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Sugar Prices, Labor Income, and Poverty in Brazil

Why the hell should I give up what I have if in fact it's not going to be to the benefit of anyone but a middleman? . . . The poorest of the poor gets hardly anything, but this is being advertised as a benefit of reform.

—Jack Wilkinson, President of the International Federation of Agricultural Producers

Sugar is produced in 121 countries in the world.[1] It remains one of the most distorted sectors, and only in a handful of countries do producers face world prices. In many industrialized countries, sugar producers benefit from all sorts of border protection, as well as domestic and export subsidies. There has been significant pressure on member countries of the Organization for Economic Cooperation and Development (OECD) to liberalize the sugar sector. Some estimates suggest that world prices could increase by as much as 40 percent following the elimination of all trade-distorting policies in this sector.[2] This could benefit the many developing countries that have a natural comparative advantage in the production of sugar. Brazil is likely to be one of the largest beneficiaries.[3] It is the largest

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1. Around 60 to 70 percent of world production takes place in tropical countries and is based on sugar cane, and 30 to 40 percent in more temperate climates using sugar beet.

2. Mitchell (2005),

3. Brazil recently won a World Trade Organization (WTO) dispute that requires the European Union to reduce its sugar subsidies. Moreover, the European Union has announced a reform that would cut its reference price by around 40 percent. If accompanied by a reduction in border barriers in the European Union, this could lead to a significant increase in the world

producer and exporter of sugar in the world, accounting for 28 percent of world sugar cane production and 25 percent of world sugar exports.

But who is likely to be the largest winner within Brazil? Some have argued that given the structure of the sugar sector and the large mechanization it has experienced in recent years, very little of the economic gains would go to small farmers and agricultural workers in Brazil. Rather, reforms in the OECD are likely to benefit almost exclusively large multinational firms investing in Brazil and their skilled and often foreign workers. Indeed, since Brazil opened its sugar sector to foreign investment in the late 1980s, around thirty European firms have established their presence in Brazil and currently represent about 10 percent of the sector's total output.[4] Nevertheless, the impact of an increase in sugar prices on the poorest segments of the population could be quite large. The sugar sector accounts for a substantial share of employment among the poor in Brazil. A third of sugar workers in the north and northeast are illiterate, and almost 60 percent of sugar workers in Brazil have not completed primary school. Moreover, the sugar sector's overall contribution to GDP and employment is around 1 percent and reaches 3 to 4 percent in Pernambuco. General equilibrium effects may lead to a relatively high impact on wages and employment in other sectors as well, depending on interindustry linkages and factor mobility across sectors and industries. Thus the presence of foreign capital in a relatively concentrated sector does not preclude significant impacts on labor markets.

This paper investigates how changes in the world price of sugar could affect individuals within different segments of the income distribution by focusing on the relationship between sugar prices, wages, and employment. We first estimate the extent of price transmission from world markets to eleven Brazilian states. Some states are more isolated than others, preventing a full price transmission from world markets to sugar producers.[5] Empirical results suggest that long-run price transmission across states is somewhat

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price of sugar. The development implications of this reform are not clear, however, as many developing countries (namely, those benefiting from Lomé preferences) would lose from the reform, as African, Caribbean, and Pacific sugar exporters benefit from quota-constrained high reference prices when exporting sugar to the European Union.

4. Moraes (2004). The largest foreign interests in the Brazilian sugar sector include Franco Brasileira S.A. Açúcar e Álcool (FBA), which is a joint venture between Brazilian group Cosan (47.5 percent) and French groups Tereos (47.5 percent) and Sucden (5 percent); Louis Dreyfus Commodities Bioenergia S.A. (formerly Coinbra), which entered the sector through a takeover of two sugar mills; and the Swiss Glencore Group.

5. See Winters, McCulloch, and McKay (2004, section 4.1).

heterogeneous, ranging from 0.75 in Pernambuco and Bahia to 1.00 in Goiás, Minas Gerais, and São Paolo. Consequently, increases in world prices are not going to be homogeneously transmitted to households in different states.

Second, we simultaneously estimate the impact of changes in local sugar prices on regional wages and employment for workers with different characteristics. These two are often examined separately, yet price changes simultaneously affect wages and labor opportunities.[6] The relative strength of these two channels of transmission from domestic prices to labor income will depend on labor demand and supply conditions, as well as labor market regulations. Our results show that better-educated workers experience higher wage increases following a rise in sugar prices. This may be partly due to the fact that mechanization and the entry of foreign multinationals has made this sector more capital and skilled-labor intensive. Also, in a setup with industry linkages through purchases of intermediate inputs, higher sugar prices may be taxing downstream sectors such as the food industry, which may be relatively more intensive in low-skilled labor. Therefore, the net effect on the relative demand for skilled and unskilled labor is ambiguous. An alternative explanation, which seems to be more consistent with our empirical results, is that an important pool of unemployed unskilled workers puts downward pressure on the wages of poor and unskilled workers, which makes their wages relatively less sensitive to changes in labor demand. This is confirmed by the fact that even though more educated workers experience higher percentage increases in wages, the largest increases in employment were observed for workers at the bottom of the income distribution. Thus, if the wage effects tend to benefit relatively more workers in the top income quintile, the employment effect benefits relatively more workers belonging to the bottom income quintile, who are moving out of unemployment. When these two effects are put together, households experience similar gains in percentage terms throughout the entire income distribution. But again, the sources of income gain are different.

This result has important implications for the theoretical and empirical literature on trade and wages. Indeed, the empirical puzzle that trade liberalization often leads to more wage inequality in developing countries may only be part of the story. Our results suggest that this pattern can be explained by the fact that in developing countries where unemployment is often high (or more generally where there are differences in the supply elasticities of skilled and unskilled labor), the focus should not be on wage inequality, but rather on

6. Winters, McCulloch, and McKay (2004).

labor income inequality. Figure 1 illustrates the case in which labor supply for skilled (and presumably rich) households is very inelastic, whereas the labor supply for unskilled (and presumably poor) workers is very elastic (partly because the presence of unemployment puts pressure on unskilled wages and partly because imperfect labor mobility across sectors and states varies across skilled and unskilled workers). Under these circumstances, and in the absence of factor reallocation across sectors, an increase in the price of unskilled-labor-intensive goods (sugar) will lead to a large increase in labor demand for unskilled workers and a small increase in labor demand for skilled workers.[7] However, because of the differences in labor supply elasticities, this relative increase in the demand for unskilled workers will translate into a decline in the relative wage of unskilled workers, combined with a large relative increase in unskilled employment.[8] The important point here is not whether there is an increase in wage inequality, which will depend on whether we allow for the reallocation of factors across sectors, but rather that the impact on employment could potentially dominate the impact on wages. In other words, it is necessary to explicitly model changes in the level of employment (or unemployment) of unskilled and skilled workers.

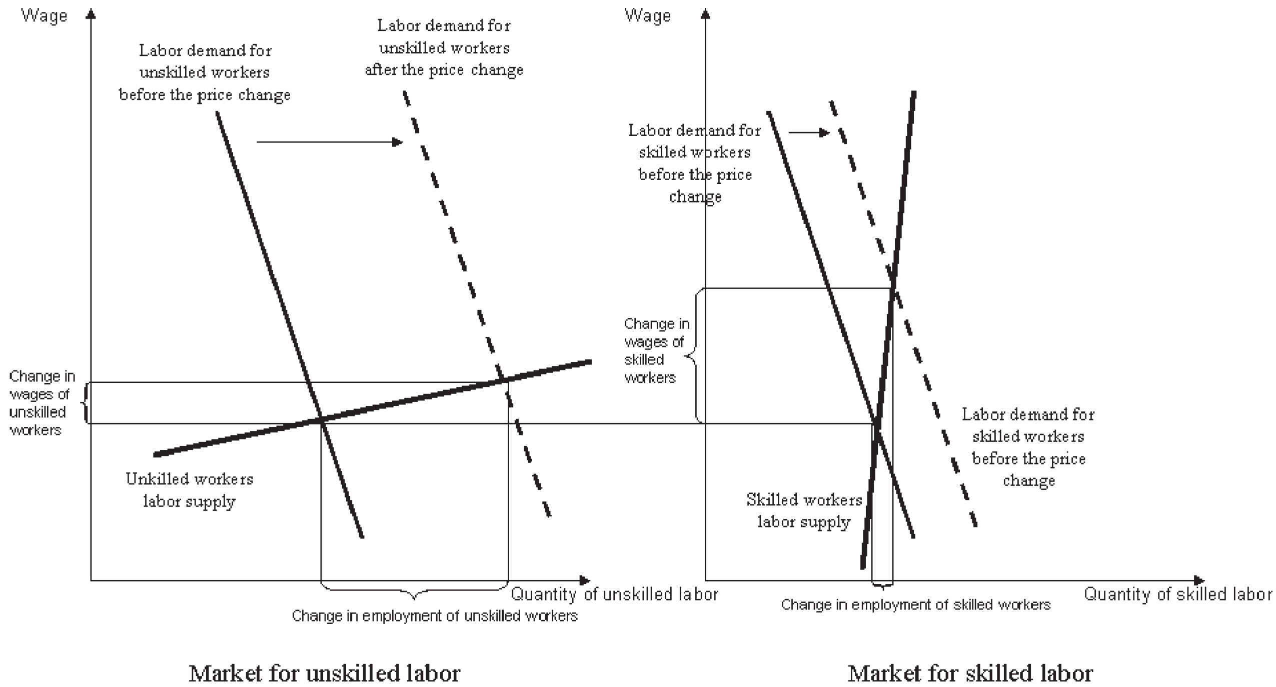
Finally, we use the estimates of the first and second stages to simulate the impact of a 10 percent increase in world sugar prices on household labor income and poverty.[9] Results suggest that the change in aggregate labor income is close to US$2 billion (or 0.4 percent of GDP). Thus Brazilian workers are likely to benefit substantially from liberalization of the sugar sector in OECD countries. Our estimates also suggest that around 280,000 Brazilians will be brought out of poverty following a 10 percent increase in world sugar prices.

7. Otherwise we are in Leamer's factor insensitivity world, in which changes in factor supply will not affect factor prices; this would bring us back to the Stolper-Samuelson prediction.

8. A Ricardo-Viner model would also be consistent with the observed pattern, while allowing for the reallocation of a mobile factor across sectors (namely, unskilled labor) with skilled labor being specific to the sugar sector. (For full details on the Ricardo-Viner model, see, for example, Jones 1971.) Assuming that there is a minimum wage or some friction in the unskilled labor market, an increase in the price of sugar will lead to a proportionately larger increase in the wage of skilled workers relative to unskilled workers. This, however, could potentially be compensated by an increase in the employment of unskilled workers as unskilled labor demand increases.

9. A 10 percent increase in the world price of sugar is at the lower end of the range of estimates provided in the literature (see Mitchell 2005). To obtain percentage changes in income for other estimates of changes in world price, see footnote 39 below.

FIGURE 1. Impact of an Increase in the Price of an Unskilled-Labor-Intensive Product on Wages and Employment



The rest of the paper is organized as follows. The next section provides background information on the functioning of the sugar sector in Brazil and the characteristics of its labor force. The paper then discusses the empirical methodology used to estimate the transmission of changes in the world price of sugar into local sugar prices and the impact of local prices on wages and employment. The subsequent section presents the empirical results, and the final section concludes. A data appendix describes our data sources and variable construction.

Brazil's Sugar Sector and Its Labor Force

Brazil is the world's largest sugar producer and exporter. In 2006 it produced around 35 percent of all sugar cane in the world and exported around 47 percent of the world's total processed raw sugar by volume.[10] One crucial feature of the sugar cane industry is the close relationship between harvesting and processing: the raw cane has to be transported to the mill fast, since the quality of sugar deteriorates rapidly following the cutting of cane. Consequently, the mills are located in the midst of the sugar cane area. There are two main sugar cane producing regions: the center-southeast and the north-northeast. There are approximately 300 plants that process sugar cane (sugar mills), almost 75 percent of which are in the center-south. The costs of growing sugar cane are higher in the north because of poorer soil quality. Processing costs are also higher in the north than in the center-south. The state of São Paulo in the center-south is by far the biggest producer. It accounts for 75–80 percent of sugar cane production and 60–65 percent of sugar production (see table 1). However, the north-northeast accounts for 70–75 percent of exports.[11] Almost 45 percent of all production is consumed domestically. Domestic food manufacturers account for approximately 35–45 percent of total consumption, the rest being direct consumption.

Prior to the reforms of the 1990s, the Brazilian sugar and alcohol industry was highly regulated, and the policies for sugar and ethanol were interconnected. Sugar mills and distilleries received credit guarantees and subsi-

10. Based on Food and Agriculture Organization (FAO) data from ProdSTAT (23 June 2009 update) and TradeSTAT (9 December 2008 update), available online at faostat.fao.org. A bit more than half of Brazilian sugar cane is used for the production of ethanol (fuel alcohol). Brazil's interest in ethanol production dates back to the first oil crisis. The ethanol content of gasoline is regulated by decree at around 20 to 24 percent.

11. Bolling and Suarez (2002).

TABLE 1. Sugar Production in Brazil by State, 2000–2006[a]
Thousands of tons

Region and state	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Share in total, 2000–06 (%)*
North-northeast								
Alagoas	2,059	1,678	1,994	2,496	2,389	2,104	2,137	9.0
Bahia	146	143	161	172	170	117	116	0.6
Paraíba	74	115	143	168	166	116	154	0.6
Pernambuco	1,099	1,104	1,231	1,393	1,464	1,215	1,357	5.4
Rio Grande do Norte	135	117	166	174	234	175	259	0.8
Other north-northeast	99	88	94	103	113	93	75	0.4
Total north-northeast	3,613	3,246	3,789	4,505	4,536	3,821	4,098	16.7
Center-South								
Goiás	397	506	577	668	730	750	766	2.7
Mato Grosso	370	448	546	579	567	521	540	2.2
Mato Grosso do Sul	232	328	374	403	412	401	576	1.6
Minas Gerais	620	747	1,093	1,347	1,665	1,742	1,910	5.5
Paraná	997	1,351	1,469	1,865	1,814	1,503	2,178	6.8
Rio de Janeiro	308	219	312	332	347	286	262	1.2
São Paulo	9,675	12,350	14,348	15,172	16,495	16,834	19,503	63.1
Other center-south	45	23	59	54	56	48	49	0.2
Total center-south	12,643	15,972	18,778	20,420	22,085	22,085	25,784	83.3
Brazil (total)	16,256	19,218	22,567	24,926	26,621	25,906	29,882	100.0

Source: União da Indústria de Cana-de-açúcar (UNICA) and the Brazilian Ministry of Agriculture, Livestock, and Food Supply (MAPA) (www.unica.com.br/dadosCotacao/estatistica/).

a. The harvest season for sugar cane in Brazil varies by region (May through November in the center-south region and September through April in the north-northeast region), so a column heading of 2000 implies the 2000–01 harvest season.

dized interest rates. Domestic marketing of sugar and alcohol was state controlled, with the Institute of Sugar and Alcohol (IAA) acting as a state trading enterprise. The IAA set production quotas and allocated them among the sugar mills and distilleries. Above-quota production was allowed to be exported subject to licensing requirements and export tax. The government fixed domestic prices paid to sugar cane growers, giving higher prices to the growers in the high-cost production areas in the north.

The IAA was dissolved in 1990. The reforms of the sugar market focused on disentangling sugar and ethanol policies and releasing the control over domestic sugar prices. The export tax on sugar was lowered and eventually eliminated. The production tax was made uniform across regions. In 1998 the state monopoly controlling ethanol distribution was abolished. The main outcomes of deregulation were market-determined sugar and alcohol prices (with domestic sugar prices following world market prices). A new competitive environment arose from changes in market structure, while sectoral concentration increased through mergers and acquisitions and inflows of foreign capital.[12] The integration between Brazil's sugar market and the world market following these reforms is illustrated in figure 2, which shows the evolution of Brazilian producer and consumer prices and world prices for raw and refined sugar.[13] The high correlation between the four series is clear from this figure.

Four distinct groups are involved in sugar production: sugar mills, independent sugar cane producers, hired agricultural workers, and industrial workers. Each is represented by one or more organizations that define the institutional setting of the sugar sector. The earnings of each group, including minimum wages of workers and the price of sugar cane paid to producers, depend on the outcome of annual negotiations between the various entities. The minimum wages negotiated in 2003–04 were US$0.51 per hour for hired agricultural workers and US$0.56 for mill workers, corresponding to US$113 and US$122 per month, respectively.[14]

Around 75 percent of sugar cane is grown by the mills, which hire seasonal workers at hourly wages, while the rest belongs to independent producers.[15] In 2002, approximately 765,000 people were employed in sugar and alcohol production. Of these, around 48 percent were employed in sugar cane production. Only 12 percent were employed in the alcohol producing sector. Based on interviews with workers' representatives in the sector, Moraes estimates that 95 percent of employment is formal.[16] Table 2 shows the distribution of workers by region, age group, and education level for both sugar cane growing and sugar production. Forty percent more workers were employed in the center-south than in the north. The ratio of employment to production (combining tables 1 and 2) suggests that the center-south is 2.5 times more productive than the north. This is mainly explained by the quality of land in the different regions and the higher degree of mechanization in the center-south. This is also reflected in the significant differences in the education level of sugar workers across regions. In the center-south, only 4 percent of workers are illiterate, whereas roughly a third are illiterate in the north.

12. Moraes (2004).

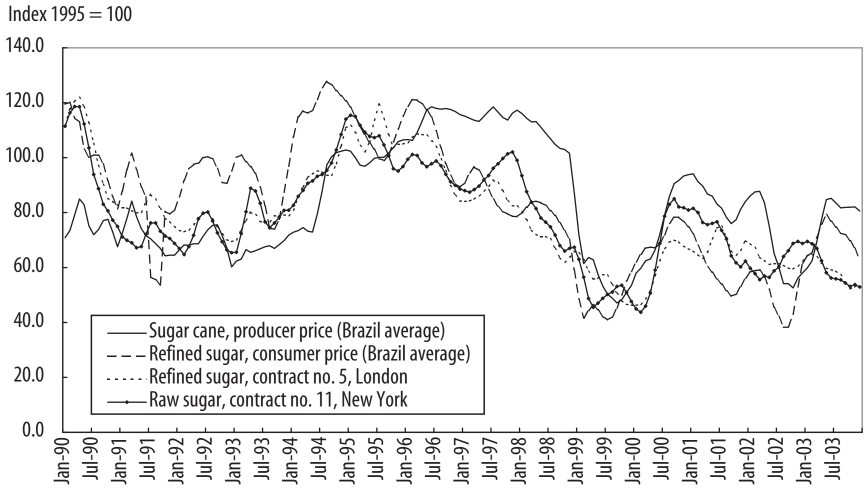
13. World prices for raw sugar are based on contract no. 11 on the New York Board of Trade; refined sugar prices are from contract no. 15 on the London International Financial Futures Exchange.

14. Moraes (2004).

15. Moraes (2004).

16. Moraes (2004).

FIGURE 2. Evolution of Sugar Prices, 1990–2003



The average education level of workers in the sugar sector (3.7 years) is higher than in the rest of the agricultural sector (2.8 years), but substantially lower than the average for the economy as a whole (6.4 years). The sugar sector has traditionally been relatively intensive in low-skilled labor. Table 3 shows the ratio of highly educated workers (defined as those with more than nine years of education) to low-educated workers (defined as those with less

TABLE 2. Employment in the Sugar Sector, 2002
Number of workers

	Brazil		*North-northeast*		*Center-southeast*	
Worker characteristic	*Cane*	*Sugar*	*Cane*	*Sugar*	*Cane*	*Sugar*
Age group						
10 to 17 years	1,571	1,035	297	629	1,274	406
18 to 29 years	160,488	175,613	36,613	94,075	123,875	81,538
30 to 49 years	169,916	185,080	39,903	90,424	130,013	94,656
50 and above	35,645	35,245	9,516	18,050	26,129	17,195
Total	367,620	396,973	86,329	203,178	281,291	193,795
Education level						
Illiterate	46,567	70,722	33,722	63,489	12,845	7,233
Completed 8th grade	297,810	273,239	50,190	128,320	247,620	144,919
High school degree	20,095	43,238	2,099	9,543	17,996	33,695
College degree	3,148	9,774	318	1,826	2,830	7,948

Source: Moraes (2004).

TABLE 3. Ratio of Highly Educated Workers to Low-Educated Workers by Sector, 1990–2002[a]

Sector	*1990–93*	*1995–98*	*1999–2002*	*Change (%)*
Sugar growing	0.01	0.03	0.06	359
Sugar processing	0.07	0.12	0.56	701
Agriculture other than sugar	0.04	0.05	0.08	92
Industry other than sugar	0.45	0.56	0.85	90
Food industry	0.89	0.97	1.20	35
Beverages	1.21	1.72	2.55	111
Services	1.01	1.36	1.94	93

Source: PNAD surveys, 1990–2002. See data appendix for more details.

a. The ratio is calculated as the average number of workers in the sector with nine or more years of education divided by the number of workers in the sector with less than five years of education. Similar patterns are found when one uses the number of workers below and above the average education level in the survey, which is around seven years.

than five years of education) in different sectors in Brazil. The sugar growing and processing sectors employ a relatively small share of highly educated workers relative to other sectors, with the exception of other agricultural sectors. Sectors that are heavy sugar consumers, such as food and beverages industries, are relatively intensive in highly educated workers, which suggests that this type of general equilibrium linkage would only reinforce the relatively low-educated intensity of the sugar sector. Over the last decade, however, the share of highly educated workers in the sugar processing and growing sectors grew drastically relative to the rest of the economy, growing six times faster on average (see the last column of table 3). This is partly due to the transformation of the sector in the period, from a network of primarily family-owned farms and production facilities to an industry dominated by larger, technologically advanced factories. Sugar cane loading, transport, and cultivation is 100 percent mechanized, and harvesting is around 35 percent mechanized.[17] The mechanization has reduced the demand for workers, especially for those with low skills.[18] The sector has become relatively capital intensive: labor costs now represent around 25 percent of value added, versus an average of 35 percent in manufacturing.

These changes led to growing demand for high-skilled workers. The Luiz de Queiroz School of Agriculture (ESALQ) and the Ribeirão Preto School of Economics, Administration, and Accounting (FEARP), both at the University of São Paulo, have graduated several classes in their Master of Business

17. According to Ricci, Alves, and Novaes (1994), this mechanization was prompted by sector reforms that created incentives for firms to undertake cost-reducing investments and by legislation banning cane burning as a trash removal method.

18. Guilhoto and others (2002).

Administration (MBA) programs targeting the sugar sector, and they also offer shorter technical courses with a similar orientation. The fact that MBA courses are being targeted to the sugar sector seems to suggest that a certain level of sector-specific skills needs to be acquired. One may thus expect that changes in sugar prices would have a higher impact on wages of skilled versus unskilled workers in the sugar sector if they have relatively more sector-specific skills. This will be tested in the empirical section.

Empirical Methodology

We evaluate the impact of world sugar prices on household income in three steps. First, we estimate the extent of price transmission from world sugar prices to local markets. Second, we estimate the impact of local sugar prices on wages and employment in different categories of the labor force.[19] Finally, using these estimates, we simulate for each income quintile the impact of a 10 percent increase in world prices on household income. The three steps are described below.

From World to Local Sugar Prices

The extent of price transmission from world to local markets depends on how well integrated these markets are. Distance to ports, road infrastructure, and access to information all play a role. These characteristics are likely to vary from one region to another, affecting the impact of changes in world prices on earnings in each region.

First we use an Engle-Granger residual-based test to determine the long-term cointegrating relationship between each of the local prices and the world price. This is done by regressing the price in each state on the world price:

$$\ln p_t^d = \alpha + \gamma \ln p_t^w + \mu_t . \tag{1}$$

19. We do not estimate the impact of world prices on wages and employment in one step for two reasons. First, we are interested in understanding the mechanisms behind the transmission from world prices to wages and employment and, in particular, the role played by the transmission from world prices to local prices. Second, and more pragmatically, price data vary by month at both the local and world levels, but world prices do not vary by region. On the other hand, wage and employment data are annual, but vary by region. Merging the two steps would result in a loss of degrees of freedom with which the price coefficient is identified in the wage and employment equation.

If, in fact, there is a cointegrating relationship between the price pairs, then the ordinary least squares (OLS) estimator is consistent despite the apparent problem of nonstationarity of the price-time series and the problem of replacing a simultaneous-equation model for all states with a single equation.[20] Equation 1 is estimated for each of the states using a seemingly unrelated regression (SUR) to control for any exogenous shock that may be affecting prices in a similar way in all regions. The prices used in the analysis are in log form, which allows us to interpret the coefficients of cointegration as long-term elasticities of the local prices with respect to the world price. We use these estimates when simulating the impact of a 10 percent increase in world prices on local wages and employment. To establish cointegration, the residuals μ_t are tested for unit roots using the augmented Dickey-Fuller (ADF) procedure.[21]

In addition to estimating the cointegrating vectors, we estimate an error correction model to explain the dynamics around the long-term cointegrating relationship. The response of domestic prices to changes in the world price is decomposed into an immediate change following the shift in prices and an adjustment to the long-term equilibrium in the following period:[22]

$$(2)\ \ln p_t^d - \ln p_{t-1}^d = \eta + \delta\left(\ln p_t^w - \ln p_{t-1}^w\right) + \theta\left(\ln p_{t-1}^d - \alpha - \gamma \ln p_{t-1}^w\right) + \varepsilon_t,$$

where p_t^d is the domestic price in period t, p_t^w is the corresponding world price; δ captures the instantaneous response of domestic prices to changes in world prices, and θ is the error correction parameter, which captures the speed of adjustment of p_t^d to its long-run equilibrium, γp_t^w. Given that the OLS estimates of equation 1 are asymptotically efficient, we then use $\ln p_{t-1}^d - \hat{\alpha} - \gamma \ln \hat{p}_{t-1}^w$ as the error correction term.[23] Again, SUR is used to estimate equation

20. Greene (2000).

21. The ADF test for a unit root without trend involves estimating the following equation for a time-series variable, y_t: $\Delta y_t = \beta + \gamma y_{t-1} + \sum_{j=1}^{k} \eta_j \Delta y_{t-j} + v_t$ where k is the number of lags of the first differences used. The null hypothesis is that each of the time series follows a nonstationary process with a unit root, that is, $\lambda = 0$ (which is tested against $\lambda < 0$). If the null hypothesis of unit root is rejected, we proceed as if the domestic and world price series are cointegrated.

22. See Baffes and Gardner (2003) for a detailed derivation.

23. The asymptotic properties of the estimator are valid regardless of whether we use the OLS estimator or the leads and lags à la Stock and Watson (1993) in case we are worried about endogeneity bias in the estimation of equation 1. Given that p^w is integrated of the first order, using the leads and lags of p_t^w around time t is equivalent to introducing all random determinants of p^w as control variables, which ensures that the error term of equation 1 is orthogonal to p_t^w.

2 for each of the states in our sample, resulting in eleven equations. Prior to estimation, we ensure that the first differences of the price-time series used in the error correction model (equation 1) are stationary using an ADF test.

From Local Sugar Prices to Wages and Employment

To estimate the impact of local prices on wages and employment in Brazil, we use a Heckman sample selection model in which we only observe the wages of the respondents that have been employed during the survey period. The wage equation estimates the impact of sugar prices (as well as individual and regional characteristics) on a person's wage. We allow the impact of sugar prices to vary according to individual characteristics, including sector of employment and geographical location of the household. Note that even workers in nonsugar sectors in non-sugar-producing regions can see their wage change, if labor markets are integrated or if sugar is a complement or a substitute in the production or consumption of other goods.[24]

The Heckman model corrects for the potential selection bias that OLS estimation would produce given that we only observe the wages of employed individuals. Correction involves specifying a selection equation that describes the latent variable, z_i^*:

$$z_i^* = \xi' \mathbf{x}_i + \varepsilon_i; \tag{3}$$

$$z_i = \begin{cases} 1 & \text{if } z_i^* > 0 \\ 0 & \text{otherwise,} \end{cases} \tag{4}$$

where ξ is a vector of parameters and $\mathbf{x}_i$ is a vector of independent variables determining the employment status of individual i (time period subscripts are dropped for simplicity). This can be written as a probit model. The probit equation describes employment as a function of individual and regional characteristics. The variables included in this equation are the real price of sugar, the number of children under the age of fifteen in the household, the worker's age and age squared, the worker's education level, race, and gender, a dummy for urban versus rural household location, and interaction terms where the real price of sugar is interacted with education level and the dummy for being located in a major sugar-producing region. The coefficients on sugar prices

24. In the case of consumption, one would need the complement or substitute good to be a nontraded good so that its price is not exogenously determined by world markets.

allow us to capture the impact that changes in sugar prices have on the employment probabilities of different individuals. Changes in sugar prices thus affect both individuals' reservation wage and the demand for jobs by firms. We are not able to disentangle the two in this setup.[25]

The second equation in the labor market model is the wage regression:

$$\ln w_i = \beta_0 + \sum_s \beta_s S_{s,i} + \sum_c \beta_c C_{c,i} + \beta_p \ln p_s^d + \sum_k \beta_k K_{k,i} \ln p_s^d + e_i, \quad (5)$$

where w_i is the hourly real wage of individual i, $S_{s,i}$ are state variables for individual i (such as the share of sugar employment in the state and the evolution of food prices other than sugar), $C_{c,i}$ are individual characteristic variables for individual i (such as gender, age, and education), and p_s^d is the real local price of sugar in state s (prices are normalized by consumer price index in each state). The last term (the sum over k) captures the interaction term between real sugar prices and a subset, K_k, of individual and state characteristic variables.

The wage equation is estimated using the observations for which wage data are available (that is, observations on individuals that were employed at the time of the survey). The explanatory variables are the same variables as in the selection equation (except the number of children and its interaction with gender, which are likely to determine labor market participation but not wages), with the addition of some employment-specific variables such as sector dummies (sugar growing, sugar processing, agriculture other than sugar, industry other than sugar, and services) and dummies for the type of employment (hired worker, self-employed, and employer).[26] Sugar prices are also interacted with these additional variables to capture the heterogeneity of the sugar price impact along these dimensions.[27]

25. Porto (2008) is able to disentangle whether individuals deciding to participate in the labor market are offered a job. This allows him to distinguish between demand- and supply-side variables affecting the equilibrium level of employment and unemployment.

26. The number of children and its interaction with gender are included in the selection equation because the number of children may have different effects on men and women's labor market participation decisions. Women may be more likely to stay at home, whereas men are pushed into the labor market in response to the household's increased need for income. One may worry that our exclusion restrictions are a bit weak and may lead to biased estimates in the wage equation. We therefore also run the wage and employment equation separately, assuming that there is no correlation between the error terms and compare the estimated coefficients with those of the Heckman estimates. These results are available on request. They show that the estimates are not statistically different from the ones reported in table 6, which gives us some confidence in the reported estimates. See Panizza and Zhen-Wei Qiang (2005) for a similar approach.

27. See Porto (2005, 2006, 2008) or Nicita (2009) for a similar approach.

The interaction terms that are used in both the selection and wage equations imply that the elasticities of wage and labor market participation with respect to sugar prices vary from one individual to another, according to his or her level of education, geographic location, and the sector in which he or she works, and the type of employment. This proves to be important in estimating the impact of changes in sugar prices on household income at different points of the income distribution.

The Heckman selection model is estimated using maximum likelihood. The estimates from this model allow us not only to calculate how wages would change following a change in the price of sugar, but also to measure the impact that changes in sugar prices may have on the labor market participation of each individual. We can thus estimate the impact of changes in local sugar prices on both wages and employment.

To correct for possible correlation of the error terms within survey sample strata in each year, we use cluster robust error terms, where the clusters are defined by sample strata or year. All regressions include year and state dummies.

Impact on Household's Labor Income

The third step consists of simulating the impact of a 10 percent increase in world sugar prices on household labor income, using the estimates from the first and second steps.[28] The change in sugar prices will affect labor income through two channels: wages and employment. We first calculate the predicted change in wages using the individual-specific wage elasticity of sugar prices. We then calculate the change in expected income, which includes predicted changes in both wages and employment for each individual.

We define the wage elasticity of individual i as ω_i. Then using equation 5,

$$\omega_i \equiv \frac{\partial \ln w_i}{\partial \ln p_s^d} = \beta_p + \sum_k \beta_k K_{k,i}. \tag{6}$$

28. To determine the full impact on households' real income, we would need information on the share of sugar in the consumption basket of each household, as well as the sensitivity of sugar demand to changes in prices (see Nicita, 2008). This information is not available from labor surveys, so we focus only on the impact on labor income. Our calculations therefore overestimate the impact on real income, since sugar prices are increasing. However, a back-of-the-envelope calculation suggests that overestimation is not a serious problem. The weight that the Brazilian statistical office (IBGE) uses for sugar in its consumer price index is 0.8. So on average, sugar accounts for 0.8 percent of household expenditure. Thus an upper bound for the real income loss associated with a 10 percent increase in sugar prices (that is, abstracting from any substitution possibility and frictions in price transmission) is around 0.08 percent.

These elasticities are computed for different groups of individuals. However, we are actually interested in the wage elasticity with respect to world prices, not domestic prices. The estimates in equation 1 yield $\partial \ln p_s^d / \partial \ln p^w = \gamma_s$. Thus the percentage change in real hourly wages experienced by individual i following a 10 percent increase in the world price of sugar is given by

$$\hat{\omega}_i = 0.10\gamma_s \omega_i. \tag{7}$$

Before turning to the change in expected income following a world sugar price change, we use $\bar{w}_i$ to denote the predicted real hourly wage of person i before the sugar price change. The predicted real hourly wage after the 10 percent sugar price increase is then $\bar{w}_i' = (1 + \hat{\omega}_i)\bar{w}_i$. The change in expected income of individual i is given by the difference between predicted income after the price change net of predicted income before sugar price liberalization. This takes into account the change in wages as well as the change in the probability of being employed. More formally,

$$\Delta y_i = \left[\bar{\pi}_i' \bar{w}_i' \ell_i + \left(1 - \bar{\pi}_i'\right) U_i \right] - \left[\bar{\pi}_i \bar{w}_i \ell_i + \left(1 - \bar{\pi}_i\right) U_i \right], \tag{8}$$

where ℓ_i is the number of hours worked per month by individual i, U_i are unemployment benefits, and $\bar{\pi}_i$ and $\bar{\pi}_i'$ are the predicted probabilities of individual i of being employed before and after the sugar price change, respectively.[29] The predicted probabilities were obtained using the estimates from the Heckman model. Equation 8 assumes that anyone entering the labor force works full-time (forty hours per week) and gets the average expected wage across sectors.[30] It also assumes that other types of income, such as interest and dividends, are unaffected by sugar prices, and they therefore do not appear in the equation.

Finally, to disentangle the total income change associated with changes in sugar prices into wage and employment effects, equation 8 can be rewritten as follows:[31]

$$\Delta y_i = \bar{\pi}_i' \left(\bar{w}_i' - \bar{w}_i \right) \ell_i + \left(\bar{\pi}_i' - \bar{\pi}_i \right) \left(\bar{w}_i \ell_i - U_j \right), \tag{9}$$

29. With regard to unemployment benefits, we do not observe U_i for individuals who are currently working, so for them we assume that $U_i = 0$. Only 18 percent of unemployed individuals in the survey report receiving some form of social benefit.

30. Alternatively, one could estimate the impact of changes in sugar prices on hours worked, but Neumark, Cunningham, and Siga (2006) show that the number of hours worked is not very sensitive to wages in Brazil during this period.

31. We are indebted to Cristina Terra for this decomposition.

where the first term captures wage changes and the second term represents changes in the probability of being employed. The first term is labeled the wage effect and the second term the employment effect.

Empirical Results

We start by presenting the results of price transmission estimates. We then turn to the estimates of wage and employment elasticities with respect to sugar prices, and we conclude this section with the simulation results.

Price Transmission Results

We first check which of the Brazilian states in our sample are cointegrated with the world market and estimate the parameters of the long-term relationship between the local and world sugar prices. The stationarity of the price-time series used in the model is tested, and the appropriate ADF statistics are reported in table 4. The ADF test does not reject the null hypothesis that prices follow a unit root process for either the London Daily Price or the Brazilian prices.[32] However, redoing the test in terms of first differences leads to rejection of the unit root hypothesis at the 1 percent level for all price-time series. Price differentials can thus be used in the error correction model.

We then test for a long-term cointegration between local and international prices as described by equation 1. The test statistics, also reported in table 4, imply that for all states except Pernambuco and Pará, we should reject the hypothesis of no cointegration between local and world prices at the 1 percent level of significance. In Pernambuco, we reject the hypothesis at 10 percent. In Pará, the ADF statistic for the residual is very close to the 10 percent critical value, so we estimate an error correction model for Pará along with the other states, although we cannot conclude that the prices in that region are closely integrated with world prices.

The results of error correction estimation for the eleven states are reported in table 5. The long-term cointegration coefficient (γ) was obtained from equation 1.[33] The coefficients of short-term transmission (δ) and adjustment (θ)

32. ADF tests with and without trends give similar results.

33. Results are not sensitive to the use of a four-month lead and lags of changes in world prices as a control variable to correct for the potential correlation between the error term and world prices.

TABLE 4. Prices: Stationarity and Engle-Granger Test of Cointegration[a]

	Stationarity		*Cointegration*	
	Levels	*First differentials*		
Region	*ADF*	*ADF*	*ADF*	R^2
World price	–1.74	–4.56***		
Federal District	–2.17	–5.35***	–3.64***	0.49
Goiás	–1.93	–5.40***	–3.71***	0.53
Ceará	–1.76	–5.53***	–3.93***	0.64
Pernambuco	–2.06	–5.10***	–2.81*	0.43
Bahia	–2.11	–4.95***	–3.50***	0.47
Minas Gerais	–2.27	–5.68***	–3.98***	0.56
Paraná	–2.40	–5.75***	–4.20***	0.56
São Paulo	–2.00	–5.22***	–3.61***	0.56
Rio de Janeiro	–2.15	–5.19***	–3.66***	0.53
Rio Grande do Sul	–2.40	–5.03***	–4.11***	0.52
Pará	–2.06	–4.50***	–2.55	0.47

*The null hypothesis of unit root or no cointegration is rejected at the 10 percent significance level.
**The null hypothesis of unit root or no cointegration is rejected at the 5 percent significance level.
***The null hypothesis of unit root or no cointegration is rejected at the 1 percent significance level.
a. The critical values of ADF are –2.58 at 10 percent, –2.89 at 5 percent, and –3.49 at 1 percent. The lag length is six months, and all prices are in logs. The world price is the contract no. 5 London Daily Price for refined sugar, FOB Europe, spot. Local prices are consumer prices.

were estimated using equation 2. In São Paulo, where most sugar is produced and traded, a 1 percent increase in the world sugar price leads to a 1 percent increase in the local price in the long run (the elasticity is 1.01).[34] Perfect transmission was also found in Goiás and Minas Gerais, which could be explained by the proximity of these states to São Paulo. In other states, transmission ranges from 0.75 in Pernambuco and Bahia to 0.94 in Rio de Janeiro. An immediate adjustment in prices of around 25 percent takes place in the Federal District, Goiás, and Ceará; this is significant at the 10 percent level. In the other states, the adjustment begins after the first period (the first month), as reflected by the parameters in the error correction term.

The estimated coefficients can be used to calculate the adjustment in local prices n periods (months) after a one-time change in the world price. With a 1 percent change in the world market price occurring at time $t = 0$, the initial percentage change in the local price is given by δ. In the following period, the

34. See Mundlak and Larson (1992) for similar estimates of agricultural price transmission across countries and goods.

TABLE 5. From World to Local Prices: Error Correction Model[a]

State	Trend (γ)	Immediate adjustment (δ)	Adjustment to long-run equilibrium (θ)	Speed of adjustment: After three months	Speed of adjustment: After one year
Federal District	0.91***	0.43**	–0.20***	0.66***	0.88***
	(0.070)	(0.167)	(0.025)		
Goiás	1.01***	0.37**	–0.20***	0.69***	0.97***
	(0.072)	(0.162)	(0.022)		
Ceará	0.92***	0.24	–0.19***	0.57***	0.87***
	(0.052)	(0.152)	(0.027)		
Pernambuco	0.75***	0.25	–0.19***	0.48***	0.71***
	(0.065)	(0.156)	(0.019)		
Bahia	0.75***	0.27*	–0.15***	0.46***	0.68***
	(0.061)	(0.146)	(0.018)		
Minas Gerais	1.02***	0.32**	–0.20***	0.66***	0.97***
	(0.068)	(0.153)	(0.017)		
Paraná	0.86***	0.28*	–0.20***	0.56***	0.82***
	(0.058)	(0.144)	(0.018)		
São Paulo	1.00***	0.33**	–0.18***	0.63***	0.94***
	(0.068)	(0.144)	(0.015)		
Rio de Janeiro	0.94***	0.28*	–0.19***	0.59***	0.89***
	(0.067)	(0.154)	(0.017)		
Rio Grande do Sul	0.77***	0.22	–0.22***	0.51***	0.74***
	(0.057)	(0.139)	(0.021)		
Pará	0.87***	0.33**	–0.13***	0.52***	0.78***
	(0.070)	(0.146)	(0.019)		

*The null hypothesis that the coefficient is equal to zero is rejected at the 10 percent significance level.
**The null hypothesis that the coefficient is equal to zero is rejected at the 5 percent significance level.
***The null hypothesis that the coefficient is equal to zero is rejected at the 1 percent significance level.
a. An error-correction model is run for each state to capture differences in price transmission across regions. A SUR technique is used to correct for common shocks across states. The world price is the contract no. 5 London Daily Price for refined sugar, FOB Europe, spot. Local prices are consumer prices. Standard errors are in parentheses.

error correction component θ is added; n periods after the change in the world price has occurred, the domestic prices change by a percentage m_n:

$$m_n = \gamma - (\gamma - \delta)(1 + \theta)^n. \quad (10)$$

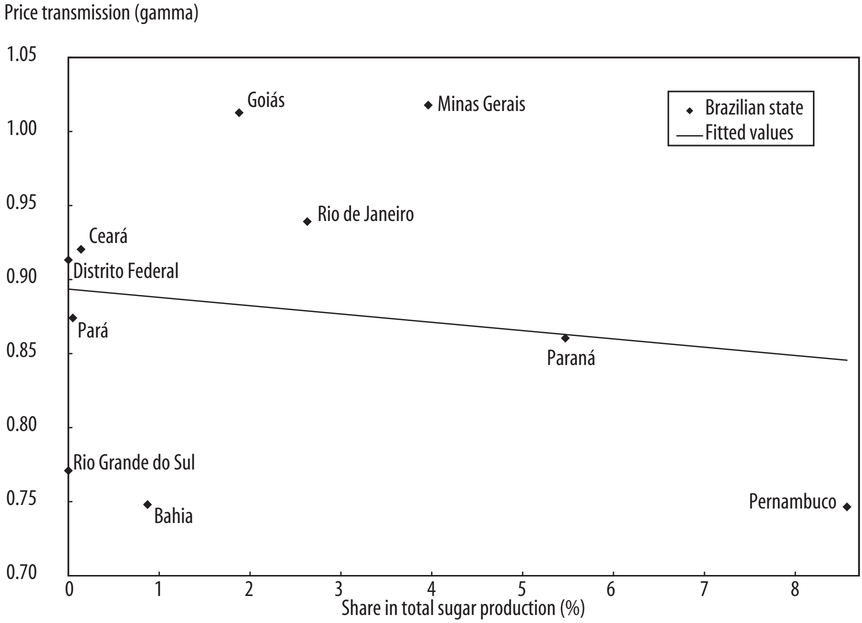
Table 5 shows the adjustment after three months and one year. In most states, a 1 percent increment in the world price would only increase local prices by 0.4–0.6 percent after three months. After a year has passed, however, the prices in most states become close to their new long-term equilibrium: on average, 92 percent of the adjustment occurs within the first year. Given the relatively rapid adjustment, we prefer to use the long-term elasticity of local prices with respect to world prices (γ) to evaluate the impact of the change in the international price of sugar on labor income.

A final concern with our estimate of the long-run price transmission has to do with reverse causality.[35] As argued in the introduction, Brazil is a big player in world markets, so our estimates could be biased as a result of endogeneity of prices in Brazil. To check for this, we perform a number of Granger causality tests on world and domestic prices. The null hypothesis in each case is that there is no Granger causality between the excluded variables and the dependent variable. The results establish Granger causality from world prices to sugar cane producer prices and to consumer prices of crystal sugar, but reject Granger causality from producer and consumer prices in Brazil to world prices. Thus the evidence of causality from world to domestic prices is rather strong.

To further test for the importance of reverse causality, we checked the correlation between world prices and Brazilian exports. If the correlation is positive, then the movement in exported quantities is mainly along Brazil's export supply curve, which is indicative of world prices driving domestic prices and not vice versa. A negative correlation would imply that movements occur along with the rest of the world's import demand, thereby suggesting that Brazil's export quantities drive world prices. The correlation is indeed positive and statistically larger than zero, at around 0.16 during 1961–2006. As a final and indirect check for the absence of reverse causality, we look at the correlation between our long-run price transmission estimates and the share of production in each Brazilian state. If reverse causality were a driving force, we should observe a positive correlation between these two variables. Figure 3 shows a negative correlation between these two variables in a sample that excludes São Paolo, which suggests that reverse causality is probably not an issue in the case of these other Brazilian states. This is not surprising since around 70 percent of Brazilian production takes place in São Paolo, and most other Brazilian states are relatively small players in world markets. In the case of São Paolo, reverse causality concerns may be valid, but the average coefficient of long-run price transmission is estimated at around 0.9 in other Brazilian states, and it is as high as in São Paolo in states such as Goiás and Minas Gerais, which produce ten times less sugar than São Paolo. Thus, even in the case of São Paolo, the endogeneity bias cannot be too large.

35. We are grateful to Andrés Rodríguez-Clare for his suggestions on how to address the issue of reverse causality.

FIGURE 3. Relationship between Sugar Production and Long-Term Price Transmission from World to Domestic Price



Wages and Employment Results

The results of the maximum likelihood estimation of the Heckman model are presented in table 6. The first part contains the coefficients of the wage equation; the second part contains the results of the sample selection equation that determines whether the person was employed. The standard errors are adjusted for clustering, where the clusters are state/years. Real sugar prices appear to have a significant and positive effect on the average conditional probability of being employed, but not a direct significant impact on wages (after we control for changes in other food prices by state). However, the interaction of sugar prices with state, sector, and worker characteristics has a statistically significant impact on both the wage and employment equation, which implies that the wage elasticity of sugar prices varies across various demographic groups, depending on the level of education, among other things.

Regarding worker characteristics, both wages and employment are increasing and concave in age and are positively correlated with education, being a

TABLE 6. Wage and Employment: Heckman Selection Model[a]

	Wage equation		*Employment equation*	
Explanatory variable	*Coefficient*	*Std. error*	*Coefficient*	*Std. error*
Real price of sugar (log)	−0.028	0.036	0.083**	0.023
Interaction with sugar prices[b]				
Years of schooling	0.009**	0.002	−0.019**	0.002
% employment in sugar sector	−4.364**	1.102	4.980**	1.660
Sugar-growing sector	0.326**	0.055		
Sugar-processing sector	0.395*	0.189		
Agriculture other than sugar	0.136**	0.019		
Industry other than sugar	0.120**	0.010		
Employee	−0.038	0.026		
Self-employed	−0.048	0.027		
State characteristics				
% employment in sugar sector	−0.496	0.711	1.140	0.872
Real price of food	0.006**	0.001	0.011**	0.001
Worker characteristics				
Age	0.122**	0.001	0.168**	0.000
Age squared	−0.001**	0.000	−0.002**	0.000
Race (1 = white)	0.098**	0.002	−0.079**	0.003
Gender (1 = male)	0.585**	0.004	0.866**	0.002
Urban/rural (1 = urban)	0.154**	0.005	0.039**	0.007
Years of schooling	0.133**	0.001	0.045**	0.001
No. of children[c]			−0.029**	0.001
No. children x gender			0.040**	0.001
Sector dummies[d]				
Sugar-growing sector	0.162**	0.034		
Sugar-processing sector	0.355**	0.119		
Agriculture other than sugar	−0.169**	0.012		
Industry other than sugar	0.123**	0.007		
Employment category dummies[e]				
Employee	−0.652**	0.017		
Self-employed	−0.621**	0.018		
State and year dummies	Yes		Yes	
Summary statistic				
Constant	−4.074**	0.081	−4.460**	0.058
No. observations	2,106,448			
No. censored observations	1,094,867			
No. uncensored observations	1,011,581			
Wald test of independent equations ($\rho = 0$)	4295.45 (rejected)			

*Statistically significant at the 5 percent level.

**Statistically significant at the 1 percent level.

a. The Heckman selection model is estimated using maximum likelihood. Standard errors are clustered by state x year.

b. Each of the variables is interacted with the log of the real price of sugar.

c. Measured as the number of children in the household who are fourteen years old or younger.

d. Services are omitted.

e. The employer category is ommitted.

male, and living in an urban area. Having young children affects labor market participation negatively in the case of women, but positively in the case of men: the interaction of the number of children and the male gender dummy has a large positive coefficient in the employment equation, suggesting that the presence of young children affects the labor market participation decisions of men and women differently. Whites earn higher wages than nonwhites, but nonwhites participate more actively in the labor force.

When it comes to sectoral differences, wages in sugar-processing sectors are substantially higher than in all other sectors, while wages in agriculture other than sugar growing are the lowest. The impact of a change in sugar prices on wages is stronger in the sugar-growing sector and the sugar-processing industry than in sectors that are not linked to sugar, which signals some sector specificity. Also, changes in sugar prices affect the wages of well-educated people more than those with less education.[36] However, there are greater employment opportunities associated with sugar price increases among people with fewer years of schooling.[37]

To further explore how sugar prices affect different demographic groups in Brazil, we compute wage elasticities with respect to prices for people with different characteristics. These elasticities and their standard errors are reported in table 7. Workers in the sugar-growing and sugar-processing sectors clearly gain the most from sugar price increases: their wage would increase by approximately 0.1–0.4 percent (depending on their level of education) if sugar prices rose by 1 percent.[38] Other sectors, apart from services, benefit as well, and well-educated workers seem always to have a larger wage elasticity. Workers in the service sector, on the other hand, seem to lose from increases in the price of sugar, especially those that have a low level of education and are located in major sugar-producing areas.

36. Because unobserved time-varying shocks could be simultaneously affecting sugar prices and returns to education, we run a similar specification, introducing an interactive term between education and a time trend, but dropping year dummies to avoid multi-collinearity with the time trend. The coefficient on the interaction of education and sugar prices remains positive and significant. The point estimate is a bit lower (0.009), but it is not statistically different from the value reported in table 6.

37. This may also explain why the interaction of sugar prices with percent of employment in sugar growing or processing by state appears to have a negative impact on wages and a positive impact on employment.

38. See Pavcnik and others (2004) for evidence of imperfect intersectoral mobility in Brazil's labor markets.

TABLE 7. Estimated Wage Elasticities with Respect to Local Sugar Prices[a]

	Type of employment and education level of worker					
	Employee		*Self-employed*		*Employer*	
Region and sector	*Low*[b]	*High*[c]	*Low*[b]	*High*[c]	*Low*[b]	*High*[c]
In major sugar region[d]						
Sugar growing	0.15	0.23	0.14	0.22	0.19	0.27
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Sugar processing	0.22	0.30	0.21	0.29	0.26	0.34
	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Agriculture other than sugar	–0.04	0.04	–0.05	0.03	0.00	0.08
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Industry other than sugar	–0.06	0.02	–0.07	0.01	–0.02	0.06
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Services	–0.18	–0.10	–0.19	–0.11	–0.14	–0.06
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Not in major sugar region[e]						
Sugar growing	0.24	0.32	0.23	0.31	0.27	0.36
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Sugar processing	0.30	0.39	0.30	0.38	0.34	0.42
	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
Agriculture other than sugar	0.05	0.13	0.04	0.12	0.08	0.17
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Industry other than sugar	0.03	0.11	0.02	0.10	0.07	0.15
	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Services	–0.09	–0.01	–0.10	–0.02	–0.05	0.03
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)

a. Obtained using the estimates provided in table 6 and taking averages over a group of individuals (using sample weights). Standard errors are in parentheses and were calculated as the square roots of the corresponding variance:

$$\text{var}\left(a_1\beta_1 + \cdots + a_n\beta_n\right) = \sum_{i=1}^{n} a_i^2 \,\text{var}\left(\beta_i\right) + \sum_{i=2}^{n}\sum_{j=1}^{i-1} a_i a_j \,\text{cov}\left(\beta_i \beta_j\right),$$

where $\beta_1 \ldots \beta_n$ are the parameter estimates on the interaction variables in the wage equation of the Heckman model and $a_1 \ldots a_n$ are indicators that signal whether a person belongs to a particular group (all a_i, except years of education, are either zero or one).

b. Individuals with a low level of education are defined as those with less than five years of education. Elasticities are computed at the average level of education within this group, which is 2.3 years.

c. Individuals with a high level of education are defined as those with more than eight years of education. Elasticities are computed at the average level of education within this group, which is 11.8 years.

d. States with an average of 3 percent employment in the sugar sector.

e. States with an average of 1 percent employment in the sugar sector.

Simulating an Increase in Sugar Prices

First, we provide an estimate of how a 10 percent increase in the world sugar price would affect wages.[39] We use the actual survey data to calculate the predicted change in wages for each person employed and aggregate the results for various groups. The results by sector and education level are presented in table 8. Again, workers in sugar growing and sugar processing stand to gain the most. The only workers that are likely to experience losses are service sector employees with low or average education, who would experience declines in wages of 0.80 and 0.28 percent, respectively, after a 10 percent increase in sugar prices. All other types of workers would experience wage increases varying from 0.3 to 3.7 percent, depending on their level of education and the sector in which they work.

Table 9 provides the results by income quintile using the decomposition into wage and employment effects provided by equation 9. The first column of table 9 provides an estimate of the percentage change in income associated with changes in wages, while the second column shows the employment effect. The wage effect is uniformly increasing in income. The poorest households gain 0.23 percent of their income when the world sugar price increases by 10 percent, while the richest gain 0.52 percent. On the other hand, the employment effect is larger at the bottom of the income distribution and is actually negative for the top three quintiles. As expected, the contribution of the wage effect to changes in total labor income is larger at the top of the income distribution: it is 153 percent of the total change in income in the top income quintile, but only 61 percent of the total change in income in the bottom income quintile. In other words, the poor gain mostly through expansions of employment opportunities, and the rich gain mainly through wage increases. This result is not surprising, since unemployment is mostly a phenomenon among poor households—and at the bottom of the income distribution, if an unemployed household member gets a paid job, it could translate into a substantial increase in household income.

The effects of the different channels described above are such that the total gain is almost perfectly homogeneous across quintiles, with an average

39. All changes in income provided in this section are based on a somewhat arbitrary 10 percent increase in the international sugar price. Dividing the percentage income changes reported here by ten would produce easily interpretable income elasticities with respect to the world sugar price. In other words, the percentage change in income is linear in the percentage change in world prices, so the percentage change in income after an x percent change in world prices can be obtained simply by multiplying the percentage change in income reported here by $x/10$.

TABLE 8. Changes in Wages after an Increase in the World Sugar Price, by Sector and Education Level[a]
Percent

	Education level		
Sector	*Low*	*Average*	*High*
Sugar growing	1.71	2.39	2.99
Sugar processing	2.44	2.99	3.74
Other agriculture	0.35	0.90	1.54
Other industry	0.29	0.77	1.34
Services	–0.80	–0.28	0.35

a. Changes are obtained using the estimates provided in tables 5 and 6 and taking averages over a group of individuals, adjusted with sample weights. The exercise is based on a 10 percent increase in the world sugar price. Workers' education level is defined as follows: low education, less than five years; average education, five or more years but less than nine years; high education, nine or more years.

increase in total labor income of approximately 0.33 percent. The only exception is the bottom quintile, which experiences a 0.38 percent gain, mainly driven by the employment effect. The total effect on incomes in Brazil is equivalent to US$2 billion (at 2002 prices).

What are the effects of a potential sugar price increase on poverty rates in Brazil? To answer this question, we adopt a nominal one dollar per day per capita poverty line (close to a two-dollar poverty line in purchasing power parity terms) and calculate the predicted number of poor in each state before and after a 10 percent increase in the world price of sugar. This is done as follows. We first calculate the share of the population below the poverty line in

TABLE 9. Changes in Household Income after an Increase in the World Sugar Price, by Income Quintile[a]
Percent

Income quintile	*Wage effect*[b]	*Employment effect*[c]	*Total effect*[d]
Bottom quintile	0.23	0.15	0.38
Second quintile	0.29	0.04	0.32
Third quintile	0.38	–0.05	0.32
Fourth quintile	0.46	–0.13	0.33
Top quintile	0.52	–0.18	0.34
Total	0.46	–0.13	0.33

a. Changes are obtained using the estimates provided in tables 5 and 6 and taking averages over a group of individuals, adjusted with sample weights. The exercise is based on a 10 percent increase in the world sugar price.
b. The wage effect is given by the first term in equation 9.
c. The employment effect is given by the second term in equation 9.
d. The total effect is the sum of the wage and employment effects (that is, the sum of the first and second columns); differences in totals are due to rounding approximations.

each state using its observed income: 23.4 percent of the population lived below the poverty line in 2002. We then calculate the predicted income for each individual before and after the price change as described earlier and calculate the corresponding predicted poverty rates before and after the change. Finally, we recalculate the number of individuals below the poverty line using the predicted change in the poverty rates. On aggregate, the impact of a 10 percent increase in world prices is small: the poverty rate declines from 23.2 to 23.0 percent. This, however, implies that around 280,000 individuals raised their income above the poverty line. The largest changes in the number of poor are observed in São Paolo and Paraná, which experience declines of almost 2 percent.

Concluding Remarks

It has sometimes been argued that liberalizing sugar policies in OECD countries will mainly benefit rich owners of sugar mills in Brazil—the largest sugar exporter in the world. This paper focuses on the impact that liberalizing sugar policies in the OECD, and the consequent increase in world prices, would have on Brazilian workers through general equilibrium changes in wages and employment. By focusing on labor income gains, we assess the extent to which the liberalization of sugar policies in the OECD is likely to affect the poorest segments of the population in Brazil.

To assess the implications of a 10 percent increase in world sugar prices (which is a conservative estimate of the effect that the elimination of OECD sugar policies would have on world prices), we first estimated the extent of sugar price transmission from world markets to eleven different Brazilian states. We found that domestic markets are closely connected with international markets: in the long run, almost 90 percent of world price changes are transmitted to Brazilian domestic prices. The price transmission also occurs relatively fast, as on average 92 percent of the adjustment occurs within the first year.

We then estimate the impact of changes in domestic sugar prices on wages and the probability of being employed. We allow these elasticities to vary according to individual and regional characteristics. Workers in the sugar sector experience larger increases in wages than workers in other sectors, signaling some sector specificity.

We also found that changes in wages lead to large income gains for highly educated workers, but individuals with low levels of education tend to benefit relatively more from increases in employment. A potential explanation for this is that the labor supply of unskilled workers is relatively more inelastic because of the presence of a large pool of unemployed low-educated workers, which puts downward pressure on the wages of these workers. Thus, in spite of a relatively larger demand increase for low-educated workers, unskilled wages are relatively unaffected. Once we aggregate the wage and employment effects, however, the income gains are quite homogeneous across income quintiles. This important result highlights the need for correctly modeling labor supply and unemployment in trying to assess the impact of trade liberalization on income inequality.

Our estimates suggest that the average elasticity of labor income with respect to sugar prices is 0.03, which indicates that a 10 percent increase in sugar prices will lead to an average increase in the income of Brazilian workers of about 0.3 percent, or US$2 billion. This alone would bring 280,000 Brazilians out of poverty.

More generally, our methodology could also be used to measure the impact of broader reforms, such as the ones currently being considered in the World Trade Organization's Doha Round. A detailed analysis is clearly beyond the scope of this paper, but an extrapolation of our results suggests that if the Doha Round were to include some significant liberalization of other agricultural sectors in which Brazil also has a comparative advantage (such as dairy, meat, cereals, or soybean), this may lead to some large income gains in Brazil. More importantly, these large income gains are likely to be experienced by those that need them most.

Data Appendix

The main source of data for this study is Brazil's National Household Survey (*Pesquisa Nacional por Amostra de Domicílios,* PNAD), which is managed by the Brazilian Geographical and Statistical Institute (IBGE). Surveys have been conducted every year since 1976 with a few exceptions (namely, 1980, 1991, 1994, and 2000). The PNAD contains extensive information on the wages and other sources of income of each person in the selected household. The sector categories used in replies are highly disaggregated, which allows us to single out workers in the sugar-growing sector and the sugar-processing industry. The samples are redrawn every year for each survey, resulting in repeated cross-sectional data. For this exercise we use the surveys from 1990 to 2002.

Wages used in the regressions are real hourly wages, and prices are real sugar prices by state. Consumer price indexes and food prices that were used to convert the variables into real terms were taken from the Broad Consumer Price Index (IPCA) collected by the IBGE. The data are available for eleven major cities: Goiânia, Belém, Fortaleza, Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba, Porto Alegre, and Brasília. The city-level data were used to calculate real wages, real income, and real sugar prices for ten states: Goiás, Pará, Ceará, Pernambuco, Bahia, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Rio Grande do Sul, and the Federal District. The world prices used in the cointegration analysis are the monthly London Daily Price for refined sugar, contract no. 5 FOB Europe, which probably corresponds best to consumer prices. We use refined rather than raw sugar because the available Brazilian sugar prices, which vary by state and time, are consumer prices, not producer prices. While the use of consumer prices may seem a bit strange given that we are focusing on the impact of sugar prices on wages (not on consumption), consumer prices are not a bad proxy for producer prices. As shown in figure 2, there is a strong correlation between world prices for raw and refined sugar in the London and New York stock markets, as well as between consumer and producer prices of sugar in Brazil (at the aggregate level). The evolution of producer and consumer prices in Brazil, and of raw and refined sugar prices in world markets, has been quite similar throughout the 1990 to 2002 period. This suggests that consumer prices can be considered an adequate proxy for producer prices.

We constructed state-level consumer prices for the period 1990 to 2002 using two sets of data: monthly changes in sugar prices reported in IPCA and the 1996 average sugar prices from household budget surveys (*Pesquisa de Orcamentos Familiares*), also reported by the IBGE. Since sugar prices could only be constructed for these eleven states, PNAD observations from other states were dropped, reducing the number of observations by approximately 25 percent.

The two types of sugar most commonly consumed in Brazil are refined sugar and crystal (mill white sugar). Crystal is usually cheaper and inferior in quality to refined sugar. For five states, only the prices of crystal sugar are available from the budget surveys (the Federal District, Goiás, Pernambuco, Bahia, and Minas Gerais), so we converted crystal prices into refined prices using the average ratio of refined to crystal prices in Brazil. The ratio varies over years.