have a secondary education), we create a composite index of relative supply that takes into account information from all workers using the Linear Skills Synthesis hypothesis of Welch (1979). Welch suggested that while measures of differences in individuals' productive attributes could take on many, even infinite dimensions, skill differences could be characterized in terms of two or three dimensions. Welch characterized these dimensions as physical strength ("brawn") and agility and cognitive ability ("brain"). Individuals would be weighted averages of these two dimensions, and range from mostly "brawn" to mostly "brain." We proxy these two dimensions by those with primary-complete educations and those with university educations, while holding other dimensions of skill constant. Workers with either primary-complete or university educations are allocated entirely to their respective groups. The wages of persons with combinations of the two skill types should be weighted averages of their skill endowments and the returns to those polar skill types. Thus, we regress the time series of wages of these individuals—say workers with secondary educations—on to the time series of wages of workers with primary-complete and the wages of university-educated workers, and construct the weights from the estimated coefficients. We then use these weights to assign workers into the primary or univer-

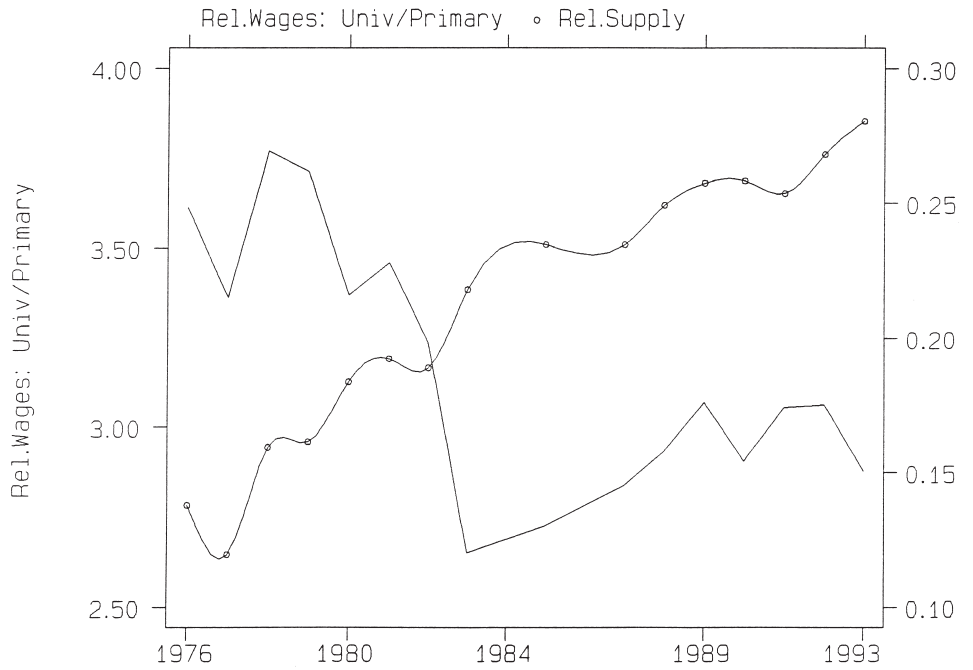

Figure 2. Relative Wages and Relative Supply, in Terms of Primary and University Equivalents

sity categories. For example, on this basis workers with secondary educations were allocated 82% to primary education equivalents, and 18% to university equivalents; workers with special education were allocated 88% to primary education equivalents, and 12% to university equivalents.

Figure 2 plots relative supply over this period. These measures of relative supply rise steadily throughout the 1976–93 period.[6] These results are robust to different definitions of supply. We focus on the relative supply measure that includes employees, self-employed, and unpaid family workers. This measure grows at an average 4.3% annual rate, and more than doubles from 0.12 to 0.28 between 1976 and 1993. Since the rise in relative wages occurs concurrent with a continued rise in relative supply, this suggests that relative demand shifted towards more-skilled workers after trade liberalization in the mid-1980s. We investigate this proposition further in the following subsection.

The inner product test of Katz and Murphy (1992) provides another test of the hypothesis that changes in relative supply alone are sufficient to explain changes in relative wage structure across various time periods. This test relies on the observation that, if relative demand is unchanged, then relative wage changes will move in the opposite direction from relative supply shifts. In this case, the inner product between the vectors of changes in relative wage and quantity vectors would be negative. Thus, we test the pure supply hypothesis across the interval t to $t + m$ by calculating

$$(w_{t+m} - w_t)'(n_{t+m} - n_t). \tag{4}$$

To test the pure supply hypothesis we calculate a normalized inner-product. We normalize the inner-product by the length of the vector of supply changes.[7] This allows us to compare the measures across intervals and, potentially, across countries.

Table 3. Inner Products

	1978–81	*1981–85*	*1987–90*	*1990–93*
Counts	–0.006	–0.011	0.002	–0.002
	(–1.85)	(–2.87)	(1.10)	(–0.47)
Hours	–0.011	–0.018	0.002	–0.003
	(–3.39)	(–3.25)	(0.63)	(–0.97)
Normalized:[a]				
Broad supply[b]	–0.44	–0.59	0.11	–0.13
Potential labor force	–0.26	–0.44	0.16	–0.10

Notes: Figures in parentheses are *t*-statistics in absolute value.
[a] Inner-products divided by length of supply change vector.
[b] Broad Supply includes employees, self-employed, unpaid family workers, unemployed and discouraged workers.

In Table 3 we see that the inner-products for counts and hours went from negative and generally significant values in 1978–81 and 1981–85, to positive or zero after 1987. These results suggest that relative supply movements were sufficient to explain relative wage changes before 1985, but not after 1987, the period of trade liberalization.

Estimation of Relative Demand

In the last subsection, we presented evidence that suggested that trade liberalization in Costa Rica was accompanied by shifts in relative demand towards more-skilled workers. Following Katz and Murphy (1992), in this subsection we infer what relative demand shifts were under a variety of assumptions about the elasticity of substitution between more- and less-educated workers. To do this we examine the time series of relative wages and the constructed time series of relative supply, then net-out relative supply shifts from relative wage changes to get estimates of the time series of relative demand shifts. We find rising relative demand after 1985, suggesting that relative demand became skill-biased in the second half of the 1980s.

The approach employed builds upon Freeman (1980) and follows Katz and Murphy (1992). For a simple CES production function we may write relative wage shifts as a function of relative demand and supply shifts, and the elasticity of substitution between more-skilled (1) and less-skilled (2) workers:

$$\log(W_{1,t}/W_{2,t}) = (1/\sigma)[d_t - \log(s_{1,t}/s_{2,t})], \tag{5}$$

or $w_t = (1/\sigma)[d_t - s_t]$, where $W_{i,t}$ and $s_{i,t}$ are, respectively, wages and supplies of group i in time t; and where w_t, s_t, and d_t are relative wages, supplies and demand shifts at t, and σ is the elasticity of substitution between type 1 and 2 workers. Freeman originally estimated this equation using simple supply measures and manpower (fixed input–output coefficients) extrapolations of demand shifts. We incorporate a more complete supply measure and employ a different estimation strategy reflecting that both the elasticity of substitution and demand shifts are unobserved. We proceed in three stages. First we construct the time series of relative wages and supply (see previous section). Second, we estimate equation (5), approximating demand by a linear trend to obtain a rough estimate of the true elasticity of substitution. Third, we impute

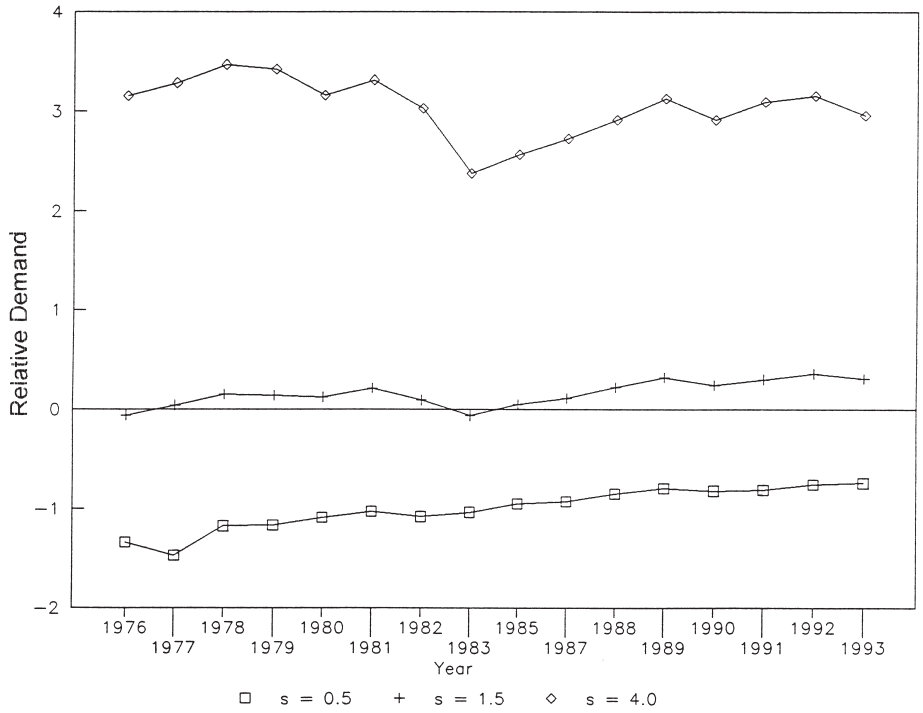

Figure 3. Imputed Relative Demand for a Range of Elasticities of Substituation, s

(simulate) the time series of relative demand assuming a variety of different elasticities of substitution around this rough estimate.

Estimates of equation (5) assuming a linear trend for demand yield implied elasticities of substitution of between 1.4 and 1.8. Broader supply measures including unemployed workers, or even the entire potential labor force, had little affect on the estimates of the elasticities of substitution.

To impute demand, we solve (5) for d_t:

$$d_t = \sigma \cdot w_t + s_t. \tag{6}$$

Using (6), we impute d_t assuming a range of elasticities of substitution around 1.5. In Figure 3 we present imputed relative demand for elasticities ranging from 0.5 to 4.0. The point we wish to emphasize is that imputed relative demand did not fall with trade liberalization. We see that imputed relative demand rose after 1976, leveled off and then fell in the early 1980s. Relative demand then increased consistently (in every year but one) after the mid-1980s and trade liberalization, contrary to the extended Hecksher–Ohlin–Samuelson hypothesis (HOS-X). As one can see, the same qualitative results hold for a wide range of elasticities. This is the main result of our analysis; trade liberalization in Costa Rica did *not* lead to a decrease in relative demand for more-skilled workers, as predicted by HOS-X.[8]

5. Correlates of Relative Demand Shifts

In the previous section we found that the estimated time series of relative demand shifts rose with trade liberalization. In this section we examine the correlates of these

demand shifts to shed more light upon their causes, in particular in relation to trade variables. Our ability to apply sophisticated econometric techniques is severely limited by the small sample size. Nonetheless, important patterns emerge.

We model relative demand shifts here as potentially affected by GDP, trade flows as percentages of GDP, and a measure of the stock of machinery imported relative to GDP. *Ex ante* there is no particular reason or evidence why relative demand should follow a trend. For example, while most US economists now believe that the rising relative demand after 1980 was due to skill-biased technological change, Goldin and Katz (1995) have shown that technical change is not always skill-biased. *Ex ante* we would expect balanced economic growth to lead to skill-neutral labor demand. HOS-X is a theory of unbalanced growth, where unskilled-labor-intensive LDCs should produce and export unskilled-labor-intensive products. Therefore, trade liberalization in LDCs like Costa Rica should lead to unbalanced growth biased towards these unskilled-labor-intensive sectors. Trade liberalization in LDCs is expected to induce unbalanced growth in the form of higher imports and higher exports to GDP. On the other hand, the Skill-Enhancing Trade (SET) hypothesis suggests a channel by which trade liberalization could induce rising relative demand—by raising the imported capital/GDP ratio, tending to raise the overall capital/GDP ratio and serving to accelerate the transfer of skill-biased technology from developing countries (Stokey, 1994). To control for the SET effect we included estimates of the stock of imported machinery divided by GDP.

More explicitly, we employ the time series of imputed relative demand, discussed in section 3. Recall that relative demand was estimated above as

$$d_t = \sigma \cdot w_t + s_t, \tag{7}$$

where rough s on σ were obtained by regressing relative wages on to a trend and the constructed relative supply. We now estimate equations of the form

$$d_t = f(X,\ M,\ ICS,\ GDP), \tag{8}$$

where X are measures of export flows divided by GDP, M are measures of import flows divided by GDP, and *ICS* is the imported capital stock divided by GDP. Trade flows for exports and imports were taken from the World Bank's *World Tables*, while imported capital stock was constructed from the COMTRADE database. The results were not sensitive to different depreciation rates (here we report using a 20% rate). Various specifications were estimated. [9]

Table 4 reports representative findings for regressions of imputed relative demand (assuming an elasticity of substitution of 1.5) on to these correlates (estimates using Cochrane–Orcutt are reported, as moderate autocorrelation was typical). Because of the small sample size we regard these results as indicative and not conclusive, yet some strong patterns emerge. We report regressions of imputed demand on to logged trade flows, log (*GDP*) and Imported Capital Stock (*ICS*). Results did not change significantly when also controlling for the stock of domestically produced capital and a linear trend variable. *F*-statistics are high, ranging from 32.7 to 79.2, and adjusted R^2 from 0.89 to 0.93.

The principal finding is that log (*GDP*) and the Imported Capital Stock (*ICS*) divided by GDP have positive and statistically significant coefficients. The estimated coefficients on *ICS* ranged from 0.39 to 0.66, with *t*-statistics ranging from 4.1 to 6. We interpret these findings cautiously as consistent with the SET hypothesis. The SET hypothesis is supported by the positive, significant and stable estimated coefficients on imported capital stock. The HOS-X hypothesis is weakly supported by the negative

Table 4. Correlates of Implied Relative Demand

Independent variables (in logs; trade variables divided by GDP	*Dependant variable: imputed relative demand of skill*										
	(1)	*(2)*[a]	*(3)*	*(4)*[a]	*(5)*	*(6)*[a]	*(7)*[c]	*(8)*[a,c]	*(9)*[b]	*(10)*[b]	*(11)*[a,c]
Exports	–0.08	0.31							0.42		
	(–0.6)	(0.9)							(1.0)		
Manufactured exports			–0.026	0.24	0.14	0.27					
			(–0.26)	(1.5)	(1.1)	(1.7)					
Imports	–0.06	–0.35			–0.21	–0.53			–0.24		
	(–0.5)	(–1.4)			(–1.3)	(–1.9)			(–0.9)		
Manufactured imports			–0.04	–0.42							
			(–0.3)	(–1.9)							
GDP	1.06	2.9	1.11	3.5	1.0	2.96	1.1	1.5	0.34	0.25	0.24
	(4.2)	(1.9)	(3.8)	(2.9)	(4.2)	(2.2)	(4.3)	(2.7)	(3.1)	(4.8)	(1.5)
Imported capital stock	0.61	0.66	0.63	0.39	0.52	0.56	0.61	0.59	0.59	0.51	0.51
	(5.6)	(5.7)	(5.1)	(2.6)	(4.2)	(4.6)	(6.0)	(5.7)	(4.1)	(4.8)	(3.6)
N	16	16	16	16	16	16	16	16	16	16	16
R^2 (adjusted)	0.91	0.91	0.89	0.93	0.92	0.93	0.91	0.91	0.92	0.93	0.92
F-statistic	40.9	32.7	34.7	38.7	35.7	32.07	79.2	54.2	33.1	61.96	42.7

[a] These equations included a linear trend variable.
[b] These equations include domestic capital stock (total fixed capital minus imported capital stock).
[c] These equations include primary exports as a share of GDP.
[d] The *ICS* variable here was constructed assuming 20% annual depreciation and zero initial value in 1970; alternative depreciation rates did not substantively change results. Similar results were obtained in other specifications and when controlling for inflation, terms-of-trade or primary exports.
[e] Estimated using Cochrane–Orcutt.

but insignificant estimates on import to GDP ratios. However, the tendency for the coefficients on export to GDP ratios to be positive and insignificant tends to undermine HOS-X. GDP growth appears to raise relative demand, and hence wage dispersion, but it does not affect most other coefficients, in particular those on the imported capital stock variable.

6. Conclusions

A prominent argument regarding the effects of trade liberalization on the dispersion of wages, which we term the extended Hecksher–Ohlin–Samuelson (HOS-X) hypothesis, argues that in LDCs trade liberalization should lower relative demand, and hence relative wages, by inducing between-sector shifts towards sectors intensive in unskilled labor. Our analysis of the Costa Rican experience does not support the extended Hecksher–Ohlin–Samuelson hypothesis. Using a disaggregating, nonparametric approach that imposes little structure on the data, we measure the changes in relative wages and relative supply for more-skilled workers in Costa Rica. For Costa Rica, relative supply rose continually throughout the period studied, while subsequent to trade liberalization relative wages stopped falling and began to rise, suggesting skill-biased relative demand shifts. Analyzing the inner-product test of Katz and Murphy (1992) provides additional evidence that relative supply movements were sufficient to explain relative wage changes before 1985, but not after 1987, the period of trade liberalization. Using a time-series approach that builds on the disaggregating results, we estimate the relative demand for more skilled workers in Costa Rica. The estimated time series of relative demand showed a marked rise in relative demand coincident with trade liberalization.

Analysis of the correlates of relative demand shifts suggests a somewhat heterodox interpretation. Imports and imports of manufactures are associated with lower relative demand, along the lines of HOS-X, while less consonant with HOS-X, exports and particularly exports of manufactured products are associated with rising relative demand. Growth and imported capital stock, though, appear much more important in determining relative labor demand, suggesting that economic growth and rising stock of imported machinery are important causes of the skill-biased relative demand shifts after trade liberalization. Thus, we find little support for HOS-X, and some support of the Skill-Enhancing-Trade hypothesis, whereby trade liberalization induces an acceleration of physical capital imports, which through capital-skill complimentarily raises relative demand.

Our results imply that trade liberalization in developing countries, by itself, will be disequalizing. The unequal impact of trade liberalization may make it unattractive, and governments may want to implement other policies to counteract its disequalizing effects. One such policy implied by our results would be one of increasing the relative supply of university graduates. This increase in the relative supply of more-skilled workers may counteract the increase in relative demand brought on by trade liberalization.

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Notes

1. The structural adjustment program also included the selling of state enterprises, a 1987 tax reform which lowered the maximum marginal tax rate to 25% and increased the threshold for contributions, instituted in 1985 a 30% flat corporate tax rate and increased sales, property, social security and stamp tax rates, a loosening of the monopoly of state owned banks, beginning in 1985 a reduction of some agricultural subsidies (for example, to rice, beans, sorghum and maize producers), together with the elimination of all quantity restrictions on agricultural imports, and

a program to promote nontraditional exports to third markets via the creation of free-trade zones, tax breaks, import duty exemptions, and production and marketing extension services.
2. Funkhouser (1994) estimates changing returns to education, an index of relative supply, and an index of relative demand for Costa Rica and other Central American countries. In this paper, Funkhouser extends his 1993 analysis by using cross-country data to control for differences in quality of education in his estimates of returns to education. The results of this analysis are similar to Funkhouser (1993).
3. Monthly salaries are reported only for salaried employees (and not for self-employed workers and "patronos") for the entire 1976–93 period. We use only the wages of salaried employees in our analysis. The household surveys report monthly salaries and hours worked per week. We construct hourly wages by dividing monthly salaries by (hours worked per week multiplied by 4.3 weeks in July).
4. To maximize comparability of wages across workers and over time, only full-time employees 15 years and older are used in calculating wages.
5. Several variants of the employment vectors are constructed, and used as appropriate; these range from only employees to the total potential labor force (employees, self-employed, unpaid family workers, unemployed workers discouraged [unemployed] workers, and out-of-labor-force persons). Relative employment matrices are calculated both in hours worked and in numbers of persons, or counts, per cell.
6. To address the issue of the change in survey design and sample between 1985 and 1987, we make the assumption that relative supply is the same in 1985 and 1987. Broader measures of supply adding unemployed and discouraged workers, and even the total potential labor force, follow similar paths. Similarly, simpler measures of relative supply, where we divide the absolute number (or hours worked) of university to primary school graduates, follow similar patterns.

If the relative supply of skill were mis-measured, a biased estimate of relative demand shifts would result. This might occur because the definition of relative supply was too narrow. We tested this by using various measures of relative supply: first, including employed, self-employed, unpaid family workers and unemployed workers; second, adding discouraged workers; and third, adding all persons above 15 years of age. We also controlled for the unemployment rate. The results were robust to these different supply measures and the inclusion of the unemployment rate.
7. Our approach differs in two respects from the Katz and Murphy (1992) work on the US. First, a zero inner-product corresponds to neutral demand shifts only if relative supply is unchanged. However, if relative supply has changed, a zero inner-product then implies that there is a non-neutral relative demand shift that counterbalances the relative supply shift. Second, we examine alternative measurements of supply. Katz and Murphy (1992) assume full employment, and use the distribution of hours of employees and self-employed above age 15 to measure supply. To reflect the possibility of disequilibrium in the labor market, we test the robustness of the inner-product results using various supply measures, including total labor above 14 years old for the total potential labor supply, and intermediate measures for supply including employees, self-employed, unemployed and discouraged workers, or "broad" labor supply.
8. In Robbins and Gindling (1997) we discuss possible alternative explanations for the increase in relative wages, including changes in: minimum wages, public sector employment, union power, educational quality, and the skill composition of the unemployed. While we cannot completely reject any of these as possible causes of the increase in relative wages, we believe that the weight of the evidence points to trade liberalization as a main cause of the increase in demand for more-skilled workers in Costa Rica. Even if these alternative explanations are valid, this does not invalidate our main result. HOS-X implies that the increase in relative demand for more-skilled workers should have reversed itself after the introduction of trade liberalization—it did not. Trade liberalization in Costa Rica did not lead to a decrease in relative demand for more-skilled workers as predicted by the extended Hecksher–Ohlin–Samuelson hypothesis.