Returns from Mexican Sugar Processing: Measuring the Contribution of Capacity Usage, Technological Adaption, and Output Prices

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Abstract: Mexico is soon expected to be a larger supplier of sugar to the U.S. market. The magnitude of Mexican sugar sourcing depends on the profitability of the Mexican sugar milling sector. This article analyzes trends in gross returns from sugar sales and production costs for the Mexican milling sector, and analyzes the contribution of important determinants to earnings per hectare. Technological adaptions have been fundamental in making the Mexican processing sugar sector profitable since the early 1990's. Although high domestic prices that are in part traceable to supporting Mexican Government policies have played their role, the industry has done much to advance its production potential. The data show that processing mills are diverse but almost all show consistently positive rates of return. While some mills are more vulnerable than others with respect to price and supply shocks, most have potential for continuing gains in production. Analysis shows that mills that produce more relative to their rated capacities and have longer campaign lengths receive higher per-unit returns. Results also indicate that mills with lower earnings have relatively more to lose by not maintaining the pace of adapting technological improvements. An associated implication is that the marginal return to technological adaptation is higher for lower-earning mills.

Keywords: Costs of production, Mexico, sugar, sugarcane.

Returns from Mexican Sugar Processing

The U.S. sugar sector is increasingly dependent on developments within the Mexican sugar industry. With the North American Free Trade Agreement (NAFTA) in place, Mexico is soon expected to be a larger supplier of sugar to the U.S. market. Under the terms of the side-letter agreement to the NAFTA, Mexico's duty-free access to the U.S. sugar market will increase up to a maximum of 250,000 metric tons, raw value (MTRV) as of October 1, 2000. By fiscal year (FY) 2008, there will be no quantitative limit on Mexican duty-free imports. The NAFTA high-tier tariff schedule, currently at 12.09 cents a pound for raw sugar and 12.81 cents a pound for refined sugar, decreases at a rate of 1.51 and 1.60 cents a pound for raw and refined sugar for each fiscal year through 2007. The U.S. Department of Agriculture's (USDA) sugar baseline shows high-tier sugar imports from Mexico at 121,000 short tons, raw value (STRV) in FY 2003 and above 600,000 STRV for FY 2004 through 2007 (USDA, 2000). By FY 2004, 8.1 percent of U.S. sugar consumption is projected as coming from Mexico. This rises to above 9 percent in FY 2005 and grows steadily thereafter.[2] Downward price adjustments emanating from the expansion of U.S. sugar supply from duty-free Mexican imports cannot be directly offset by the USDA.

Under the terms of the Uruguay Round Agreement (URA), the United States agreed to bind sugar imports under the sugar tariff-rate quota (TRQ) at a minimum access level of 1.256 million STRV. With record increases in U.S. sugar production, the USDA does not project sugar TRQ imports above minimum access levels through 2010. Also, the declining NAFTA high-tier tariff implies an eventual upward limit on U.S. sugar prices. The incentive for Mexico to change its level of high-tier sugar exports is signaled by a pricing threshold. This threshold is the sum of the world price for sugar, marketing costs, applicable premiums and discounts, and the NAFTA high-tier tariff. As the tariff is reduced each year, the threshold is reduced and the likelihood of increased imports is enhanced. As long as Mexico has enough sugar to ship at the threshold level, this level

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[2] For a full exposition, see special article entitled "Conceptual Overview of the U.S. Sugar Baseline: Incorporating the Effects of the North American Free Trade Agreement," in the *Sugar and Sweetener Situation and Outlook.* SSS-227, January 2000, pp. 11-19.

sets the price of sugar in the U.S. market. Without specific policy interventions, a U.S. price higher than the threshold would result only if Mexican export potential were limited. In this case, pricing would be higher than the implied threshold level but less than the level implied if there were no high-tier tariff imports from Mexico.

Mexican export potential is influenced by a variety of factors. On the demand side, the chief influence is how much high fructose corn syrup (HFCS) will substitute for sugar in beverage and food processing industries. According to the original NAFTA, the tariff on imports of U.S.-sourced HFCS was to reach zero in 2004. Although the Mexican Government currently levies an anti-dumping duty on HFCS imports from the United States, the incentive to eventually switch from sugar to HFCS is huge and could therefore make available for export over an additional million tons of sugar beyond that already projected. On the supply side, an important question is how much Mexican sugar production can be expected to expand in the future. Garcia and others are pessimistic regarding Mexican production potential (Garcia and others, 1999). They cite the preponderance of unsustainable high-cost sugar mills and the heavy indebtedness (about $2.5 billion) of the largest of the sugar groups that own many of the mills. Although the USDA does not do an official baseline for Mexican sugar, it implicitly assumes that production will continue to expand through 2010 and that Mexico will have over 1.0 million STRV to export.

The purpose of this article is to examine more closely factors underlying Mexico's capacity to produce sugar. In particular, it analyzes trends in gross returns from sugar sales and production costs for the Mexican milling sector. These data are made available by the *Fideicomiso Para El Mercado Azucar* (FORMA). Besides sales and cost data, FORMA makes available data on area harvested in hectares (ha), sugar and sugarcane production, sucrose recovery rates, campaign length, petroleum use in milling, and milling capacity levels. These data are reported on factory, State, and national levels for the 1988-98 marketing years. They provide a rich data set that is amenable to analysis. In order to account for inflationary trends in the data reported in pesos, these data have been converted into U.S. dollars at the prevailing exchange rates.

The hypothesis of this paper is that technological adaptions have been fundamental in making the Mexican processing sugar sector profitable since the early 1990's. Although high domestic prices that are in part traceable to supporting Mexican Government policies have played their role, the industry has done much to advance its production potential. The data show that processing mills are diverse, but almost all show consistently positive rates of return. While some mills are more vulnerable than others with respect to price and supply shocks, most have potential for continuing gains in production.

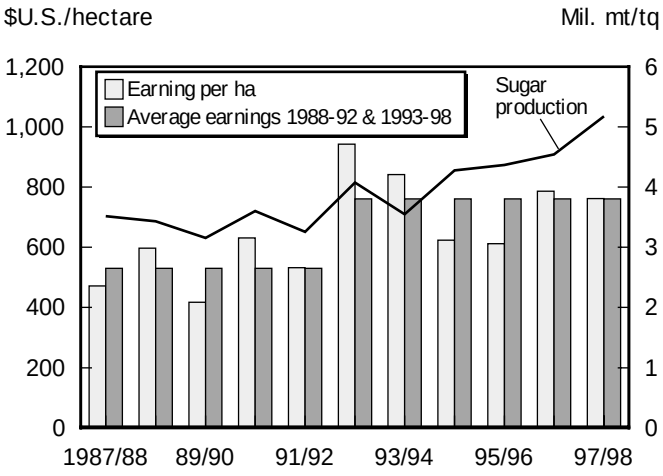
The analysis is carried out in three ways. The first way examines earnings, gross returns, and costs across firms for the period 1993-98. The goal is to determine which variables within the available data set help explain earning differences between factories. Although this analysis reveals certain illuminating relationships based on capacity usage measures, its basic conclusion is that differing endowment factors differentiate firms according to earnings potentials. This conclusion suggests a second way of analyzing the data based on the examination of subsets of the data across time. This analysis emphasizes the effects of exogenous price movements and adaption of technology to improve earnings for groupings of mills along endowment, ownership, and location characteristics. The third analytical method modifies the second by using its results to project earnings out to 2011. This sensitivity analysis draws out the implications of estimation results for future developments within the Mexican sugar sector, about which there is much interest and speculation.

Cross-Factory Analysis

Figure A-1 shows net earnings per hectare (revenues less costs divided by total hectares harvested) and sugar production at the national level for the period 1988 through 1998. The data reveal contrasts in the two periods. The first covers the years 1988-92 where the average earnings per hectare amounted to $529.85. The average for 1993-98 is almost 44 percent higher at $761.16. The first period corresponds to that period when the mills were undergoing privatization after having been run by the Mexican Government. Most of the mills had been suffering from a lack of investment. Many of the mills had been sold at inflated values that would later contribute to the debt repayment problems experienced by some sugar companies. In this pre-NAFTA

Figure A-1

Sugar in Mexico: Earnings per hectare and production



Source: FORMA.

period, many analysts doubted the potential of the industry to produce at levels high enough to justify exports. Sugar production, along with earnings, grew in the second period. It increased an average of 940,000 metric tons, tel quel (MTTQ) over the first period average, up to 4.332 million MTTQ. Sugar production in 1998 grew to a record 5.174 million MTTQ.

Table A-1 presents some of the earnings data for the individual sugar mills for 1993-98. There are 64 mills but only 61 have been operating since 1992. The mills are organized into six categories based on the average earnings per hectare. Group no. 1 is comprised of the 11 mills (not counting the inoperative mills) with the lowest earnings. Groups numbered 2 through 6 represent grouped mills of 10 each and are ordered on the basis of ascending earnings per acre. Columns 2 and 3 show the companies that own each of the mills and the Mexican State where each mill is located. Data include gross returns per ton, costs per ton, daily cane milling capacity, average sugarcane harvested, and average campaign length.

Analysis of Data Through Scattergrams

Relationships between the data are not immediately apparent. Figures A-2 and A-3 show scattergrams between average earnings per hectare and milling capacities and sugarcane milled. The regression lines shown in the figures represent the relationship between the variables: a positive or negative slope would indicate that as one variable changes, so does the other, either in the same (positive slope) or opposite (negative slope) direction. The flatness of the lines in both figures indicate no relationship between earnings per hectare and capacity or volume of sugarcane milled for the mills. If there were economies of scale in sugar milling, positive relationships would have been expected.

Further pursuit yields more insight. Figure A-4 shows a scattergram between earnings per hectare and capacity usage (that is, the ratio of average daily sugarcane milled to rated daily capacity). The regression line slopes upward. The coefficient on the slope parameter indicates that as capacity usage increases by 1 percent, average earnings per hectare increases by $10.27. This result, while statistically significant, explains less than 9 percent (R2 = 0.0881) of the variance in earnings per hectare. Another constructed variable from the data set that measures capacity usage is total sugarcane milled relative to daily capacity. This measure essentially takes the previously defined capacity usage measure and multiplies it by the campaign length. Figure A-5 shows the scattergram and regression line. The line slopes upward and an increased amount of earnings variance is explained, about 15 percent, or 6 percent more than the daily capacity usage measure.

Regression Analysis

These scattergram results suggest that more sophisticated regression analysis involving gross unit returns and unit costs would likely benefit from the inclusion of capacity usage measures as explanatory variables. Also, the low level of the R2 measures from the scattergram analysis suggest that other factors may help explain earnings differences between mills. One possibility is that firm ownership or geographical location may influence earnings differences between mills. A regression model encompassing these factors is specified as follows:

$$Z = A + \sum B_i * FIRM_i + \sum B_j * STATE_j + \sum D_k * X_k$$

The variable Z represents either gross returns per ton or costs per ton on a factory-level basis. The general explanatory variables X are capacity usage variables. In one case, average daily capacity usage and number of campaign days can be used in a single regression. In an alternative case, the two measures are combined in the single measure of total sugarcane milled relative to a mill's daily grinding capacity. The variables $FIRM_i$ and $STATE_j$ are indicator variables whose respective values are equal to 1 if a factory is owned by the i^{th} firm or located in the j^{th} State; the value is zero, otherwise.

In results discussed below, firm-specific and State-specific effects are not both included in a single equation. This means that if firm-specific (location-specific) effects are analyzed in an equation, the B_j (B_i) coefficients corresponding to the location-specific (firm-specific) are restricted to zero. In other words, multiple regressions are run including only one set of specific factors at a time, and then the specifications are compared for their relative advantage in making out-of-sample predictions.[3] This approach potentially allows a determination of which specific factors are better in explaining earnings differences among mills.

Table A-2 shows the estimation results for eight cases. Cases numbered 1-4 examine gross returns per ton, and cases 5-8 examine costs per ton. Cases 1, 2, 5, and 6 include firm-specific factors, while cases 3, 4, 7, and 8 consider State-specific factors. Cases 1, 3, 5, and 7 include two measures of capacity usage (daily capacity usage and campaign length), while cases 2, 4, 6, and 8 consider the composite measure (total sugarcane milled relative to daily capacity). Originally, all firm- or State-specific variables were included in their respective equations. Most of the estimated coefficients did not test differently from zero—only those whose t-statistics indicate statistical significance are presented in the table.

[3] The Schwarz Information Criterion (SIC) is used. It is a measure of the 1-step ahead out-of-sample prediction error variance. A smaller value associated with an equation indicates that the equation has better forecasting ability relative to those equations with higher values.

Figure A-2

Relationship between earnings per hectare and milling capacity, by factory

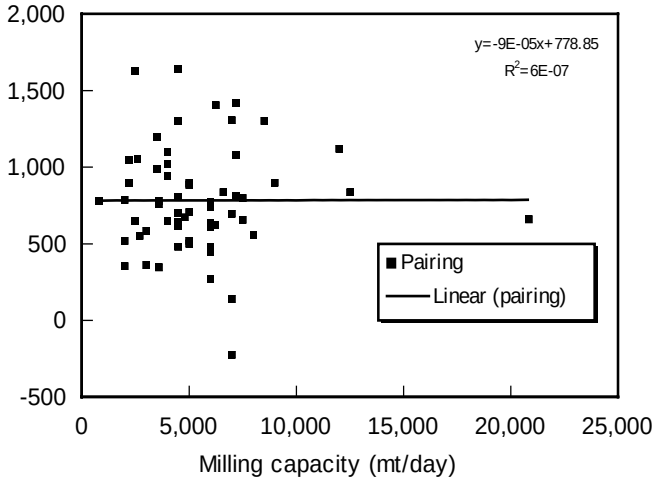


Figure A-3

Relationship between earnings per hectare and sugarcane milled, by factory

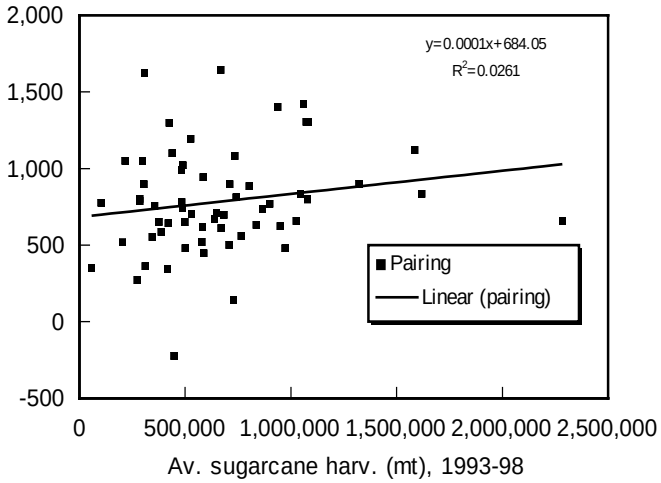


Figure A-4

Relationship between earnings per hectare and ratio of average daily sugarcane milled to capacity, by factory

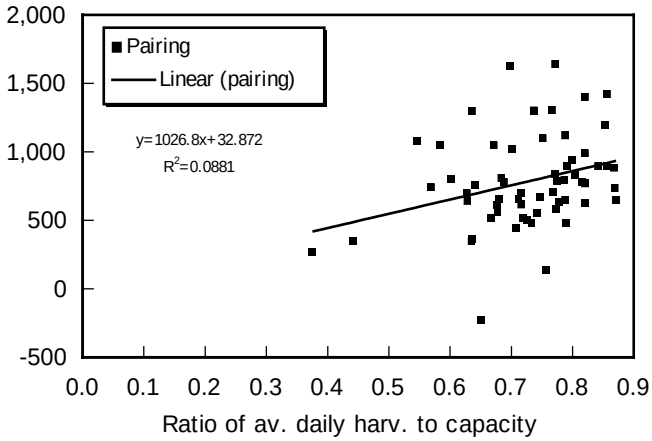
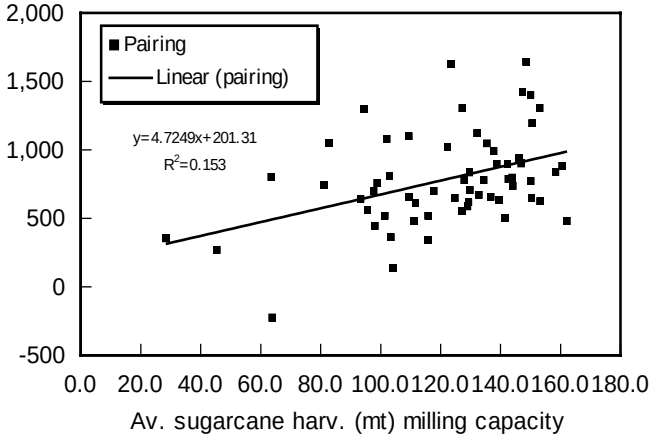


Figure A-5

Relationship between earnings per hectare and sugarcane milled relative to milling capacity, by factory



For the analysis of gross returns per ton, results indicate that all the capacity usage measures make a positive and significant contribution to accounting for differences among mills. Judging from the lower Schwarz criterion values (cases 2 and 4 relative to 1 and 3, respectively), the single measure of total sugarcane milled relative to capacity is more successful in explaining differences. This result is not unexpected considering that daily capacity usage and campaign length have a positive correlation coefficient of over 0.55. Each affect is likely partially picking up the effect of the other.

Consideration of firm-specific effects (cases 1 and 2) indicate that mills owned by the Grupo Porres and the Consorcio Industrial Escorpion (CAZE) have higher returns than accounted for by capacity usage alone. Likewise, consideration of State-specific effects (cases 3 and 4) indicate that mills in the State of San Luis Potosi have higher returns and that mills in the State of Sinoloa have lower returns than accounted for by capacity usage alone. Lower Schwarz criterion values associated with cases 3 and 4 imply that State-level characteristics have more predictive power in forecasting than firm-specific effects.

Cases 5-8 examine costs per ton for the mills. The capacity effects are much less certain compared with their effects on gross returns per ton. In cases 5 and 6 (the firm-specific cases), the coefficients on campaign length and total sugar-

Table A-1--Sugar mills in Mexico--earnings, costs, milling capacities, sugarcane production, and campaign lengths

Mill Name	Owner	Estado	Average earnings per hectare, 1993-98	Gross return, per ton, 1993-98	Costs per ton, 1993-98	Cane milling capacity 1998	Average cane harvested, 1993-98	Average length of campaign 1993-98
				--$ U.S.--		Tons per 24 hours	Metric tons	Days
Group # 1								
La Purisima	(Closed)	Jalisco	na	na	na	na	0	0
Puruaran	(Closed)	Michoacan	na	na	na	na	0	0
L. Portillo Juchitan	(Closed)	Oaxaca	na	na	na	na	0	0
San Rafael de Pucte (Alvaro Obregon)*	Beta San Miguel Group	Quintana Roo	495	23.36	14.53	6,000	930,328	206
Santo Domingo	Concorcio Machado	Oaxaca	354	19.12	12.50	2,000	56,736	64
Los Mochis*	Consorcio AGA	Sinaloa	141	21.58	20.24	7,000	727,968	137
El Dorado	Grupo Azucarero Mexico	Sinaloa	346	22.46	18.62	3,600	417,057	182
A. Saenz (Xicotencatl)*	Grupo Saenz	Tamaulipas	480	24.41	16.83	6,000	972,679	205
El Mante*	Grupo Saenz	Tamaulipas	502	26.05	16.89	5,000	707,176	195
Independencia	Grupo Seoane	Veracruz	272	17.73	13.33	6,000	272,495	121
La Primavera	Grupo Zucarmex	Sinaloa	-224	20.05	23.70	7,000	447,058	98
CIA Industrial Azucarera (Cuatotolapam)*	Impulsora de Marcas Mexicanas	Veracruz	479	23.18	13.80	4,500	500,199	152
La Joya	Independente	Campeche	362	24.46	16.25	3,000	310,148	163
Belisario Dominguez (Huixtla)	Porres Group	Chiapas	446	21.42	15.22	6,000	588,278	139
Group # 2								
San Pedro	Administracion Multiple	Veracruz	560	23.07	15.11	8,000	765,094	141
Constancia	Beta San Miguel Group	Veracruz	616	24.24	14.54	4,500	581,703	181
Zapoapita	Concorcio Machado	Veracruz	612	25.90	17.06	6,000	669,847	165
Santa Rosalia	Fideliq	Tabasco	642	23.81	11.95	4,500	419,883	149
Pedernales	Grupo Santos	Michoacan	554	25.49	18.98	2,700	343,304	171
El Higo	Grupo Zucarmex	Veracruz	520	25.00	15.99	5,000	578,745	161
Plan de Ayala*	Impulsora de Marcas Mexicanas	San Luis Potosi	633	26.76	14.94	6,000	835,935	179
San Gabriel	Impulsora de Marcas Mexicanas	Veracruz	588	23.61	14.69	3,000	386,840	167
Tenosique (H. Galeana)	Independente	Tabasco	520	23.35	14.29	2,000	202,749	152
Adolfo Lopez Mateos	Promotora Industrial Azucarera	Oaxaca	624	21.98	13.90	6,200	949,489	187
Group # 3								
San Francisco Naranjal	Administracion Multiple	Veracruz	741	23.63	13.51	6,000	485,806	142
Queseria	Beta San Miguel Group	Chiapas	674	23.24	15.00	4,800	637,269	178
Central Motzorongo	Concorcio Machado	Veracruz	658	25.68	15.14	7,500	1,025,243	192
Central Progresso	Concorcio Machado	Veracruz	702	25.70	13.36	4,500	529,767	164
Plan de San Luis*	Consorcio Industrial Escorpion (CAZE)	San Luis Potosi	697	28.16	15.89	7,000	683,562	156
San Cristobal*	Consorcio Industrial Escorpion (CAZE)	Veracruz	659	24.64	14.40	20,844	2,283,645	161
La Providencia*	Consorcio Industrial Escorpion (CAZE)	Veracruz	706	26.11	15.30	5,000	648,765	169
Bellavista	Grupo Santos	Jalisco	650	26.33	17.64	4,000	498,968	158
Alianza Popular	Grupo Santos	San Luis Potosi	737	27.11	14.57	6,000	864,424	166
San Nicolas	Independente	Veracruz	652	24.13	14.44	2,500	375,604	173

See notes at end of table.

Table A-1--Sugar mills in Mexico--earnings, costs, milling capacities, sugarcane production, and campaign lengths--continued

Mill Name	Owner	Estado	Average earnings per hectare, 1993-98	Gross return, per ton, 1993-98	Costs per ton, 1993-98	Cane milling capacity 1998	Average cane harvested, 1993-98	Average length of campaign 1993-98
				--$ U.S.--		Tons per 24 hours	Metric tons	Days
Group # 4								
San Miguel del Naranjo (Ponciano Arriago)	Beta San Miguel Group	San Luis Potosi	771	27.06	13.05	6,000	900,458	183
Jose M. Moreles	Concorcio Machado	Jalisco	779	24.60	14.36	3,600	483,695	165
El Rufugio	Concorcio Machado	Oaxaca	757	24.21	13.42	3,600	355,637	154
Puga	Consorcio AGA	Nayarit	798	26.32	15.76	7,500	1,078,727	183
Jose M. Martinez (Tala)	Grupo Azucarero Mexico	Jalisco	835	26.10	15.46	12,500	1,619,337	161
Lazaro Cardenas	Grupo Azucarero Mexico	Michoacan	788	26.83	17.09	2,000	285,062	184
Rosales*	Grupo Azucarero Mexico	Sinaloa	803	19.99	26.26	4,500	285,823	106
Benito Juarez*	Grupo Azucarero Mexico	Tabasco	811	24.61	12.16	7,200	740,886	151
Tamazula*	Grupo Saenz	Jalisco	836	28.37	20.36	6,600	1,044,616	205
Dos Patrias	Independente	Tabasco	778	22.53	12.46	800	102,278	186
Group # 5								
San Francisco Ameca	Beta San Miguel Group	Jalisco	896	27.20	15.54	5,000	711,117	169
Don Pablo Machada Llosas (La Margarita)	Concorcio Machado	Oaxaca	885	26.00	12.93	5,000	802,341	185
La Gloria	Grupo Seoane	Veracruz	1,082	27.89	16.68	7,200	734,621	187
Mahuixtlan	Grupo Zucarmex	Veracruz	896	24.37	14.60	2,200	305,131	162
El Molina	Independente	Nayarit	943	25.37	13.45	4,000	584,996	183
Calipam	Independente	Puebla	1,051	25.00	14.06	2,600	215,467	142
San Jose De Abajo	Independente	Veracruz	990	27.63	13.96	3,500	481,729	168
El Carmen*	Independente	Veracruz	1,020	24.34	13.50	4,000	489,097	174
La Concepcion	Independente	Veracruz	1,048	25.41	14.50	2,200	297,832	202
Tres Valles*	Promotora Industrial Azucarera	Veracruz	901	28.00	15.60	9,000	1,321,430	186
Group # 6								
E. Zapata (Zacatepec)*	Consorcio Industrial Escorpion (CAZE)	Morelos	1,403	26.68	14.18	6,250	937,244	183
Casasano La Abeja*	Consorcio Industrial Escorpion (CAZE)	Morelos	1,624	25.20	11.55	2,500	308,571	177
Atencingo*	Consorcio Industrial Escorpion (CAZE)	Puebla	1,303	26.68	15.18	8,500	1,081,425	173
El Potrero*	Consorcio Industrial Escorpion (CAZE)	Veracruz	1,121	27.90	13.41	12,000	1,584,929	168
San Miguelito	Consorcio Industrial Escorpion (CAZE)	Veracruz	1,195	27.13	13.47	3,500	526,569	177
El Modelo	Consorcio Industrial Escorpion (CAZE)	Veracruz	1,423	27.21	14.35	7,200	1,060,369	172
Pujiltic	Grupo Zucarmex	Chiapas	1,306	27.30	12.21	7,000	1,071,109	200
Melchor Ocampo	Grupo Zucarmex	Jalisco	1,644	27.71	12.38	4,500	667,801	192
Santa Clara	Porres Group	Michoacan	1,099	28.13	16.33	4,000	437,722	146
San Sebastian	Porres Group	Michoacan	1,300	28.90	16.42	4,500	424,362	148

*=Joint sugarcane mill and refinery.

Source: FORMA

Table A-2--Across-firm regression results: Gross returns and costs per ton

	Model: Variable Z = A +$\sum B_i$*FIRM$_i$ + $\sum C_j$*STATE$_j$ + D*(Variable X)															
	Case 1		*Case 2*		*Case 3*		*Case 4*		*Case 5*		*Case 6*		*Case 7*		*Case 8*	
Independent Variables / statistics	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic	Coeff.	T-statistic
	---------- Gross return per ton ----------								---------- Costs per ton ----------							
Constant (A)	13.171	7.203	18.279	17.399	14.993	8.396	19.587	18.743	19.170	8.213	17.624	13.390	14.427	7.914	14.462	13.997
Firm-specific effects (Bi)	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--
Consorcio AGA	--	--	--	--	--	--	--	--	3.240	1.993	3.576	2.225	--	--	--	--
Grupo Saenz	--	--	--	--	--	--	--	--	4.683	3.346	4.378	3.193	--	--	--	--
Grupo Santos	--	--	--	--	--	--	--	--	2.437	1.794	2.848	2.140	--	--	--	--
Grupo Azucarero Mexico	--	--	--	--	--	--	--	--	3.143	2.990	3.157	3.003	--	--	--	--
Porres Group	2.634	2.456	2.614	2.410	--	--	--	--	--	--	--	--	--	--	--	--
Consorcio Industrial Escorpion (CAZE)	1.605	2.484	1.576	2.405	--	--	--	--	--	--	--	--	--	--	--	--
State-specific effects (Cj)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sinaloa	--	--	--	--	-2.299	2.480	-2.327	2.504	--	--	--	--	7.949	8.555	7.911	8.757
Tamaulipas	--	--	--	--	--	--	--	--	--	--	--	--	2.659	2.147	2.691	2.223
San Luis Potosi	--	--	--	--	1.954	2.253	1.934	2.200	--	--	--	--	--	--	--	--
Jalisco	--	--	--	--	--	--	--	--	--	--	--	--	1.746	2.352	1.764	2.425
Michoacan	--	--	--	--	2.592	3.003	2.624	2.988	--	--	--	--	2.976	3.435	2.972	3.470
(Average daily sugarcane harv./milling capacity) (D)	5.595	1.984	--	--	6.113	2.313	--	--	1.268	0.345	--	--	-0.139	0.051	--	--
Length of campaign - days (D)	0.045	4.098	--	--	0.033	3.072	--	--	-0.034	2.328	--	--	-0.001	0.055	--	--
(Total sugarcane harv./milling capacity) (D)	--	--	0.052	6.263	--	--	0.043	5.301	--	--	-0.026	2.441	--	--	-0.002	--
Adjusted R2	0.457	--	0.437	--	0.524	--	0.506	--	0.278	--	0.278	--	0.601	--	0.608	--
Standard error of regression	1.766	--	1.798	--	1.654	--	1.686	--	2.226	--	2.226	--	1.656	--	1.640	--
Schwarz criterion	4.227	--	4.214	--	4.145	--	4.134	--	4.788	--	4.739	--	4.196	--	4.128	--

-- = Not applicable.

cane milled relative to capacity are statistically significant and negatively related to unit costs, as would be expected. In cases 7 and 8, these same coefficients cannot be distinguished from zero. The State-specific effects are sufficient to produce a relatively high adjusted R2s above 0.60 and much lower values for the Schwarz criterion. These results imply that unit costs are similar in most producing areas except for these States, arranged in order of increased unit costs: Jalisco (6 mills), Tamaulipas (2 mills), Michoacan (4 mills), and Sinaloa (4 mills). These States account for about 23 percent of total hectares harvested in Mexico. Mills in Sinaloa seem the worst off, considering their lower relative gross returns (cases 3 and 4) and their higher unit costs.

Summarizing, mills that produce more relative to their rated capacities and have longer campaign lengths receive higher per-unit returns. There is less variation on unit costs except for mills in 4 of the 15 States where there is sugar production. Better statistical results from inclusion of State-specific factors suggest that agronomic or locational conditions rather than ownership patterns are likely more important for differentiating mills on the basis of earnings.

Times-Series Analysis

The next step in the analysis is to extend it dynamically by considering what factors are important in causing earnings to change over time. The static results presented in the previous section suggest diversity across mills that probably hinders accurate analysis of factors accounting for the changes. For this reason, the data are divided into various subsets according to the level of earnings (the six groupings previously described), ownership by the 14 major sugar-processing companies and the independents considered together, and the 15 States.

Data Analysis

Table A-3 presents some basic production and earnings data for the groupings. Within each grouping, the members are organized on the basis of ascending earnings per hectare. In order to emphasize changes through time, averages for the early (1988-92) and more recent (1993-98) periods are presented side-by-side for comparison.

The changes have been noteworthy. Total hectares harvested have increased 5.2 percent; sugarcane yields have increased 6.6 percent; and most remarkably, sugar yields per hectare have increased by nearly 20 percent. Gross unit returns have increased 26 percent, but unit costs have increased only 21 percent. On a sugarcane-metric-ton basis, earnings have increased almost 35 percent over the early period.

Within each of the groupings, both sugarcane yield and sugar yield data increase significantly, going from the lower earning group member to the highest. For the grouping based on earnings, the average increase is 6.3 mt/ha for sugarcane and 0.98 mttq/ha for sugar. Corresponding increases are 1.3 mt/ha and 0.20 mttq/ha for the company classification, and 3.4 mt/ha and 0.46 mttq/ha for the State classification. Although these increases have little value in themselves, they indicate that earnings are correlated with productivity in both production and processing.

Annual computed increases in sugarcane and sugar yields, on the other hand, do not correlate with the within-group ordering. It is more relevant to note that across all earning group members, and across most company and State group members, annual yield growth rates have been significantly positive. This suggests that productivity gains have been distributed fairly evenly across almost all mills.

Table A-4 shows how mills are distributed across the company and State groupings by earnings per hectare. Individual companies own mills that typically span across the earnings spectrum. The same is true for mills in individual States except possibly for Sinoloa, Campeche, Tamaulipas, and Quintana Roo at the low end, and for Puebla and Morelos at the high-earnings end. The ninth and tenth columns show average earnings per hectare, and the eleventh column shows the ratio of the later period to the earlier. Earnings growth has been evident in all companies and in almost all States. The aggregate increase has been almost 44 percent.

Regression Analysis

The major hypothesis of this article, supported by the analysis presented thus far, is that productivity growth and technology adaption have been the primary factors in increasing earnings of Mexican sugar mills. The next step is to explicitly test the hypothesis. The model employed for the testing is as follows:

$$Log(Earning\ per\ hectare)=A+B*(Time\ Trend)+ C*Log(Sales\ revenue\ per\ ton\ of\ sugar)+D*Log(Sugar\ yield)$$

Earnings per hectare are modeled as a function of the unit value of sugar sales (average sugar prices faced by mills), sugar yield per hectare, and a time trend. Sugar yield is interpreted as an output measure for technological adaptation. Sugar yield has both trend and weather-related random aspects. As seen in appendix table 2, the weather-related portion is correlated highly with sugarcane yields, leaving a trend portion that is interpreted as that portion of output gain from a fixed land input measure. As seen both in the appendix table and in table A-3, the sugar yield growth rate has averaged about 1.90 percent a year over 1988-98 and has been statistically significant across almost all elements of the three data groupings (earnings level, mill ownership, and State location). The value of unit sugar sales is interpreted as the average price at which mills have sold their sugar. It, along with sugar yield, is expected to be highly correlated with earnings per hectare. The time trend variable is included to account for miscellaneous effects not specifically captured by the other two variables.

Table A-3--Area harvested, sugarcane yields, sugar yields, gross returns, and costs, by earnings classifications, companies, and State, 1988-98

	Area harvested		Sugarcane yield			Sugar yield			Gross return per ton		Cost per ton	
	Averages		Averages		Yearly growth rate	Averages		Yearly growth rate	Averages		Averages	
	1988-92	1993-98	1988-92	1993-98	1988-98	1988-92	1993-98	1988-98	1988-92	1993-98	1988-92	1993-98
	Hectares		Tons/ha		Percent	Tons/lb		Percent	------- U.S. dollars -------			
Earnings Classifications 1/												
Number 1 - Low earnings group	92,845	93,706	60.22	63.21	0.63	4.93	5.70	1.44	18.29	22.89	12.73	16.68
Number 2	79,610	88,030	63.48	65.62	0.95	5.78	6.91	2.01	19.42	24.25	11.59	14.97
Number 3	113,417	121,958	60.27	65.66	1.41	5.50	7.00	2.68	19.33	25.48	12.28	14.85
Number 4	87,230	92,348	69.60	74.54	0.94	6.75	8.00	1.65	20.98	26.98	13.46	16.39
Number 5	67,046	73,422	73.07	80.86	2.27	7.35	8.94	1.54	21.34	26.55	12.57	14.67
Number 6 - High earnings group	78,153	84,087	93.55	96.44	0.99	9.80	11.11	1.41	22.38	27.37	12.12	13.66
Company												
Consorcio AGA	23,073	24,134	65.45	74.78	2.24	5.82	7.59	2.25	19.54	24.51	14.03	17.24
Impulsora de Marcas Mexicanas	29,371	31,077	53.88	55.26	0.42	4.97	5.76	1.74	19.34	25.05	10.38	14.34
Grupo Saenz	35,497	37,424	65.60	73.17	1.33	6.19	7.48	1.55	20.54	26.41	13.87	18.18
Administracion Multiple	17,791	17,238	69.11	72.54	0.94	5.60	7.22	3.93	17.50	23.26	11.66	14.54
Fideliq	8,062	7,677	62.40	56.83	-1.63	5.03	4.89	4.90	17.22	23.81	9.98	11.95
Beta San Miguel Group	50,842	57,347	60.85	65.38	0.78	5.76	6.74	0.55	20.54	25.07	12.61	14.45
Grupo Santos	20,012	24,318	66.99	68.18	0.09	7.05	7.77	1.13	21.80	26.54	13.15	16.39
Grupo Azucarero Mexico	42,583	44,517	72.12	75.81	0.83	6.61	7.73	1.72	20.32	26.83	13.14	17.16
Concorcio Machado	56,115	59,039	59.38	66.38	1.84	5.43	7.05	2.83	19.22	25.45	12.06	14.45
Grupo Seoane	10,892	11,864	72.00	84.41	2.89	6.80	9.02	1.39	20.39	24.84	13.58	15.57
Promotora Industrial Azucarera	28,990	29,999	66.52	76.21	3.71	6.72	8.85	2.79	21.66	25.53	13.45	14.92
Independente	38,869	41,426	72.48	73.71	2.26	7.03	7.56	0.83	20.45	25.00	12.10	14.05
Porres Group	13,514	16,288	95.14	89.52	1.04	9.53	9.64	1.49	21.54	25.80	14.28	15.99
Grupo Zucarmex	34,592	37,227	79.46	80.84	0.77	7.84	8.65	1.36	21.25	25.72	11.82	14.79
Consorcio Industrial Escorpion (CAZE)	108,098	113,976	76.34	80.68	0.92	7.34	8.96	2.57	20.68	26.56	11.90	14.14
States 2/												
Sinaloa	29,623	25,750	73.94	73.39	-0.48	5.52	6.27	2.08	17.74	24.63	13.43	23.01
Campeche	6,672	6,993	46.83	45.01	2.49	4.25	4.43	1.27	19.74	24.46	14.89	16.25
Tamaulipas	26,471	27,197	51.90	61.62	1.97	4.47	5.71	1.37	18.78	25.10	13.12	16.84
Quintana Roo	13,688	15,958	58.94	59.05	-0.53	5.12	5.22	0.58	19.58	23.14	12.44	14.54
Colima	8,129	7,485	57.95	83.19	6.74	4.73	7.96	3.72	18.30	23.24	15.37	15.00
San Luis Potosi	48,938	57,748	53.07	57.23	-1.45	5.32	6.28	1.42	20.82	27.27	11.81	14.50
Tabasco	22,008	23,229	66.23	63.03	-0.51	5.66	5.86	3.30	18.05	23.95	10.98	12.37
Oaxaca	37,724	30,316	60.83	71.52	1.57	5.84	7.71	2.55	20.04	24.06	12.06	13.56
Veracruz	203,341	219,552	66.91	72.20	1.37	6.25	7.60	2.26	19.99	25.65	12.11	14.57
Nayarit	20,118	21,769	70.82	76.12	0.98	7.12	8.29	2.64	20.90	25.98	12.57	14.96
Jalisco	53,888	58,341	80.92	86.42	2.04	8.35	9.54	1.12	22.23	26.84	13.53	16.23
Michoacan	15,276	16,303	93.93	91.86	0.05	10.17	10.81	1.48	22.96	27.52	15.41	17.08
Chiapas	16,076	19,725	82.79	84.15	2.37	8.38	8.58	0.18	21.52	25.33	11.15	13.25
Puebla	11,418	11,553	106.67	111.26	0.34	10.50	12.00	2.67	21.00	26.40	12.65	14.98
Morelos	12,850	11,631	108.53	108.41	0.39	10.43	11.56	3.35	20.87	26.47	11.41	13.00
Mexico	526,219	553,551	68.85	73.42	1.60	6.52	7.81	1.90	20.35	25.74	12.48	15.13

1/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly-equal groups - #1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on. 2/ Average hectares harvested for 1988-92 includes 7,919 hectares for mills that ceased operation after 1992.

Table A-4--Earnings classification of Mexican sugar mills, earnings per hectare, and milling capacities, by company and state

	Number of factories within earnings per hectare classification 1/						Average earnings per hectare			Average capacity
							1988-92	1993-98	Ratio	
Lowest-to-highest earnings classification:	#1	#2	#3	#4	#5	#6				
								--U.S. dollars--		Tons/day
Company										
Consorcio AGA	1	0	0	1	0	0	355	538	1.51	7,250
Impulsora de Marcas Mexicanas	1	2	0	0	0	0	469	580	1.23	4,500
Grupo Saenz	2	0	0	1	0	0	412	583	1.41	5,867
Administracion Multiple	0	1	1	0	0	0	404	622	1.54	7,000
Fideliq	0	1	0	0	0	0	446	642	1.44	4,500
Beta San Miguel Group	1	1	1	1	1	0	465	679	1.46	5,260
Grupo Santos	0	1	2	0	0	0	575	681	1.18	4,233
Grupo Azucarero Mexico	1	0	0	4	0	0	486	714	1.47	5,960
Concorcio Machado	1	1	2	2	1	0	424	721	1.70	4,600
Grupo Seoane	1	0	0	0	1	0	510	767	1.51	6,600
Promotora Industrial Azucarera	0	1	0	0	1	0	567	781	1.38	7,600
Independente	1	1	1	1	5	0	595	798	1.34	2,733
Porres Group	1	0	0	0	0	2	671	848	1.26	4,833
Grupo Zucarmex	1	1	0	0	1	2	728	870	1.19	5,140
Consorcio Industrial Escorpion (CAZE)	0	0	3	0	0	6	654	980	1.50	8,088
States										
Sinaloa	3	0	0	1	0	0	299	115	0.39	5,525
Campeche	1	0	0	0	0	0	224	362	1.62	3,000
Tamaulipas	2	0	0	0	0	0	281	489	1.74	5,500
Quintana Roo	1	0	0	0	0	0	410	495	1.21	6,000
Colima	0	0	1	0	0	0	161	674	4.18	4,800
San Luis Potosi	0	1	2	1	0	0	465	710	1.53	6,250
Tabasco	0	2	0	2	0	0	432	711	1.64	3,625
Oaxaca	1	1	0	1	1	0	507	745	1.47	4,200
Veracruz	2	5	6	0	6	3	521	784	1.51	6,097
Nayarit	0	0	0	1	1	0	588	847	1.44	5,750
Jalisco	0	0	1	3	1	1	685	901	1.32	6,033
Michoacan	0	1	0	1	0	2	691	950	1.37	3,300
Chiapas	1	0	0	0	0	1	856	976	1.14	6,500
Puebla	0	0	0	0	1	1	878	1,254	1.43	5,550
Morelos	0	0	0	0	0	2	1,037	1,458	1.41	4,375
All Mexico	11	10	10	10	10	10	530	761	1.44	5,428

1/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly equal groups - #1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on.

Source: FORMA

Regression results for the three groupings and the Mexican industry as a whole are displayed in appendix table 3. For the earnings grouping, the adjusted R2 are in the range 0.628-0.919, with an average of 0.763. Serial correlation is not a problem. Only for group members 1 and 2 (representing the 21 poorest performing mills) are the time trend coefficients significantly different from zero, and they are negative. Results for the company and State groupings are roughly similar. With the exception of two cases, all adjusted R2 are greater than 0.500. The average R2 for the company regressions is 0.768, and is 0.838 for the State regressions. The whole Mexico adjusted R2 is 0.818.

Coefficient values on the sugar price and sugar yield variables that are significantly different from zero are shown in table A-5. The values of the sugar price coefficients tend to be slightly under the value of 1.0. This is true for 6 of the 6 cases for the earnings' grouping; 10 of the 15 cases for the company grouping, and 7 of the 15 cases for the State grouping. The coefficient value for whole Mexico cases is 0.754. The coefficient value on the values of the sugar yield coefficients, on the other hand, are mostly greater than one, indicating that earnings per hectare are elastic with respect to changes in yield values. This is true for 6 of the 6 cases for the earnings' grouping; 11 of the 15 cases for the company grouping, and 9 of the 15 cases for the State grouping. The coefficient value for whole Mexico case is 2.026.

This indicates that the effect of sugar price changes are likely very uniform on earnings per hectare across the grouping.[4] Applying the test to the sugar yield coefficients yields the opposite result: the coefficients differ according to the grouping of the data for analysis. The coefficient value for the group no. 1 is 3.516, which is about 2.5 times as much as the average of group nos. 2-6. Applying the test while excluding group no. 1 still indicates that the yield coefficients differ significantly from each other for group nos. 2-6.

Beta Coefficients

It is difficult to gauge the importance of how explanatory variables account for changes in a dependent variable by focusing on elasticities alone. An elasticity reports how much the dependent variable changes when the independent variable changes by 1 percent. If there is more than a single independent variable in an equation, it may be that the likelihood of one variable changing by a single percentage point is vastly different from the likelihood of the other independent variable changing by the same amount. Essentially, one of the independent variables may be much more variable than the others. In order to adjust for differing relative variances, a regression coefficient can be weighted by the ratio of its standard deviation to the standard deviation of the dependent variable. The interpretation of the resulting coefficient, called a beta coefficient, is that a one-standard deviation change in the independent variable leads to a standard deviation change in the dependent variable equal to the value of the beta coefficient. The normalization process that transforms regression coefficients into beta coefficients allows the effects of differing independent variables to be directly comparable.

Table A-5 reports beta coefficients for the sugar price and sugar yield. The underlying model from which the beta coefficients are calculated is the non-logarithmic version of the model defined in the equation above. The sugar price beta coefficient values average about 0.70; and except for group no. 3, are pretty close in value to each other. The sugar yield beta values show more variability. They decrease in size, going from the low earnings group to the higher groups.

The last column shows the ratio of the sugar yield betas to the price betas. The descending pattern going from group 1 to 6 is very evident, indicating that sugar yield changes have a relatively less effect on earnings for higher earning firms. An implication is that the mills with lower earnings have relatively more to lose by not maintaining the pace of adapting technological improvements. An associated implication is that the marginal return to technological adaptation (which of course must be weighed against marginal costs) is higher for lower-earning mills.

Simulation Analysis

The estimation results presented thus far can be used to project earnings per hectare into the future. The goal, however, is not to forecast but rather to illustrate the importance of technological adaption to the Mexican sugar industry. Certain exogenous assumptions must be made, including that estimated relationships will hold for the future.

Table A-6 shows the equations of a projections model for Mexican sugar earnings per hectare. The equations track each of the elements of the earnings grouping. Model coefficient values for the first three equations are taken from the results in the appendix tables 1-3. Cane yield is a function of trend and hectares harvested. Sugar yield is a function of trend and cane yield. Earnings per hectare are a function of trend, sugar price, and sugar yield. Sugar prices faced by mills are a function of a national price, which is assumed constant to its 1998 value throughout the baseline simulation. Hectares harvested are assumed to grow at a 1-percent rate throughout the projections period.

Figure A-6 shows baseline results for earnings per hectare for each of the earnings group members. The two lowest

[4] The formal test run is the Wald Coefficient Test. It measures how close an unrestricted regression comes to a regression with restrictions placed on particular coefficient values. The resulting statistic follows a chi-square distribution if the unrestricted estimates are close to those in the restricted case. The Wald statistic for the sugar price coefficients restriction is 3.37, which is consistent with the chi-square distribution.

Table A-5--Responsiveness of earnings per hectare to changes in sugar prices and sugar yields

	Elasticity of earnings per hectare with respect to: 1/		Beta coefficients defined with respect to: 2/		Ratio of sugar yield beta coefficient to the sugar price beta
	Sugar price	Sugar yield	Sugar price	Sugar yield	
Earnings Classifications 3/					
Number 1	0.883	3.516	0.779	1.117	1.433
Number 2	0.856	1.579	0.720	0.831	1.154
Number 3	0.763	1.379	0.508	0.626	1.231
Number 4	0.884	1.483	0.710	0.458	0.645
Number 5	0.906	1.207	0.706	0.469	0.664
Number 6	0.792	1.330	0.726	0.401	0.552
Company					
Consorcio AGA	0.613	3.831	0.442	1.315	2.972
Impulsora de Marcas Mexicanas	1.080	2.133	0.958	1.052	1.098
Grupo Saenz	4/ n.s.	2.615	n.s.	0.998	5/ n.d
Administracion Multiple	0.898	2.654	0.702	1.507	2.146
Fideliq	0.233	n.s.	0.188	n.s.	n.d
Beta San Miguel Group	0.570	2.054	0.470	0.702	1.493
Grupo Santos	0.605	n.s.	0.512	n.s.	n.d
Grupo Azucarero Mexico	1.194	2.200	0.935	0.509	0.544
Concorcio Machado	0.855	1.615	0.629	0.809	1.287
Grupo Seoane	0.874	0.779	0.634	0.467	0.737
Promotora Industrial Azucarera	1.240	n.s.	0.841	n.s.	n.d
Independente	0.806	1.257	0.741	0.428	0.578
Porres Group	1.262	2.008	0.561	0.449	0.799
Grupo Zucarmex	0.881	2.000	0.870	0.618	0.711
Consorcio Industrial Escorpion (CAZE)	0.521	1.626	0.434	0.725	1.668
States					
Sinaloa	1.724	n.s.	0.977	n.s.	n.d
Campeche	n.s.	2.586	n.s.	0.774	n.d
Tamaulipas	n.s.	3.483	n.s.	1.173	n.d
Quintana Roo	0.873	n.s.	0.755	n.s.	n.d
Colima	n.s.	1.654	n.s.	0.698	n.d
San Luis Potosi	0.992	1.936	0.584	0.793	1.359
Tabasco	1.414	2.196	1.090	0.570	0.523
Oaxaca	1.204	0.670	0.821	0.342	0.416
Veracruz	0.713	1.868	0.613	0.804	1.311
Nayarit	0.833	1.330	0.597	0.612	1.027
Jalisco	0.679	0.938	0.733	0.383	0.523
Michoacan	0.569	n.s.	0.556	n.s.	n.d
Chiapas	1.210	1.121	1.105	0.259	0.234
Puebla	n.s.	1.637	n.s.	0.697	n.d
Morelos	0.808	n.s.	0.725	0.620	0.855
Mexico	0.754	2.026	1.062	0.662	0.623

1/ Coefficients "C" and "D" from model: log(Earnings per hectare) = A +B*(Time Trend)+ C*log(Sales revenue per ton of sugar) + D*LOG(Sugar yield); see appendix table 3 for complete estimation results.

2/ Beta coefficients are regression coefficients weighted by the ratio of the standard deviations of the explanatory variable to the earnings per hectare. Model: (Earnings per hectate)=A+B*(Time Trend)+C*(Sales revenue per ton of sugar) +D*(Sugar yield)

3/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly equal groups - #1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on.

4/ n.s. = Not significantly different from zero at • = .05

5/ n.d. = Not defined

Table A-6--Model Specification

Cane Yield for i = Income Group

$$Log(Cane\ Yield(t)_i) = A_i + B_i*(Time\ Trend) + C_i*Log(Hectares\ Harvested(t)_i)$$

Sugar Yield for i = Income Group

$$Log(Sugar\ Yield(t)_i) = D_i + E_i*Log(Time\ Trend) + F_i*Log(Cane\ Yield(t)_i)$$

Earnings for i = Income Group

$$\left(\frac{Earnings}{Hectare}(t)_i\right) = G_i + H_i*(Time\ Trend) + I_i*(Sugar\ Price(t)_i) + J_i*(Sugar\ Yield(t)_i)$$

Sugar Price for i = Income Group

$$Log(Sugar\ Price(t)_i) = K + L_i*(Time\ Trend) + M_i*Log(Sugar\ Price_{National\ level})$$

National Sugar Price

$$Sugar\ Price_{National\ level} = N(t)$$

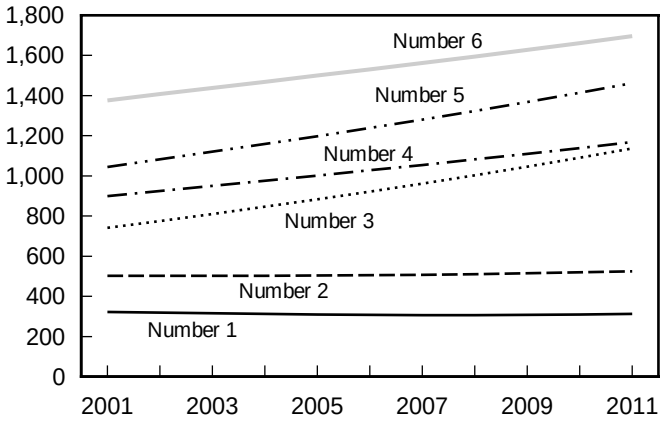
Hectares Harvested for i = Income Group

$$Hectares\ Harvested(t)_i = O_i*(Hectares\ Harvested(t\text{-}1))$$

i = Incomes for Groups 1 through 6
t = 2001 through 2011

Figure A-6

Sugar processing in Mexico: Projected earnings per hectare, by earning categories



Source: ERS projection.

groups (1 and 2) are projected to have flat earnings throughout the 10-year projections horizon. Earnings per hectare are 3 percent less in 2011 than in 2001 for group no. 1, and are only projected 4.7 percent higher for group no. 2. Yearly sugar yield growth rates of 1.4 percent for group no. 1 and 2.0 percent for group no. 2 are insufficiently high to counter the observed downward trend in earnings for these two groupings.

The other four earnings groups are projected to have high earnings growth. Relative to 2001, earnings per hectare in 2011 are projected 53 percent higher for group no. 3, 30 percent for group no. 4, 40 percent for group no. 5, and 23 percent for group no. 6. Each of these groups are projected to have good yearly sugar yield growth: 2.7 percent - group no. 3; 1.6 percent - group no. 4; 1.5 percent - group no. 5; and 1.4 percent - group no. 6. Unlike groups 1 and 2, there is no negative trend growth to offset to achieve higher earnings per hectare.

To highlight the importance of technological adaption, three scenarios are run that remove the effects of the following: (1) sugarcane yield growth; (2) sugar yield growth; and (3) combined sugarcane and sugar growth. Table A-7 shows projected earnings for 2006, the middle of the projection period, for the groups for the base and for the scenarios. Percentage changes from the base are shown in the three right-most columns.

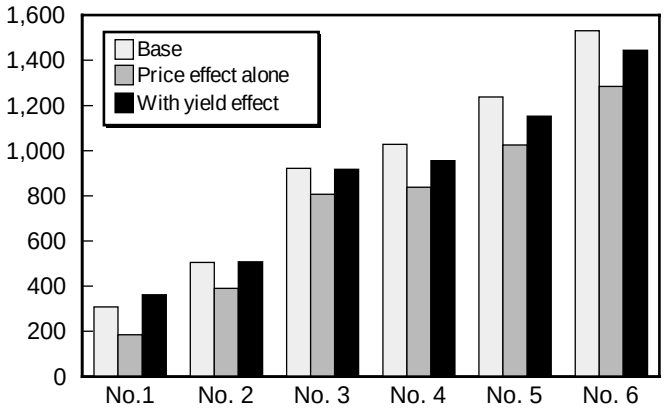
The percentage changes attributable to the lack of technological adaptation are inversely proportional to the earnings ranking of the mills; that is, the largest percentage changes are concentrated in the lower earnings groups 1 and 2 and

become smaller with the higher earning groupings. As would be expected, the percentage changes from scenarios 2 and 3 are correlated very highly with the sugar yield beta coefficients from table A-5: scenario no. 2, 0.978; and scenario no. 3, 0.963. The results imply that technology adaption is particularly crucial to sugar mills with lower returns.

Another way to see the importance of technological adaptation to lower earning mills is illustrated in figure A-7. Two scenarios are run: the first specifies a 25-percent decrease in the national sugar price, and the second imposes a 10-percent increase in sugar yields on top of the price decrease scenario. The effect of the price decrease hits the lower earning groups 1 and 2 especially hard: 40 percent and 23 percent earnings drop per hectare. Earnings per hectare reductions for group nos. 3-6 are between 12 and 18 percent. The sugar yield effect serves to offset the price reduction effect. The offset effect is the strongest for groups 1 and 2: earnings per hectare are higher than in the baseline. The offset effect becomes progressively smaller, going from group no. 3 up through no. 6.

Figure A-7

Projected earings, 2006: 25 percent price reduction and 10 percent yield increase



Source: ERS projection.

Extensions

There are many uncertainties for the Mexican sugar producing sector. Many of the firms are heavily indebted, and returns to selling on the world market have been low. The terms under which they will be able to ship into the U.S. market are in dispute. The industry faces demand-side competition from high fructose corn syrup that is imported from the United States and also produced in Mexico. Relationships between the mills and sugarcane growers have not been cordial. Nonetheless, the sector has realized gains in production that were not predicted by most observers only a few years ago. Although analysis presented in this article points to further potential gains, the future remains hard to predict with a high degree of reliability. Additional analysis is needed for enhancing forecast ability. This article has focused on the demand by processors for hectares planted to sugarcane. More work needs to be done on the suppliers of area, or actual producers. Data on alternative crops in each of the producing areas, especially cost and return data, are needed. Emergent technologies that enhance yields and sucrose recovery need to be analyzed for their potential to expand production. This work, along with that on the demand-side, will lead to better forecasting ability.

References

Garcia, Luis R., Thomas H. Spreen, Gretchen Greene. "Structural Reform and Implication for Mexico's Sweetener Market," paper presented at conference entitled "Sweetener Markets in the 21st Century," sponsored by The University of Florida, Department of Food and Resource Economics, Miami, FL., November 1999.

Table A-7--Simulation result: Effect on earnings of productivity changes in sugar production and processing

	Projected earnings (U.S. dollars) per hectare, 2006				Percentage change relative to base		
	Base	Simulation #1: No trend growth in cane yields	Simulation #2: No trend growth in sugar yields	Simulation #3: No trend growth in cane and sugar yields	Simulation #1:	Simulation #2:	Simulation #3:
Number 1	307	200	130	41	-34.9	-57.7	-86.6
Number 2	505	448	350	301	-11.3	-30.7	-40.4
Number 3	922	858	773	680	-6.9	-16.2	-26.2
Number 4	1,028	969	899	847	-5.7	-12.5	-17.6
Number 5	1,238	1,074	1,109	961	-13.2	-10.4	-22.4
Number 6	1,531	1,445	1,381	1,303	-5.6	-9.8	-14.9

Appendix table 1--Regression results - cane yield

	Model: log(Cane Yield) = A + B*(Time Trend) + C*log(Hectares)							
	Coefficient values and T-statistics						Adj. R2	Durbin-Watson 1/
	Coeff. A	T-stat	Coeff. B	T-stat	Coeff. C	T-stat		
Earnings Classifications 2/								
Number 1	5.133	9.297	0.006	2.899	-0.091	-1.883	0.295	1.91
Number 2	6.888	6.635	0.010	2.046	-0.244	-2.656	0.000	1.98
Number 3	4.074	355.244	0.014	6.191	na	na	0.472	2.00 *
Number 4	4.233	200.260	0.009	2.220	na	na	0.140	2.22
Number 5	7.805	6.013	0.023	5.960	-0.320	-2.730	0.612	2.46
Number 6	7.836	6.199	0.010	3.514	-0.295	-2.617	0.064	2.02 *
Company								
Consorcio AGA	7.160	3.194	0.022	2.859	-0.300	-1.340	0.390	1.65
Impulsora de Marcas Mexicanas	3.977	79.298	0.004	0.490	na	na	0.000	1.99
Grupo Saenz	4.175	110.090	0.013	2.078	na	na	0.249	1.89
Administracion Multiple	4.215	355.710	0.009	4.608	na	na	0.624	2.54 *
Fideliq	9.286	4.679	-0.016	-2.486	-0.572	-2.593	0.456	2.49
Beta San Miguel Group	4.109	141.034	0.008	1.599	na	na	0.040	1.82 *
Grupo Santos	4.209	167.564	0.001	0.213	na	na	0.000	2.13
Grupo Azucarero Mexico	4.262	107.714	0.008	1.246	na	na	0.052	2.56
Concorcio Machado	4.047	85.160	0.018	2.301	na	na	0.204	2.10 *
Grupo Seoane	5.661	4.371	0.029	3.499	-0.155	-1.102	0.509	1.99
Promotora Industrial Azucarera	25.699	5.284	0.037	6.428	-2.100	-4.431	0.588	2.16 *
Independente	20.357	2.502	0.023	1.922	-1.526	-1.976	0.171	2.23
Porres Group	10.996	7.216	0.010	1.573	-0.680	-4.202	0.610	2.38 *
Grupo Zucarmex	6.601	4.421	0.008	1.410	-0.215	-1.500	0.087	1.88
Consorcio Industrial Escorpion (CAZE)	4.320	157.068	0.009	2.015	na	na	0.103	1.98 *
States								
Sinaloa	6.562	6.098	-0.005	-0.720	-0.220	-2.093	0.040	2.41 *
Campeche	16.573	4.342	0.025	2.098	-1.462	-3.353	0.390	2.19 *
Tamaulipas	-2.246	-0.757	0.020	2.141	0.607	2.087	0.402	2.05
Quintana Roo	4.100	72.362	-0.005	-0.555	na	na	0.000	2.48
Colima	3.906	44.202	0.067	4.510	-2.246	-0.757	0.659	2.57
San Luis Potosi	-3.389	-0.819	-0.015	-1.003	0.686	1.783	0.113	1.66
Tabasco	4.191	140.298	-0.005	-1.011	na	na	0.002	2.14
Oaxaca	8.806	4.544	0.016	1.888	-0.450	-2.451	0.665	2.16
Veracruz	4.175	135.214	0.014	2.620	na	na	0.370	2.36
Nayarit	4.244	59.541	0.010	0.810	na	na	0.000	1.35
Jalisco	9.792	4.777	0.020	3.220	-0.500	-2.647	0.496	2.54
Michoacan	9.778	7.627	0.001	0.134	-0.544	-4.063	0.467	2.58 *
Chiapas	9.732	2.414	0.024	1.554	-0.554	-1.321	0.074	2.54 *
Puebla	4.675	145.317	0.003	0.624	na	na	0.000	2.30
Morelos	4.664	97.946	0.004	0.486	na	na	0.000	2.36
Mexico	10.222	5.065	0.016	4.310	-0.458	-2.976	0.696	2.15 *

1/ Presence of * indicates that the equation has been estimated correcting for serial correlation.

2/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly equal groups - #1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on.

Appendix table 2--Regression results - sugar yield

	Model: log(Sugar Yield) = A + B*log(Time Trend) + C*log(Cane Yield)							
	Coefficient values and T-statistics						Adj. R2	Durbin-Watson 1/
	Coeff. A	T-stat	Coeff. B	T-stat	Coeff. C	T-stat		
Earnings Classifications 2/								
Number 1	-4.287	-8.079	0.014	5.763	1.427	11.152	0.957	1.90 *
Number 2	-1.307	-3.560	0.020	8.381	0.737	8.338	0.937	2.46
Number 3	-0.829	-1.837	0.027	6.039	0.611	5.511	0.843	1.63
Number 4	-1.408	-3.739	0.016	5.083	0.778	8.740	0.845	2.20
Number 5	-1.747	-4.389	0.015	5.459	0.868	9.291	0.931	1.89
Number 6	-1.351	-5.316	0.014	13.704	0.799	14.204	0.970	2.05
Company								
Consorcio AGA	-2.671	-10.050	0.023	11.494	1.049	16.371	0.981	2.27 *
Impulsora de Marcas Mexicanas	-3.001	-2.969	0.017	2.655	1.149	4.524	0.751	1.82
Grupo Saenz	-2.082	-2.148	0.016	2.858	0.926	3.990	0.841	1.83
Administracion Multiple	-1.465	-0.679	0.039	3.318	0.730	1.429	0.719	1.90 *
Fideliq	-0.212	-0.099	0.049	0.371	0.346	1.545	0.099	1.47 *
Beta San Miguel Group	-3.637	-2.807	0.005	0.911	1.313	4.160	0.710	1.47
Grupo Santos	-2.339	-1.630	0.011	2.600	1.018	2.986	0.598	1.61
Grupo Azucarero Mexico	-2.039	-2.748	0.017	2.493	0.912	5.233	0.850	1.59 *
Concorcio Machado	-2.739	-4.082	0.028	3.095	1.065	6.554	0.916	2.35 *
Grupo Seoane	-4.579	-5.010	0.014	1.114	1.500	7.085	0.910	1.59 *
Promotora Industrial Azucarera	-1.221	-2.702	0.028	5.895	0.734	6.679	0.966	2.07
Independente	-2.048	-3.652	0.008	3.216	0.931	7.107	0.867	1.86
Porres Group	-4.104	-5.680	0.015	4.483	1.391	8.844	0.832	2.43 *
Grupo Zucarmex	-0.990	-1.012	0.014	3.716	0.692	3.087	0.745	1.89
Consorcio Industrial Escorpion (CAZE)	-0.400	-0.310	0.026	4.720	0.544	1.815	0.843	1.99
States								
Sinaloa	-3.512	-3.474	0.021	3.700	1.203	5.122	0.783	2.04
Campeche	-3.010	-10.548	0.013	3.149	1.150	15.436	0.961	2.09
Tamaulipas	-3.485	-4.429	0.014	1.817	1.252	6.280	0.878	1.55
Quintana Roo	-1.575	-2.410	0.006	0.509	0.781	5.067	0.646	1.42 *
Colima	-2.254	-5.078	0.037	4.057	0.923	8.138	0.978	2.18
San Luis Potosi	-3.741	-4.159	0.014	1.794	1.357	6.031	0.800	1.93
Tabasco	-1.895	-2.580	0.033	1.192	0.824	5.273	0.831	2.63 *
Oaxaca	-1.707	-3.029	0.025	4.909	0.836	6.027	0.956	1.79
Veracruz	-1.459	-1.201	0.023	3.739	0.777	2.671	0.854	1.43
Nayarit	-1.873	-4.211	0.026	3.246	0.880	8.285	0.944	2.62 *
Jalisco	-1.975	-2.569	0.011	2.593	0.930	5.284	0.861	1.65
Michoacan	-3.097	-5.102	0.015	5.363	1.187	8.925	0.894	2.36
Chiapas	-1.648	-2.538	0.002	0.767	0.853	5.777	0.806	1.67
Puebla	-4.496	-3.171	0.027	1.606	1.450	4.879	0.726	1.30 *
Morelos	-1.214	-1.775	0.034	2.315	0.731	4.936	0.834	1.72 *
Mexico	-1.744	-1.705	0.019	4.344	0.849	3.498	0.879	1.77

1/ Presence of * indicates that the equation has been estimated correcting for serial correlation.

2/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly equal groups - #1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on.

Appendix table 3--Regression results - earnings per hectare

Model: log(Earnings per hectare) = A +B*(Time Trend)+ C*log(Sales revenue per ton of sugar) + D*log(Sugar Yield)

	Coefficient values and T-statistics								Adj. R2	Durbin-Watson 1/
	Coeff. A	T-stat	Coeff. B	T-stat	Coeff. C	T-stat	Coeff. D	T-stat		
Earnings Classifications 2/										
Number 1	-4.378	3.158	-0.098	6.406	0.883	4.678	3.516	6.929	0.648	2.49
Number 2	-0.910	0.915	-0.060	4.605	0.856	5.462	1.579	4.906	0.628	2.31
Number 3	-0.335	0.418	na	na	0.763	5.465	1.379	8.758	0.781	1.78
Number 4	-1.322	1.818	na	na	0.884	8.044	1.483	7.945	0.802	1.75
Number 5	-0.758	1.833	na	na	0.906	13.237	1.207	11.854	0.919	1.71
Number 6	-0.371	0.510	na	na	0.792	7.247	1.330	5.230	0.799	1.46
Company										
Consorcio AGA	-3.835	-2.675	-0.141	-4.965	0.613	2.193	3.831	6.394	0.878	2.67
Impulsora de Marcas Mexicanas	-2.787	-2.721	-0.069	-6.220	1.080	7.322	2.133	7.437	0.851	2.57
Grupo Saenz	-0.952	-0.322	-0.066	-1.657	0.455	1.128	2.615	2.526	0.522	2.44
Administracion Multiple	-3.147	-3.917	-0.076	-5.638	0.898	8.486	2.654	9.966	0.927	2.65
Fideliq	4.409	5.336	0.054	8.490	0.233	2.221	0.212	0.721	0.841	1.77
Beta San Miguel Group	-0.539	-0.360	na	na	0.570	2.383	2.054	4.086	0.698	2.30
Grupo Santos	3.124	1.465	na	na	0.605	2.175	0.053	0.065	0.627	2.38
Grupo Azucarero Mexico	-4.300	-2.171	-0.043	-1.659	1.194	5.542	2.200	2.989	0.814	1.73
Concorcio Machado	-1.116	-1.545	-0.020	-1.845	0.855	7.749	1.615	8.466	0.963	1.73
Grupo Seoane	0.142	0.086	na	na	0.874	2.974	0.779	2.290	0.583	1.96
Promotora Industrial Azucarera	-1.207	-1.014	na	na	1.240	5.822	0.517	1.572	0.797	1.98
Independente	-0.307	-0.409	na	na	0.806	7.179	1.257	3.935	0.900	2.03
Porres Group	-4.829	1.151	na	na	1.262	2.603	2.008	2.247	0.585	1.36
Grupo Zucarmex	-2.135	-1.079	-0.034	-1.809	0.881	4.784	2.000	2.350	0.740	2.22
Consorcio Industrial Escorpion (CAZE)	0.456	0.419	na	na	0.521	2.864	1.626	4.916	0.789	1.75
States										
Sinaloa	-6.201	0.944	-0.159	1.387	1.724	1.987	1.611	0.941	0.118	1.60
Campeche	-1.302	0.647	0.041	1.640	0.549	1.477	2.586	7.108	0.871	1.45
Tamaulipas	-4.039	1.155	-0.100	2.135	0.862	1.488	3.483	5.122	0.748	2.50
Quintana Roo	-0.687	0.459	0.000	0.000	0.873	3.993	1.206	1.845	0.665	2.28
Colima	1.966	0.689	0.000	0.000	0.174	0.323	1.654	4.998	0.881	1.53
San Luis Potosi	-2.235	1.642	-0.033	2.255	0.992	4.281	1.936	8.129	0.927	2.46
Tabasco	-5.190	3.405	0.000	0.000	1.414	8.738	2.196	4.243	0.883	1.38
Oaxaca	-1.294	1.219	0.000	0.000	1.204	6.303	0.670	2.249	0.834	1.89
Veracruz	-0.903	0.928	-0.022	1.474	0.713	5.790	1.868	4.685	0.924	2.16
Nayarit	-0.591	1.090	-0.009	1.234	0.833	8.348	1.330	7.898	0.963	2.29
Jalisco	0.948	0.920	0.000	0.000	0.679	3.535	0.938	2.449	0.741	1.93
Michoacan	2.124	1.633	0.000	0.000	0.569	2.944	0.674	1.443	0.762	1.57
Chiapas	-2.033	1.617	-0.023	2.637	1.210	10.121	1.121	2.346	0.919	2.18
Puebla	1.938	0.829	0.000	0.000	0.188	0.513	1.637	2.975	0.422	1.56
Morelos	-0.281	0.226	0.000	0.000	0.808	4.883	1.259	3.682	0.775	1.66
Mexico	-1.450	0.931	-0.030	1.429	0.754	4.185	2.026	3.118	0.818	2.03

1/ Presence of * indicates that the equation has been estimated correcting for serial correlation.

2/ Mills are sorted by ascending average earnings per hectare for 1993-98, and divided into 6 nearly equal groups -
#1 constitutes the 11 mills with the lowest earnings, #2 constitutes the 10 mills with the next highest average, and so on.