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Adjustment and Poverty in Mexican Agriculture

How Farmers' Wealth Affects Supply Response

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By and large, it appears that the goals of agricultural reform are being met in Mexico. But measures such as decoupling income supports and price supports or reorienting research and extension could help farmers who cannot afford access to machinery and purchased inputs and services.

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Summary findings

López, Nash, and Stanton report the results of a study of Mexican farm households using 1991 survey data and a smaller resurvey of some of the same households in 1993.

One study goal was to empirically examine the relationship between assets and the output supply function. Using a production model focusing on capital as a productive input, they found that both the supply level and the responsiveness (elasticities) to changing input and output prices tend to depend on the farmer's net assets and on how productive assets are used. Regression analysis using data from the surveys shows that farmers who use productive assets such as machinery tend to be positively responsive to price changes, while those with no access to such assets are not.

Another study goal was to monitor the condition of Mexican farmers in a rapidly changing policy environment. The 1991 survey data suggest that farmers with more limited use of capital inputs (the "low-CI" group) were more likely to grow principally corn and to grow fewer crops, on average, than the others. They also had more problems getting credit and were less likely to use purchased inputs, such as seeds, fertilizer, and pesticides, or to use a tractor to prepare the soil. They tended to be less well-educated, and their land tended to be of lower quality.

Results from the panel data showed conditions generally improving for the average farmer in the sample area between 1991 and 1993, during a period when agricultural reforms were implemented. Cropping patterns were more diversified, the average size of landholdings increased, the average farmer received more credit (in real terms), more farm households earned income from off-farm work, and more farmers used purchased inputs. Asset ownership and educational attainment also improved modestly.

The very small low-CI group in this sample fared as well as, or better than, the other groups. True, their level of educational achievement fell, and fewer of them had off-farm income than in 1991. But their use of credit, irrigation, machinery, and purchased inputs increased more than for other groups.

The limited data are not proof of a causal link, but the fact that the goals are being met should at least ensure that adverse conditions are not undermining reform.

Farmers that lacked access to productive assets did not respond as well to incentives or take advantage of the opportunities presented by reform and may need assistance, particularly to get access to credit markets. There may be a good argument for decoupling income supports from price supports for farmers, since income payments that are independent of the vagaries of production could provide a more stable signal of creditworthiness than price supports do.

Possibly reorienting research and extension services more to the needs of low-CI producers could also improve the efficiency with which the sector adjusts to new incentives.

Hypotheses and tentative conclusions from this study will be explored further when more data are collected in 1995.

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ADJUSTMENT AND POVERTY IN MEXICAN AGRICULTURE: HOW FARMERS' WEALTH AFFECTS SUPPLY RESPONSE*

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I. Introduction

I.1 Background: Recent and planned reforms in trade and agricultural policy

The Mexican economy has become increasingly open over the last eight years. Since mid-1985, when almost all imports were subject to controls, protection has declined dramatically. Almost all imports are now free from controls, and the maximum tariff now is only 20 percent. Mexico acceded to the GATT in 1986, and recently completed negotiations for the North American Free Trade Agreement (NAFTA), further institutionalizing its commitment to trade policy reform.

Until recently, however, the agricultural sector has been a prominent exception to the trade liberalization. Imports of maize, beans, wheat, and barley still require licenses and their levels of protection have remained high. The large devaluation of 1994-95, combined with support prices fixed in nominal terms, have reduced the level of domestic (support and "agreement") prices vis-a-vis border prices, but an increase in these domestic prices is under discussion. One obstacle to liberalizing the grain markets has been the fact that, although the poorest farmers are not net sellers, many poor rainfed farmers outside the subsistence sector rely on these commodities. In addition, a fall in grain prices could reduce the demand of rural labor by large farmers, thereby lowering the wages of the households who are net sellers of labor.Thus, it has been feared that a reduction in protection could significantly increase the incidence and severity of rural poverty. Politically powerful large-scale farmers also have benefitted from this protection and opposed liberalization. These obstacles notwithstanding, the Mexican government is considering moving even faster than required by NAFTA to liberalize the agricultural trade regime. It has announced that under the Programa

Nacional de Modernization del Campo (PROCAMPO), most restrictions on agricultural trade will be eliminated, with income support payments to farmers based on historical (not current) production patterns and volumes. These payments would then be phased out over a 15-year period. The first steps in PROCAMPO began in 1993, but the large-scale delinkage of price and income support is now scheduled for Spring 1996.

In addition to these significant changes in output markets that have occurred or are imminent, Mexican farmers also are being faced with monumental changes in input markets. Subsidies have been virtually eliminated for fertilizer use and the former parastatal monopoly on marketing has been opened to competition. Subsidies on electricity (used for irrigation pumps) and surface irrigation water have been reduced. Imports of agricultural machinery, which were restricted in order to protect domestic manufacturers, have been liberalized, as has the market for pesticides.

Changes in rural financial markets have reflected the on-going restructuring of the whole financial sector in Mexico. In 1988 and 1989, limits on commercial bank lending to the private sector were first partially relaxed, then eliminated. Following this, the government removed other controls, such as interest rate caps and forced lending quotas. By July 1992, the commercial banking system was privatized. However, the reforms have not had as much effect in the rural sector as in others. Controlled on-lending interest rates, combined with subsidized credit guarantees and agricultural insurance, continue to require large government transfers (though not as large as in the past), and to impede the entry into the market by private institutions. Poor farmers still face restricted access to credit, though the previous practice on the part of governmental banks of only making loans for specific

crops and specific input packages (Heath, 1990) is being phased out.

In the land market, recent reforms have been truly fundamental. Much of Mexican agriculture has been organized since the revolution as "*ejidos*", organizations of farmers, each of whom may have usufruct rights to parcels of land, but not other ownership rights. Thus, they have been unable to pledge land as collateral, making them potentially poorer risks for lending than those with ownership rights. (This was one major raison d'etre for government rural banks.) This system also limited the incentives for investment in land improvements and impeded the consolidation of inefficiently small plots. In early 1992, the Constitution and applicable laws were amended to give *ejidatarios* much greater flexibility. In principle, they will now be able to rent land, enter into joint ventures with outsiders, sell land to members of the *ejido*, or sell it to non-members with the approval of a majority of *ejido* members. Land can now be pledged as collateral. All of these changes are intended to encourage the development of dynamic rural land and financial markets. However, these changes have been slow to be made operational. Only some of the ejidos have been given "certificates of ejido rights" (20 percent in early 1995, with another 50 percent in process), and even fewer have received full private title (de Janvry, et. al., 1995).

I.2. The purpose of this study

The economic environment in rural Mexico, as in the rest of the country, has undergone wrenching change in the recent past, with more change yet to come. This mirrors the situation in many other reforming countries, though the changes in Mexico are arguably among the most revolutionary in the world, at least outside of the economies in transition

from socialism. Two major questions facing the governments of reforming countries are whether citizens are able to readily avail themselves of the opportunities presented by the changes, and if not, what policies are needed to facilitate this? These issues are especially critical for the poor, both because they may be less capable than others of adapting to changes and because the consequences of non-adaptation may be more severe.

This study has two purposes. One is to monitor the condition of Mexican farmers, especially the poor, and see how changes in the economic environment have affected them. While it will not be possible to prove a causal link between any particular reforms and the changes in practices or circumstances, we will be able to tell if these changes are consistent with the goals of the reforms. This monitoring is important in itself, since if the goals are not being met, it may signal the need to investigate why and to take corrective measures (e.g., accelerating or fine-tuning the reforms, or responding to obstacles to implementation). One lesson of adjustment experience in many countries is that sustainability is increased when there is the perception that reforms are having a pay-off. In establishing this perception, the counterfactual (whether things would have been better or worse without the reform) matters less than whether the goals are being met.

The second purpose of this study is to investigate questions related to constraints on the ability of the poor to adjust. The myth that farmers in general fail to respond to changing incentive structures has long ago been discarded. They are neither ignorant nor tradition-bound, and can adjust their inputs, outputs, and mix of activities (both on- and off-farm) in response to changing circumstances.

However, there are several reasons that lead one to expect that poor farmers may be

less price responsive than others and, therefore, that both during the transition and in the new less static market environment, poor farmers may be less able than others to take advantage of opportunities.

First, poor farmers are more likely to face credit constraints due, in part, to lack of collateral availability. Second, poor farmers are likely to be constrained by their low-quality natural resources, particularly land, which limits the range of crops that can be efficiently grown. Some land could be improved via erosion control, improved fertilizers, access to irrigation, or use of fallow periods, but these options require resources that the poor farmers generally do not have, and also take time to implement. Thus poor farmers may be unable to change their crop and production techniques.

Third, unlike large farms which may face an essentially elastic supply of hired labor, small farms are more likely to depend on family labor which has few alternatives and which therefore can be considered quasi-fixed. Without much flexibility in hiring labor, these farmers may be expected to exhibit less price responsiveness. Fourth, the average poor farmer has achieved a lower level of formal education than other farmers. Without the skills needed to adopt new crops and production techniques or to move into non-agricultural activities, farmers may face a drop in income with any adverse change in relative prices. Finally, poor farmers by definition lack a reserve of financial resources for adjusting to shocks. A natural disaster could have immediate and lasting effects on farm productivity, which could not be offset by using more inputs, as it could by farmers with more financial resources.

This paper focusses on the first of these arguments for lower price responsiveness by

poor farmers, although we recognize that all may be important. Some of the others will be incorporated in a more general model and tested with a larger dataset as part of the ongoing followup to the current study.

I.3. Approach of the paper

The work described here will begin to answer the questions of how farmers in Mexico have adjusted to the recent structural changes, and what constraints they face, with a special focus on poor farmers. To do this, we first provide an empirical description of a sample of Mexican farmers, according to production, land and household characteristics. This includes a comparison of characteristics in 1991 and 1993 of the same households to illustrate how they have responded to, and been affected by, changes in the economic environment. We also divide the sample according to productive capital asset use to focus on the question of how relatively poor farmers differ from the other groups. (The way in which these groups are defined is explained in the Appendix.)

We next formalize the hypothesis that farmers with lower wealth are less price responsive than richer farmers, in the sense that the former show not only lower levels of agricultural production at a given price, but also impaired responsiveness to changes is prices. We then empirically test the implications of the model in our sample. The final section of the paper discusses conclusions and policy recommendations.

The empirical work in the paper is based on the results of two surveys. The first was conducted in 1991 in four states -- Sonora, Puebla, Tlaxcala, and Guanajuato -- for 881 farmers, including both *ejidatarios* and private farmers. Although the 1991 survey was not

specifically designed to address the issues raised in the current study, it included many relevant questions, which we exploit here. It was not designed to be representative in all respects of Mexican agriculture as a whole.

Sonora, situated in the northwestern part of Mexico, has received significant investment in its infrastructure, including irrigation and marketing facilities. The soils, except for recent concerns about salinization, are generally considered very fertile and the mix of production is concentrated in fruits and vegetables more so than the other states in our sample. Much of Sonora's production is intended for export to the United States.

Puebla and Tlaxcala, on the other hand, have fewer production amenities. Irrigation has not been widely available and the land is of low quality. Farmers are much more dependent on grain production and government subsidies.

Guanajuato falls somewhere near the middle of these extremes. In general, the lands and access to infrastructure are more heterogeneous than in the other regions: some farmers have more in common with their Puebla/Tlaxcala counterparts, while others compare to Sonora farmers. The *Bajío* valley of our study area is noted for variability in fertility with few very poor quality areas. However, access to irrigation is not as common as in the northwestern states.

In 1993, a limited re-survey for the current study was carried out in Guanajuato, which was chosen based on its heterogeneity. Although approximately 95 farmers were successfully located during the survey period, only 85 surveys have been accepted for analysis due to internal inconsistency or incompleteness of the others. The sample was selected via a random draw of the 300 farmers surveyed in Guanajuato in 1991, and consists

in large part of *ejidatarios*. This rather lop-sided representation, along with the small sample size, makes it difficult to draw conclusions particular to tenure class. However, the vast majority of farmers in Mexico are *ejidatarios*, so the conclusions based on this sample are still broadly applicable. As Guanajuato is not one of the poorest areas, some characteristics of this sample may not reflect those of Mexico as a whole, especially with respect to the very poorest farmers.

The organization of the remainder of the paper is as follows: Section II contains a detailed discussion of farmer characteristics, including an examination of how these have changed, and how their conditions and practices relate to their wealth. Section III presents a theoretical model emphasizing the way in which wealth affects the level and price-responsiveness of supply, and Section IV describes the empirical model used to test this theory. In Section V, we discuss the main empirical findings. Section VI concludes.

II. Statistical Description of Farmers

II.1 Overview

A principal goal of this study is an understanding of the characteristics and practices of Mexico's farmers, especially the poor, and how these characteristics and practices have been modified by changing economic conditions. The analysis in the previous sections implies that in a period of rapidly changing incentives, the poor-- and especially those without access to assets-- would not be expected to fare as well as the non-poor. But it cannot predict to what extent this would produce an observable deterioration in their relative position in response to specific changes such as those in the Mexican economy in the recent

past. In this section, we statistically describe the two samples according to various indicators of their socio-economic condition and farming practices. We compare these indicators across different groups within each year's sample and across years. This is intended not only to descriptively characterize the farmers in the samples, but also to suggest potential connections between observed changes in the sample and structural changes in the economy.

II.2 Comparisons of groups based on access to productive capital inputs

In this section, we construct an index of farmers' land holdings and access to other production-enhancing capital inputs using the full 1991 survey results. The purpose of this exercise is to gain a clearer understanding of the characteristics, conditions and practices of different economic strata of farmers, by distinguishing between three broad groups.

We refer to these groups as "capital inputs groups" (CI groups). (See Appendix 1 for the definition of the groups and the distribution of farmers across the groups). The capital inputs to which a farmer has access is not the same as the value of all assets owned by a farmer (the variable "A" in the theoretical model below). Rather, the definition of CI groups in this section is intended to proxy the potential permanent income of each farmer by focussing on productive potential. Access to these productive assets is a more reasonable proxy for this than would be either current income or total assets, which includes assets that are not involved in producing future income (e.g., housing). Given the absence of any universally accepted indicator of relative welfare or poverty, we judge this to be the most reasonable for our purposes. In the Appendix, section A.1, we give more details about the distribution of farmers across the criteria and motivate our definition of the groups. In this

section, we discuss the resulting statistical characterization of the groups.

Table 1 provides descriptive statistics for our groups on a wide variety of variables. With respect to cropping patterns, the importance of corn to producers drops significantly[1] as CI increase, with 77 percent of "low" farmers and only 11.5 percent of "high" reporting it as most important. This is consistent with the widely shared perception that poorer farmers rely more on corn and beans than other crops. Wheat, on the other hand, increases significantly in prominence as principal crop as CI increase, from 5.2 percent of "low" CI farmers to over 58 percent of the "high" group. Sorghum is most often reported as the principal crop by the "medium" asset group, and approximately 5 percent of the farmers in each group report some type of vegetable as their most important crop.

Farmers in our "low" group produce significantly fewer crops than the other two groups, which do not significantly differ from each other. That is, the farmers who either have no access to irrigation and harvest machinery or whose land holdings are small produce fewer products on average than other farmers.

An area of particular concern in Mexican agriculture is access to credit. The evidence from our sample indicates that there is a significant association between higher CI and higher credit per hectare. Further, the percentage of farmers who ask for credit that actually receive it rises with CI group, from 58 percent for the "low" group to 79 percent for the "high," while the percentage that reports problems with obtaining credit drops

[1] Statistical tests are conducted in pairs of asset groups. Differences in means are tested for value variables using SAS' Proc Test. For frequencies, a method described in Fleiss (1973) is used.

significantly as CI increase.[2] The farmers receiving higher credit and reporting fewer problems in getting it are the ones with access to irrigation or harvest machinery or who own or work larger parcels of land.[3]

The dependence of farmers on the labor market is also shown in Table 1. A significantly larger proportion hires labor as CI increase, and the "high" group hires significantly more workers on average than either other group. This may reflect greater land sizes and therefore scale of operation, or perhaps a greater production of cash crops such as vegetables, which are often hand-picked. It may also just reflect a less binding financial constraint on hiring. An interesting result is the lack of statistical difference in the wages paid by all three groups, which seems to indicate a well-functioning rural labor market.

The proportion of farmers who purchase seeds, use fertilizer, use pesticides, and prepare soil with a tractor increases with CI group. The percentage that intercrop, often thought to be associated with poorer farmers, decreases with CI group. Thus the farmers who have larger land holdings or better access to large-scale capital more often use other variable inputs that generally increase productivity. Many fewer "low" CI farmers purchase seeds and use pesticides than in the other two groups. These are inputs not necessarily limited to large-scale operations for effectiveness, so farm size probably has less influence than the conditions that lead to farmers having no irrigation and no harvest machinery. On

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[2] A problem is indicated by any of several responses by the farmer, including: asked for credit, but was rejected; received less than requested; did not apply because interest rate is too high, or did not know how to obtain credit, or it was not available in the farmer's area.

[3] Unfortunately, we are unable to extend this analysis to interest rates paid on credit because many farmers are unaware of the rate they actually pay. This phenomenon arises in part from the nature of most *ejido* loan arrangements and indeed many independent credit deals which lead the farmer to focus more on what amount is to be paid back than what the implicit rate is.

the other hand, it is not very surprising that a significantly lower proportion of "low" CI farmers use a tractor to prepare the ground, as there are economies of scale for this.

Ownership of assets such as tractors, farm implements and vehicles is also more common as we move from "low" to "high" groups. To some extent, this might be correlated

Table 1: Comparison of indicators for capital input groups (values are percentages unless otherwise indicated)

	1991			
	Low	Medium	High	tests
Principal crop[1]:				
Corn	77.3	27.0	11.5	a,b,c
Wheat	5.2	32.8	58.1	a,b,c
Sorghum	3.8	25.9	16.2	a,b,c
Vegetables	4.7	5.4	5.3	
No. of crops produced	1.6	2.0	2.1	a,b
Credit indicators:				
Credit per hectare owned[2]	0.59	1.24	1.82	a,b,c
Ask for credit	27.0	65.9	91.2	a,b,c
Receive credit	15.7	44.6	70.7	a,b,c
Receive who ask	58.0	67.9	78.5	a,c
Report problems with credit	61.7	31.3	11.5	a,b,c
Input usage:				
Hire labor	63.3	76.2	84.9	a,b,c
No. of workers hired	3.1	3.0	5.1	a,c
Daily wage (pesos)	19,986	18,656	19,928	
Purchase seeds	26.3	84.7	95.3	a,b,c
Use fertilizer	75.7	91.2	94.0	a,b
Use pesticides	39.7	86.1	90.7	a,b
Irrigate	20.9	84.0	91.3	a,b,c
Use machinery in harvest	8.5	84.2	85.3	a,b,c
Use tractor in preparation of soil	62.5	96.9	97.3	a,b
Intercrop	19.3	5.8	2.0	a,b
Farm assets:				
Own tractor	6.7	36.4	59.3	a,b,c
Own farm implements	6.7	37.1	59.3	a,b,c
Own vehicles	12.3	32.3	70.0	a,b,c
Land characteristics:				
Km to nearest paved road	4.5	3.5	2.9	a,b
pct. Irrigated	22.9	68.8	84.3	a,b,c
pct. "Very Fertile"	6.6	17.4	21.3	a,b
pct. "Fertile"	51.5	67.6	65.7	a,b
pct. "Poor"	41.6	15.0	12.9	a,b
pct. with Flat terrain	61.0	82.1	88.6	a,b,c
pct. under Cultivation	82.5	95.1	90.9	a,b,c
Education of principal:				
No education	36.0	39.8	18.0	a,c
Up to completed primary	57.7	52.4	40.7	a,c
Up to completed secondary	4.0	3.4	19.3	a,c
Beyond secondary	1.7	3.7	21.9	a,c

[1] Principal Crop refers to the crop which the farmer reports as being his most important.
[2] Credit is reported in millions of 1991 pesos.
[3] pct. Irrigated and other characteristics indicate the percentage of land area, so the figure is an average.
Tests: a: low and high groups significantly different at least 10 percent confidence level.
b: low and medium groups significantly different at least 10 percent confidence level.
c: medium and high groups significantly different at least 10 percent confidence level.

with reported "use", which is a criteria of our group definition. However, many fewer farmers own farm machinery than use (e.g. 37 percent of "medium" own while 84 percent use farm machinery), so the effect is not just an artifact of the way the groups are defined. Rather, this result may reflect the unique status of *ejidatarios*. (Generally speaking, the *ejido* collective owns the larger machinery available to *ejidatarios*, who either rent it from the *ejido* or share use of the equipment.) A significantly higher proportion of farmers own either a car or truck as CI group increases, indicating that "high" CI farmers also have access to transportation, implying lower transaction costs. Along these same lines, we find that "low" CI farmers must travel a significantly greater distance to the nearest paved road than either other group.

"Low" CI farmers report a significantly lower proportion of their land as being "very fertile" or "fertile", and a higher proportion as "poor." Further, an average of 61 percent of the land area of the low CI farmers is flat, compared to 82 and 89 percent for the "medium" and "high" farmers, respectively. Finally, there also appears to be some positive correlation between "high" CI and education, though not between the other two groups.

II.3 Year comparisons

Because of the recent changes in the economic environment, we would expect to see changes in the behavior of farmers and in the structure of the agricultural sector. In this section, we report some of the results from the sub-group of 85 farmers who were questioned in both surveys. We also relate these findings to the economic policy changes underway in Mexico. Both the findings themselves and conclusions regarding their causal relationship

with the reforms must be regarded as only suggestive, given the small size of the sample and the other factors at work in the economic environment.

As illustrated in Table 2, changes occurred in cropping patterns. There was a significant increase in the number of farmers that planted corn and wheat as the principal crop (government incentives for these crops were high in this period), while sorghum showed a large decline. Overall, the number of crops produced by the average farmer increased. More of the sample in 1993 produced vegetables, and the average output of these crops increased, as well. The greater diversity of crops was also reflected in an increase in intercropping.

Diversification can have two effects. The first is to increase average income levels, when the result is higher production of high-value crops, especially fruits or vegetables. Levy (1991) found that "(d)iversification is one of the key mechanisms to increase the returns to land," and noted that in the North and Northwest regions, there was a great deal of this kind of diversification in response to market incentives, but not much in other parts of the country.

Another effect is to reduce risk. Farmers' perceived risk may have been higher in 1993 than in 1991. One reason is the removal of the parastatal CONASUPO's guaranteed support prices for some crops. Another is the reform in the credit markets, which eliminated the de facto requirement that all farmers participate in the crop insurance program. Increased risk from these sources would be expected to increase farmers' incentives to self-insure by diversifying their crop mix, as they have apparently done.

Other changes could be linked to the reforms in the land market. One of the reasons

for the reform program was the hope that it would lead to consolidation of uneconomically small parcels and the development of a more fluid land market. And, in fact, between 1991 and 1993, the average size of the holdings in our sample increased by about 18 percent[4]. Moreover, land rentals doubled, and land area used to produce crops increased by nearly one hectare (12%) on average.

Some changes are also evident in the factor markets for credit and labor. Recent reform would be expected to increase both credit demand and supply. The supply should increase because some *ejidatarios* can now use land as security, making them better risks for commercial lending (Feder and Feeny, 1991). The demand for credit, long-term credit in particular, should increase, since more secure tenure rights enhance the incentives to invest in property. Also, a virtual write-off of much of the farm debt held by the government lending institutions in 1992 may well have increased the demand for credit by creating a perception that debt would not have to be re-paid in the future. With both supply and demand increasing, the equilibrium volume of credit should unambiguously increase as well.

Indeed, the average credit received on a per hectare basis rose from 1.06 million pesos (about US$351) to 1.15 million (about US$381) in 1991 values, and the acceptance rate for credit requests of the farmers in our sample rose from 64 to 83 percent. Nevertheless, there is still a perception among our sample of farmers that credit is difficult to obtain. This is evidenced by a significant increase in farmers reporting problems in obtaining credit (from 29 to 53 percent). There was also a drop in the percentage of farmers asking for credit (from 68 to 57 percent.) While the fall in the number asking for credit,

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[4] De Janvry, et. al. (1995) also reported this pattern of land consolidation in the ejido sector.

Table 2: Comparison of indicators for sample of 85 farmers across years

Indicator	1991	1993
Hectares owned	8.32	9.79
Hectares rented	0.46	0.93
Hectares used	7.98	8.95
Principal crop[1]:		
Corn	30.5%	48.2*
Wheat	3.7	21.7*
Sorghum	47.6	24.1*
Vegetables	6.1	8.4
No. of crops produced	2.28	3.27*
Credit indicators:		
Credit per hectare owned[2]	1.06	1.15
Ask for credit	68.3	56.6
Receive credit	43.9	47.0
Receive who ask	64.3	83.3*
Report problems with credit	29.3%	53.0*
Labor characteristics:		
Hire labor	84.1%	69.9*
No. of workers hired	3.88	8.15*
Production characteristics:		
Purchase seeds	78.0%	69.9%
Use fertilizer	90.2	94.0
Use pesticides	78.0	91.6*
Irrigate	72.0	80.7
Use machinery in harvest	63.0	81.9*
Use tractor in preparation of soil	90.1	92.8
Intercrop	13.4	22.9
Km to purchase seeds	10.51	8.83
Km to purchase fertilizer	10.73	9.14
Farm Assets:		
Own home	95.1	100.0
Own tractor	41.5	44.6
Own farm implements	41.5	44.6
Own vehicles	28.0	33.7
Income-related Characteristics:		
Households with off-farm income	37.8	54.2*
No. of family members with off-farm jobs	0.61	1.08*
Education of principal:		
None	58.5%	51.8
Up to completed primary	37.8	42.2
Up to completed secondary	0.0	0.0
Beyond secondary	2.4	3.6

* Indicates that the value in 1993 is significantly different from the 1991 value at least a 10 percent confidence level.
[1] Principal Crop refers to the crop which the farmer reports as being his most important.
[2] Credit is reported in millions of 1991 pesos.

although small, is somewhat puzzling, these results overall seem to be consistent with a hypothesis that the availability of credit is improving.[5]

Labor market conditions have also changed. A smaller fraction of the sample hired labor in 1993, which is consistent with the finding of Heath (1990) that the fraction of *ejidatarios* that hire labor is decreasing. But at the same time, the average number of workers hired (by those that did hire some) increased greatly. Thus, the net employment of workers increased in 1993 to about 2.1 times its 1991 level. Also, farm households' participation in the off-farm labor market increased. The number of households reporting off-farm income rose from 38% in 1991 to 54% in 1993, while the average number of family members with this type of employment went from 0.61 to 1.08. One explanation of the increase in off-farm labor is that the rural and nonrural labor markets are becoming better integrated.

Farmers' access to other purchased inputs seems to have improved. The distance reported to the nearest seed and fertilizer marketing outlets dropped between 1991 and 1993, as would be expected from the privatization and deregulation of marketing channels. The use of most purchased inputs and improved production practices (fertilizer, pesticides, irrigation, harvest machinery, tractor to prepare the soil) increased, though the rate of use of some was already quite high in 1991. (The sole exception was the use of purchased seeds, which declined slightly.) The increase in the incidence of use of these inputs is especially interesting in light of their higher cost (due to removal of fertilizer subsidies), the stronger efforts to recover costs of providing irrigation through higher user charges, and the relaxation of the link between credit and pre-determined input packages.[6] This is consistent with other findings that farmers are willing to pay more for inputs when they have more

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[5] De Janvry, et. al. (1995) found that access to credit increased modestly between 1990 and 1994, but that the volume of credit to the ejido sector declined as loans became smaller.

[6] De Janvry, et. al. (1995) report that in corn production on ejidos, the use of most purchased inputs declined between 1990 and 1994. Their sample also showed substantially lower use of purchased inputs in both years than did our sample.

control over the quality and conditions of provision (Knudsen and Nash, Postel).

Because of problems with the survey, it is difficult to describe changes in the level of income received by the farmers. However, a number of alternative measures seem to indicate that, in many ways, farmers are better off in 1993 than they were in 1991. First, the ownership of assets-- including home, tractor, other farm implements, and vehicles-- has increased. Second, the educational achievement in the sample has improved, with the fraction reporting no education dropping from 59% to 52%.[7] While gains in both areas have been modest, they must be interpreted in light of the short time elapsed between the surveys. In addition, the improved access to production technologies, as well as to off-farm work, appears to indicate that farmers in 1993 had more options, and were therefore arguably better off than before.[8]

II.4 CI Groups Across Years

To get some preliminary indication of how changes between 1991 and 1993 in the conditions and practices depended on the farmers' access to productive assets, we divided the 85-household sample into CI groups according to the previously described criteria. Conclusions regarding changes over time for each of these groups are even more tenuous than those based on the sample of 85, principally because of the small size of the groups, especially the "high" group. Tables A3 and A4 in the appendix present figures comparing the groups in the two years. In the paragraphs below, we briefly summarize a few of the main patterns that seem to emerge.

The evidence of increased diversification of cropping is similar for all groups.

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[7] The education level used in the calculations corresponds to the head of household. In some cases, between 1991 and 1993, the person designated as head of household changed (within the same family), usually from an elderly father to his son. Thus, while other household characteristics remain unchanged, the education level of the person responsible for most decisions could change dramatically.

[8] It is not clear what is indicated by a change in the fraction of the farm population that receives off-farm income. Lustig interprets an increase in off-farm income sources as a sign of distress in farm households in the early 1980s, basically a supply-side explanation. We, on the other hand, tend to view this as a demand-driven phenomenon, with farmers being drawn to off-farm jobs because they pay better and are less risky than farm income. Certainly, this is what has occurred in other economies as they have developed and industrialized. In this case, an increase in off-farm income indicates an increase in welfare.

However, the pattern is strongest in the high group, and weakest in the low group. Consequently, whereas in 1991 there was little difference among the groups, in 1993 the high group farmers were the most diversified (4.1 crops) and the low group the least (2.6 crops).[9] There were no clear patterns of change among the groups with respect to intercropping.

In the credit market, the credit per hectare increased for the low and high groups, while falling for the middle group. This is accompanied by an increase for all three groups of the acceptance rate of credit requests. The fraction reporting credit problems, on the other hand, stayed the same for the low group, while rising for the other two.

The number of farmers who hired labor decreased in the lower two groups, while rising in the high group. The number of workers hired increased in the lower two groups and stayed virtually the same for the high group. The rate of participation in off-farm labor markets fell slightly for the low group, while rising most for the medium and rising slightly for the high.

The improvement in production practices was most marked for the low asset group. This group showed large increases in the number of farmers purchasing seeds, using fertilizer, using pesticides, irrigating, using harvest machinery, and using a tractor to prepare the soil. The changes in the other groups were small, though they began from much higher bases in 1991. Consequently, the differences among the low, medium, and high groups narrowed substantially. The reported distance to purchase both seeds and fertilizer fell for all groups.

There has been considerable discussion of whether structural reforms hurt the poor. (For a survey, see Berg, et. al., 1993) Since our data only covers the period since 1991, which was well after many of the economy-wide reforms had taken place, they cannot shed much light on the effects of structural adjustment in general. However, many of the reforms that affected specifically the agricultural sector began about this time or later. An analysis of

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[9] De Janvry, et. al. (1995) found that small ejido farmers changed more of their area from monocropped corn to intercropping than did larger farmers. By this measure, small farmers became more diversified to a greater extent than large.

the change in welfare of the low-asset group from 1991 to 1993 may be informative.

On balance, the low CI group seems to have been better off in 1993 than in 1991, though the indicators do not all point to this conclusion. On the negative side, the education level in this group fell slightly and fewer of these households had off-farm income. But, their production practices improved across the board, their credit per hectare more than doubled, and the rate of ownership of assets (tractors, farm implements, and vehicles) increased substantially. These results suggest, though they cannot prove, that Berg, et. al. were justified in their skepticism regarding the claims that the poor become worse off during a period of adjustment.

III. Structural Model

The linkages between a farmer's wealth and supply responses can be motivated through various alternative theoretical specifications. We provide here one simple model that illustrates that the level of net total assets and the use of productive capital assets will positively affect output supply level and price responsiveness.

The theoretical model assumes that the marginal cost of credit is not equal for all farmers but rather that it varies according to the degree of "credit worthiness". Thus, the marginal cost of credit, r, is assumed to be an increasing and convex function of the amount borrowed relative to the net wealth of the farmer,[10]

$$(1) \qquad r = r\left[\frac{p_K(K - K_I)}{A}\right], \quad r' > 0, \quad r'' > 0,$$

where K is productive capital used by a farmer,[11] K_I is capital stock owned by the farmer,

[10] See Chambers and López (1987) for a detailed justification of this specification.

[11] K can include, for example, machinery, equipment, land and productive structures such as barns or silos.

p_K is the asset price of capital, and A is net total wealth, including both agricultural and non-agricultural assets. Thus, $K - K_I$ is the level of debt of the farmer, which we assume to be non-negative. That is, we assume that farmers use some capital financed by borrowing. The fact that the function $r(\cdot)$ is increasing reflects lenders' perception of greater risks as the debt/equity ratio of borrowers rise and, as a consequence, farmers with higher debt/equity ratios are required to borrow from lenders (usually in the informal sector) that are willing to lend at higher interest rates to compensate for the risks involved. The greater riskiness of lending to farmers with relatively low assets could reflect 1) their reduced ability to collateralize the loan; or, 2) the increased risk that their production will fall below the threshold that would be sufficient to re-pay the loan, since fewer productive assets reduce the average, or increase the variance, of agricultural yields.[12]

We assume that farmers maximize profit and, for simplicity, we postulate a constant returns to scale production technology. The profits accruing to the capital stock owned by the farmer, K_I, are given by

$$J \equiv \max_{K} \left[\pi(p, w)K - r\left(\frac{p_K(K - K_I)}{A}\right) p_K(K - K_I)\right] \tag{2}$$

where $\pi(p, w)$ is a (dual) per unit of capital profit function, p is output price, and w is a vector of non-capital input prices.[13] Thus, rp_K is the rental price of capital.[14] For simplicity, let p_K be normalized to 1, so that it can be dropped from subsequent derivations.

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[12] In a credit model in which a debtor will default if his income falls below a threshold, a mean-preserving spread of income will increase the probability of default, as it increases the fraction of the distribution below the threshold.

[13] A more proper specification is a dynamic model in which savings are endogenous and households can affect K_I and A in the long run. Here, for simplicity, we ignore the intertemporal aspects of the problem. See Chambers and López (1987) for a full intertemporal specification.

[14] This should also have a depreciation component, but the ensuing results are not affected by its omission.

The profit function $\pi(\cdot)$ is linearly homogenous and convex in p and w. The first order condition of the above problem is:

$$\pi(p, w) = r(\cdot) + r'(\cdot)\,\frac{(K - K_I)}{A}, \tag{3}$$

From (3), one solves for $K^* = K(p, w; K_I, A)$. Differentiating (3), one can obtain expressions for the effects of p, K_I and A on K^*

$$\text{(i)} \qquad \frac{\partial K^*}{\partial p} = \frac{\pi_p}{\frac{2}{A}r' + r''\,\frac{(K - K_I)}{A^2}} > 0, \tag{4}$$

$$\text{(ii)} \qquad \frac{\partial K^*}{\partial K_I} = 1,$$

$$\text{(iii)} \qquad \frac{\partial K^*}{\partial A} = \frac{K - K_I}{A} > 0.$$

Thus, as long as a farmer is a net borrower, i.e. $K - K_I > 0$, the effect of wealth on the level of capital used is positive. To illustrate the ensuing analysis, it is convenient to specify a functional form for $r(\cdot)$. For simplicity, we can use the following specification:

$$r = b\left[\frac{K - K_I}{A}\right]^{\beta}, \quad \beta > 1, \quad b > 0. \tag{5}$$

If $\beta > 1$, then the function $r(\cdot)$ is increasing and convex. In this case, expression 4(i), using (3) expressed in elasticity form, becomes

$$\frac{\partial \ln K}{\partial \ln p} = \frac{1}{\beta}\,\frac{(K - K_I)}{K}\,\frac{\partial \ln \pi}{\partial \ln p}\,(p, w). \tag{6}$$

Using Hotelling's lemma, the aggregate output supply of the farmer is,

(7) $$y = K^*(p, w, p_K; K_I, A)\ \pi_p(p, w).$$

Also, using 4(ii) and 4(iii) it is clear that farm output is an increasing function of K_I and A. That is, wealthier farmers produce more than poor farmers if the latter face the same prices and have identical technology as the former. Note that since both $\pi_p(\cdot)$ and $K^*(\cdot)$ are homogenous of degree zero, y is also homogenous of degree zero in p, w, and p_K.

The output supply response can be obtained from (7) by logarithmic total differentiation with respect to p,

(8) $$\frac{d\ln y}{d\ln p} = \frac{\partial \ln \pi_p(p, w)}{\partial \ln p} + \frac{\partial \ln K^*(p, w, p_K; K_I, A)}{\partial \ln p}.$$

Using (6) in (8) we obtain,

(9) $$\frac{d\ln y}{d\ln p} = \frac{\partial \ln \pi_p(p, w)}{\partial \ln p} + \frac{1}{\beta}\,\frac{K - K_I}{K}\,\frac{\partial \ln \pi}{\partial \ln p}.$$

The effect of K_I and A on the elasticity of supply can be derived from (9) by differentiating and using 4(ii) and 4(iii), respectively,

(10) (i) $$\frac{d(d\ln y/d\ln p)}{dK_I} = \frac{\partial \ln \pi(p, w)}{\partial \ln p}\,\frac{1}{\beta}\,\frac{K_I}{K^2} > 0,$$

(ii) $$\frac{d(d\ln y/d\ln p)}{dA} = \frac{\partial \ln \pi(p, w)}{\partial \ln p}\,\frac{1}{\beta}\,\frac{K_I}{K^2}\,\frac{(K - K_I)}{A} > 0,$$

Thus, farmers that have more farm capital and more net assets are more responsive to price changes (i.e., have greater price elasticities) than other farmers.

In summary, this analysis demonstrates that farmers' wealth (owned assets) affects both output levels and the ability to respond to price fluctuations. Rich farm households are likely to have higher production and to be more responsive to price changes. Testing these

two propositions and providing insights about their quantitative nature is a main objective of the empirical work.

One implication of this is that poor farmers benefit less from dynamic conditions. It is well known that the average or expected farm income increases with price variability[15]. Consider a farm (dual) profit function $G = G(p, \theta)$ where p is output price and θ are other variables that affect farm profits (including input prices, etc.). Assume for simplicity that only p is subject to stochastic fluctuations and θ is constant. $G(\cdot)$ is convex in p and moreover $G_p = y$ by Hotelling's lemma. $G(\cdot)$ can be approximated to the second order by using Taylor's expansion,

$$G(\cdot) \approx G(\bar{p}, \theta) + G_p(\bar{p}, \theta)(p - \bar{p}) + \tfrac{1}{2} G_{pp}(\bar{p}, \theta)(p - \bar{p})^2,$$

where $\bar{p}$ is the average price. The expected farm profits are,

$$E(G) = G(\bar{p}, \theta) + \tfrac{1}{2} G_{pp}(\bar{p}, \theta)\, V(p),$$

where V(p) is the variance of prices. Equivalently we can represent E(G) as,

$$E(G) = G(\bar{p}, \theta) + \frac{1}{2} \frac{G_{pp}(\bar{p}, \theta)}{G_p(\bar{p}, \theta)} \bar{p} \frac{V(\bar{p})}{\bar{p}}$$

$$E(G) = G(\bar{p}, \theta) + \frac{1}{2} \epsilon(\bar{p}, \theta)\, \rho(\bar{p}),$$

where $\epsilon(\bar{p}, \theta)$ is the output supply elasticity and $\rho(\bar{p})$ is the ratio of variance to average price[16]. Thus, an increase in the variability of prices, which should be one of the outcomes

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[15] This assumes that supply in each period responds to the current price. This is the assumption adopted in most analyses of the effects of price instability (see, for example, the early works in this area by Waugh (1944) and Oi (1961), or later work by Brook, et.al. (1978) and Just, et.al.(1977)). An alternative assumption is that production decisions are based on expected, rather than realized price each period, so that as long as the subjective distribution of prices does not change, the distribution of supply will remain the same (see Newbery and Stiglitz, 1981).

[16] In this derivation, G_p, which by Hotelling's lemma is the output level, is normalized to one.

of abandoning guaranteed support prices and linking domestic and world markets, will have a positive effect on expected or average farm profits. But since ϵ is smaller for poor than for wealthy farmers, the former will benefit less than the latter from increased price variability.

IV. The Empirical Model

The theoretical specification of output supply for each farm-household in equation (7) suggests that output is a function of output prices, variable input prices, productive capital stock and total net assets of the household including non-agricultural assets. We consider two variable inputs, namely, total labor and fertilizers. Capital stock, K, is represented by use of farm machinery and equipment; and farm assets, the variable A in the previous section, is computed as the sum of the value of land, machinery and equipment, vehicles, animals, buildings, and savings, if any.[17] Since we are interested not only in the effect of farm capital and assets on the level of output but also on the price responsiveness, we include interactive terms that capture this. We also include a dummy for use of irrigation as a determinant of output and an interactive term, since it is also considered a productive asset.

Thus, the general specification is,

$$y_{it} = F(\tilde{p}_{it}, \tilde{w}_{it}, \tilde{q}_{it}; K_{it}, A_{it}, I_{it}), \tag{11}$$

where y_{it} is output of farmer i at time t
$\tilde{p}_{it}$ is output price
$\tilde{w}_{it}$ is the wage rate
$\tilde{q}_{it}$ is the price of fertilizer
K_{it} is machinery, equipment and structure (dummy)

[17] In cases where the farmer indicates owning a particular asset but does not know or provide a value, the variable is assigned a predicted value based on the results of regressions that use the observations of farmers with complete information. Explanatory variables in these regressions include the characteristics of both the asset and the farmer.

A_{it} is the level of farm assets
I_{it} is access to irrigation facilities (dummy), and

Since $F(\cdot)$ is homogenous of degree zero in $\tilde{p}_{it}$, $\tilde{w}_{it}$, $\tilde{q}_{it}$, we can normalize by $\tilde{q}_{it}$ and define $p_{it} = \tilde{p}_{it}/\tilde{q}_{it}$, $w_{it} = \tilde{w}_{it}/\tilde{q}_{it}$. Also, we specify an extended logarithmic function for $F(\cdot)$,[18]

$$(12) \quad \ln y_{it} = \alpha_0 + \alpha_1 \ln p_{it} + \alpha_2 \ln w_{it} + \alpha_3 D^K_{it} + \alpha_4 \ln A_{it} + \alpha_5 D^I_{it} + \alpha_{13} \ln p_{it} D^K_{it} + \alpha_{14} A_{it} \ln p_{it} + \alpha_{15} \ln p_{it} D^I_{it} + \alpha_{23} \ln w_{it} D^K_{it} + \alpha_{24} A_{it} \ln w_{it} + \alpha_{15} \ln w_{it} D^I_{it} + \tilde{f}_i + \epsilon_{it}$$

where D^K_{it} is a dummy equal to one for farmers that use machinery and zero otherwise, D^I_{it} is a dummy that is equal to one for farmers that have access to irrigation and zero otherwise. $\tilde{f}_i$ are household fixed effects. ϵ_{it} is a stochastic disturbance term.

A few comments are in order about specification (12). First, the α_{1j} ($j = 3, \ldots, 5$) coefficients are intended to capture the effects of farmers' capital and assets on the own-price supply elasticity. If the hypotheses presented in the previous section hold, the α_{1j} ($j = 3, \ldots, 5$) as well as the α_k ($k = 3, \ldots, 5$) coefficients should have non-negative values. Second, the "pure" wealth effects of the resources owned by farmers are difficult to separate from the productive effects of resources actually used by farmers since there is a high degree of correlation between resources owned and actually used.[19] Thus, the coefficients α_{1j} ($j = 3, \ldots 5$) and α_k ($k = 3, \ldots, 5$) measure both the productive as well as the pure effects that occurs through the marginal cost of capital.

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[18] The assets variable is included as a level, not logarithmic, form in the interactive terms, making the α_{14} and α_{24} parameters easy to interpret as the change in output elasticity per unit change in assets.

[19] This is a reason why we do not intend to control for the asset price of capital goods separately.

Third, we have less reliable quantitative values for farm capital and irrigation than about whether or not farmers own or use such resources. For this reason we use dummy variables for these. Fourth, we allow output prices to differ across households and thereby reflect the existence of transaction costs in the formation of effective household-level prices. Household level prices are thus likely to be endogenous and need to be instrumentalized. We use variables such as total household land ownership, technology, receipt of credit and income groups, as instruments. Fifth, given the findings of other investigators that education can affect supply response, we include the education level of farmers as both independent regressors and interaction terms with price and wage.

Finally, the model emphasizes the relationship between assets or net debt and the marginal cost of credit. This may lead some to question its applicability to the *ejidatarios* whose credit is often arranged by the *ejido* authorities rather than individually. However, official and most commercial credit that is lent to the collective still depends on the viability of the group, both from credit history as well as collective productivity. Further, *ejidatarios* in our sample do report credit from sources other than BANRURAL and FIRA, presumably marginal credit at higher interest rates.

One approach to the estimation of the model would be to use first differences in order to eliminate the household specific fixed effects. A problem of doing this when there are interactive terms is, however, that unless the two components of the interactive terms both vary through time there will be perfect collinearity between the combined variable and the single variable that changes through time. We did try to estimate the model in first differences, but this problem was insurmountable. We thus estimate the model in levels, but

must recognize that this introduces some bias if the fixed effects are correlated with other explanatory variables. In future work with a larger sample, we will use other techniques to resolve this problem.

V. Results

Table 3 reports the results of estimating various specifications of equation (12), without a fixed effects variable. Output level and price are aggregate measures, with the aggregate output index defined as the value of output divided by the aggregate price index (per ton). Both the output price and the wage rate are normalized by the price of fertilizers. We use the total value of assets reported by the farmers, and for capital, we include both access to harvest machinery, and access to irrigation (both dummy variables).[20] The education level of the farmer is defined as the number of years of schooling which were completed.

In general the goodness-of-fit of the estimates presented in Table 3 are satisfactory given the rather small sample size. The F-statistic is highly significant, and the adjusted R^2 is quite satisfactory especially when one considers that cross-sectional units vastly outnumber the units of time. Tests for heteroskedasticity following White (1980) were performed and we were unable to reject homoskedasticity at even a 10 percent level of confidence.[21]

Column (i) reports the estimated coefficients using a log-linear specification with no

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[20] Land area used in production is not included as a separate regressor primarily because it is highly correlated with the value of assets, since for many farmers, land constitutes the primary asset. Therefore, we would expect the relationship between output and the value of assets to be positive, independently of the relation expected from the theoretical model. This is not true, however, of the price-asset interactive term.

[21] Test statistic is embodied in a SAS sub-routine.

interactive terms between variables. The coefficient associated with the price variable is positive, but not significant, while that associated with the wage is negative and significant as expected. The effects of machinery, irrigation, value of assets, and level of education are all positive and highly significant, and are consistent with the model of the previous section. The coefficient of the year dummy is also positive and significant, indicating that there was an increase in productivity from 1991 to 1993 that is not captured in the effects of the variables we include.

To allow the wealth variables to affect the slope coefficients of the output price and wage, we include interaction terms. Column (ii) shows the estimates when allowing only machinery and the value of assets to affect both the level of supply and the responsiveness of supply to price and wage changes. (That is, irrigation and level of education are dropped from this specification.) Farmers with access to machinery for harvest have positive and significant price responsiveness in comparison to those without this access. Further, the greater the value of the farmer's assets, the greater his price responsiveness. In fact, as shown in table 4, farmers with access to machinery are the only ones that exhibit a positive and significant response to price changes, and this responsiveness increases both in size and significance as the value of assets increases.

Interestingly, the individual effect of access to machinery on the wage response is positive and significant, possibly indicating the replacement of machinery for human labor. In addition, the effect of higher assets on wage responsiveness is low, positive, but insignificant, indicating virtually no effect. In fact, the estimated elasticities given in table 4 show that it is farmers who do <u>not</u> have access to machinery for harvest who have the

significant negative response to wage changes, and that this response varies little with increases in assets.[22]

Finally, we note that access to machinery and the value of a farmer's assets continue to have positive and significant independent effects on output as reflected by the coefficients on the non-interactive terms. This means that their effect on output is not limited to their effect on the price and wage variables.

Column (iii) of table 3 displays estimates allowing both irrigation and the education level of the farmer to enter as independent regressors and in interaction terms, otherwise maintaining the specification of column (ii). Farmers with access to harvest machinery exhibit positive and significant price responsiveness, as do those with access to irrigation. Higher asset values contribute to greater responsiveness, while the level of a farmer's education apparently does not contribute significantly. In table 4, in fact, the most significant supply responsiveness to changes in output prices arises from farmers with both harvest machinery and irrigation and who fall in the highest tercile of asset values. For lower asset values, the response is less significant. No other set of farmers exhibits a significant positive response to output prices, and those with neither machinery nor irrigation show a negative response.[23]

Further, while higher education levels and access to irrigation demonstrate the

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[22] The output price and wage elasticities of table 4 are calculated for groups of farmers based on the value of their assets. Using the entire sample of farmers from 1991 (approximately 880), the sample is sorted by increasing assets, divided into thirds, and assigned by these terciles into an asset "group".

[23] While we expect the farmers with little access to productive assets to show a lower price elasticity, we are skeptical of the finding of a negative value, or one that does not differ significantly from zero. We will investigate this further with a larger sample.

negative relationship we might expect with the wage, the effects are not significant. However, the positive impact of both access to harvest machinery and higher value of assets that was found in column (ii) is again apparent, although in this case both are significant. The resulting elasticity estimates indicate, however, that all farmers exhibit some negative response to increases in wages, with the most significant response arising from farmers without access to harvest machinery or who fall in the lowest asset groups. These are presumably the farmers who depend the most on hired and own labor to harvest their production.

To summarize, in all specifications, the impact of higher asset values is positively and significantly related to higher output levels and, in the two specifications that test this, to greater price responsiveness. This is consistent with the predictions of the theoretical model.

VI. Conclusions

One purpose of this study was to monitor the condition of Mexican farmers (with special focus on the poor) during a period of rapidly changing policy environment. This was done by re-examining "baseline" data from a large survey in 1991, and by comparing the results from a re-survey of a smaller sample of these farmers in 1993 with their responses in 1991. These data have a number of limitations, including the smaller size and geographically more homogeneous nature of the 1993 sample, as well as problems inherent to panel survey data. The results must be interpreted with some caution. Nonetheless, a number of interesting, if tentative, conclusions emerge from this analysis.

From the large 1991 sample, it appears that the farmers with more limited use of

productive capital assets (the "low capital input" group) were more likely to grow corn as their principal crop, and grew fewer crops on average, than the other farmers. They also had less access to and more problems with credit, and were less likely to use purchased inputs, such as seeds, fertilizer, pesticides, or to use a tractor for soil preparation. Their land was of lower quality on average, and their educational level lower.

The comparison across years for the sub-sample indicates that in general, conditions have improved for the average farmer in the sample area. Cropping patterns have become more diversified. The average size of land holding has increased. The average farmer receives more credit in real terms than in 1991. More farm households receive income from off-farm work. Purchased inputs have become more accessible, with a consequent rise in the incidence of use. Asset ownership and educational attainment have also improved modestly. Conclusions based on comparisons of the "CI groups" across time must be looked upon as even more tentative than those using the whole sub-sample. But what this comparison indicates is that in several ways, the "low" group fared as well or better than the other groups. The evidence includes their increased use (more so than the other groups) of credit, irrigation, machinery, and purchased inputs, as well as their greater asset ownership. On the other hand, the level of educational achievement fell for this group, and fewer had off-farm income than in 1991.

Table 3: Instrumental-variable estimates of output supply equation (in natural logs) 1991 and 1993 data

Variable	(i)	(ii)	(iii)
Intercept	-4.80 (-2.28)**	-6.22 (-1.70)*	-5.68 (-.91)
Predicted price	1.33 (1.43)	-2.17 (-1.26)	-7.40 (-2.32)**
Predicted price and Machinery[1]		4.11 (2.49)**	5.56 (1.97)*
Predicted price and Asset value		1.00 (2.11)**	1.61 (1.66)*
Predicted price and Irrigation[1]			3.23 (1.87)*
Predicted price and Education level			.256 (.76)
Real wage	-1.83 (-3.27)***	-2.83 (-2.87)***	-3.10 (-1.78)*
Real wage and Machinery[1]		3.25 (3.13)***	2.05 (1.71)*
Real wage and Asset value		.137 (1.21)	.513 (2.69)***
Real wage and Irrigation[1]			-.273 (-.14)
Real wage and Education level			-.003 (-.06)
Dummy: Use machinery in harvest	1.26 (3.07)***	11.77 (3.10)***	6.52 (1.48)
Asset value	.573 (4.19)***	.603 (4.57)***	.962 (4.11)***
Dummy: Irrigation	.718 (2.10)**		-.747 (-.11)
Education level (# years)	.365 (2.16)**		.239 (.51)
Dummy: Year	.484 (1.93)*	.274 (1.55)	.454 (1.89)*
Number of observations	74	159	75
F-statistic	15.86	18.86	10.56
Adjusted R^2	.58	.50	.73

Output price, wage, asset value and education levels are expressed in natural logs except in the case of interaction terms, when asset value and education are expressed in levels.

[1] indicates term is in Dummy variable form.
t-statistics in parentheses

* significant at 10 %
** significant at 5 %
*** significant at 1 %

Table 4. Elasticities of output supply

Column (ii) of table 3:

Asset group	Farmers with harvest machinery	Farmers without harvest machinery
Output price		
"low" group	1.97 (3.10)	-2.14 (-1.25)
"medium" group	2.07 (3.28)***	-2.05 (-1.22)
"high" group	2.53 (3.89)***	-1.50 (-.98)
Wage		
"low" group	0.429 (1.13)	-2.83 (-2.87)**
"medium" group	0.442 (1.17)	-2.81 (-2.86)**
"high" group	0.504 (1.34)	-2.74 (-2.78)**

Column (iii) of table 3:

Asset group	Farmers with machinery and irrigation	Farmers with machinery but not irrigation	Farmers without machinery but with irrigation	Farmers with neither machinery nor irrigation
Output price				
"low" group	1.61 (1.26)	n.a.	-3.86 (-1.35)	-6.98 (-2.32)*
"medium" group	1.81 (1.47)	-1.17 (-.65)	-3.55 (-1.27)	-7.11 (-2.27)**
"high" group	2.87 (2.65)**	-0.698 (-.37)	-2.49 (-.88)	-6.72 (-2.19)*
Wage				
"low" group	-1.31 (-2.20)	n.a.	-3.36 (-3.01)***	-3.09 (-1.77)
"medium" group	-1.26 (-2.11)*	-.994 (-.50)	-3.29 (-2.96)**	-3.05 (-1.75)
"high" group	-1.01 (-1.66)	-.803 (-.41)	-2.94 (-2.63)**	-2.97 (-1.70)

The second goal of this study was to examine empirically the relation between assets and the supply function. Using a production model focussing on capital as a productive input, it was shown that both the level of supply and the responsiveness (elasticities) to changing input and output prices should be expected to depend on the farmer's total net asset position, as well as use of productive capital. Empirically, regression analysis using data from the surveys shows that farmers with higher overall values of assets and who use productive assets such as machinery and irrigation have statistically significant responsiveness with respect to price changes, while farmers without access to these assets do not.

There may appear to be some inconsistency between a finding that the low asset group is less capable of adapting to changing incentives on the one hand, and on the other, the finding that they have held their own or become better off vis-a-vis the other groups during a period of rapid change. It is possible that with a larger sample, this finding would not hold up. (As noted earlier, conclusions based on the dividing the small sample into the groups are quite tentative, given the small size of each group.) This will be further explored when a larger sample is available.

However, an alternative explanation of this finding is that, *ceteris paribus*, the low group cannot adjust very well to incentive changes, but that other things were not equal during this period. In fact, it is probable that they were disproportionately aided by the rural programs of the government, such as Solidaridad, and by other reforms such as in land tenure, which were intended to improve access to credit for this group. To the extent that these programs succeeded in giving the poor access to credit, either directly or by acting in some sense as surrogates for productive assets, they may have improved the ability of poor

farmers to deal with change.

The findings of this study are germane to several policy issues. One is the question of whether the goals of the ongoing reforms in Mexican agriculture are being met. Tentatively, the answer seems to be that by and large, they are. But the finding that farmers without access to certain productive assets are less responsive to changes in incentives raises a warning flag that they may not be able to take full advantage of the opportunities presented by the reforms. They may require some assistance, particularly in order to have better access to the credit market. This may buttress the case for an income support model of assistance (in place of crop price supports), since guaranteed payments not dependent on the vagaries of production could act as a signal of credit-worthiness similar to asset ownership or use. It also supports a continuation of the reforms of the rural financial and land tenure systems which have in the past impeded the access of some farmers -- especially ejidatarios -- to credit, and have reduced farmers' flexibility to cope with change.

Finally, this may also argue that a redesign of the government's agricultural research and extension services would improve both equity and efficiency. Historically, these services have focussed disproportionately on large-scale irrigated farmers. Evidence that farmers with limited access to productive assets have more difficulty adjusting to changed incentives indicates that reorientation to increase their access would improve the efficient adjustment of the sector as a whole. This could be done by subsidizing their access to private sector providers through direct payment to providers (the "Chilean model") or vouchers, or by channeling funds through municipalities (the "Colombian model") or by some other mechanism.

Appendix

A.1 Definition of Capital Inputs Groups

The characteristics chosen to define the CI groups are important both for achieving higher agricultural yields and because they reflect the heterogeneity of our sample of farmers. In our judgement, these are more likely to be indicative of permanent income potential than would be measures of more temporary status, such as current income or consumption, which in any case is not included in our data. The characteristics we chose are particularly important in the context of Mexican agriculture. These characteristics include size of land holdings, which is linked to the economies-of-scale issues intrinsic to the *mini-fundia/lati-fundia* distinction. In addition, we focus on irrigation and capital used on the land because of their ties to infrastructure and credit availability, two important issues in Mexico. Although water may appear to be a variable factor of production irrigation is treated as a capital input in this context, since the variable cost is quite small relative to initial investment and the services of the investment extend over a long time horizon.

Just under 750 farmers are included in our analysis and are divided according to the following criteria. Farmers who have access to neither irrigation nor harvest machinery or whose land holdings are no greater than the first-quartile level are placed in the "low" CI group. One exception to this is any farmer with over 40 head of cattle, for whom, as cattle ranchers, neither irrigation nor harvest machinery would be expected to play an important role in production. These farmers are placed in the "high" group.

Farmers who report access to either or both of the assets but whose land holdings are no greater than the third-quartile are assigned to the "medium" group. Their productive

potential is greater than that of the farmers without irrigation or harvest machinery, but may be limited by land holdings.

Finally, farmers with land holdings over the third-quartile or farmers who own more than 40 head of cattle (ranchers) are placed in the "high" group. They may have one or both assets (irrigation and harvest machinery) but by virtue of their size have greater potential for output. These large-scale farmers and ranchers are included in our "high" CI group. After applying these criteria to the sample, approximately the same number of farmers fall into the "low" and "medium" groups, leaving about 20 percent of the sample classified as "high."

In Table A1, we show the distribution of these characteristics. First, the number of farmers reporting access to neither, one, or both irrigation and machinery in harvest. There are 744 farmers included in our analysis, so just under one-third report no access to either, and almost half have just one.

Second, we give an indication of farm sizes in our sample. The distribution yields a first-quartile level of 3.55 hectares and a third-quartile of 12 hectares. According to a survey of literature on Mexican agriculture, a *mini-fundia* could be described as a farm consisting anywhere from 2 to 4 hectares. (See, for example, Heath, 1990) A threshold of 3.55 hectares to define the low group is therefore not inconsistent with general thinking on what is a poor farm. The third-quartile level will also play a role in our group criteria; beyond this level, farms are considered large. While this is somewhat arbitrary, it does arise from a sample of almost 750 farmers from four rather distinct states in Mexico. Further, we perform sensitivity analysis of our groups with respect to this bound, and the overall distribution of farmers changes little, with up to 40 hectares used as a bound. Thus, we use

the third-quartile level in our group criteria.

The results of applying these criteria are shown in Table A1. As mentioned, these groups are formed for the purpose of illustration, and represent only one possible set. There are numerous other criteria possible, including production-related variables, farmer education, consumption patterns, and asset or income values.

To examine how closely our criteria conform to another possible welfare measure, in Table A2 we give a correspondence between "asset group" and "income group." Farmers were asked in the 1991 survey to categorize their average monthly income according to the four choices shown in the table. There are three principal reasons why we chose alternative criteria for our farm groups. First, the opinion of the Mexican academics who organized the survey was that the farmers had purposely understated their income for fear of adverse consequences and that this had compromised the accuracy of the variable. Second, the goal of this study is an understanding of the constraints faced by Mexican farmers in responding to prices. A classification of farmers based on production-related characteristics would thus be more illustrative in this context. Third, welfare is most appropriately measured by relatively permanent characteristics that do not fluctuate greatly over time as does current income. However, we provide the figures in Table A2 to demonstrate the level of "agreement" between the two classifications. The proportion of farmers reporting income in either of the lowest two groups falls as assets increase, from 95.1 percent for the "low" group to 49.3 percent for the "high." In contrast, the proportion in each of the two highest income groups rises with assets.

Table A1: Description of criteria for CI groups for full 1991 sample

Indicator	1991	
Incidence of Assets: (Number of farmers)		
With no irrigation and no machinery in harvest	236	
With both "assets"	159	
With only 1 of these assets	349	
Land size distribution: (hectares)	level	average
1st quartile	3.55	1.73
2nd quartile	7.0	5.17
3rd quartile	12.0	9.72
4th quartile	484.0	37.71
CI groups:[1] (Number of farmers)		
Low	300	
Medium	294	
High	150	

[1] CI groups were defined along the following criteria:

Low: Have none of the two assets (irrigation, use of machinery in harvest) OR land size is no greater than first quartile.
Farmers may not have more than 40 head of cattle.

Medium: Have one of both of the two assets but land size must fall in first three quartiles.

High: Have both assets OR land size falls in highest quartile,
OR have more than 40 head of cattle (ranchers).

Table A2: Comparison of CI and income groups for full sample of farmers

Monthly income in pesos (1991 values)	Monthly income in US dollars	Low	Medium	High
0 to 350,000 pesos	0 to $113	58.2%	37.5	14.3
350,000 to 1,100,000	$113 to $355	36.9	38.2	35.0
1,100,000 to 2,500,000	$355 to $806	3.7	17.5	19.3
over 2,500,000	over $806	0.7	6.7	31.4

Note: Only income groups are available from the survey, not levels, so it was not possible to calculate income per capita in the household.

A.2 CI groups for sub-sample of 85 across years

The criteria described in the previous section were applied to the small sample of farmers for which both years of data are available. The hope was that changes for the poor could be observed and compared to changes for other groups of farmers. To some extent, that is possible, but there is little statistical significance in the results. The tables are presented here to illustrate the limitations of the small sample size, but also provide some useful information on the effects of reforms on the poor.

Table A3 gives a summary of the characteristics of the sub-sample of farmers in each year. The criteria on land-holdings are maintained from the larger sample in absolute levels. That is, 3.55 hectares is still the critical value for small farmers, and 12 hectares for large, even though these figures do not represent the first and third quartiles of the smaller sample.

Table A4 repeats the analysis of Table 1 for these groups, conducting statistical tests on both within-year figures and across the two years. Highlights of the results were given in the text and are not repeated here.

Table A3: Description of criteria for CI groups

Indicator	1991	1993
No. of farmers:		
With no irrigation and no machinery used in harvest	18	7
With both "assets"	46	59
With only 1 these assets	18	17
Land size distribution: (number of farmers)		
under 3.55 ha.	5	9
between 3.55 and 12 ha.	72	66
over 12 ha.	5	8
CI groups:[1] (No. of farmers)		
Low	20	16
Medium	58	60
High	4	7

[1] CI groups were defined along the following criteria:

Low: Have none of the two assets (irrigation, use of machinery in harvest) OR land size is no greater than 3.55 hectares. Farmers may not have more than 40 head of cattle.

Medium: Have either or both of the assets, but land size must be no greater than 12 hectares.

High: Have both assets OR land size is greater than 12 hectares OR have more than 40 head of cattle (ranchers).

Note: In full sample from 1991, 3.55 hectares represents the first quartile of farm sizes, and 12 hectares the third quartile.

Table A4: Comparison of indicators for CI groups, by year

	1991			within year	1993			within year
	Low	Medium	High	tests	Low	Medium	High	tests
Principal crop[1]:								
Corn	75.0%	17.2	0.0	a,b	56.3	46.7*	57.1	
Wheat	0.0	5.2	0.0		25.1*	21.7*	14.3	
Sorghum	15.0	56.9	75.0	a,b	6.3	33.4*	0.0*	b
Vegetables	5.0	6.9	0.0		6.3	8.3	14.3	
No. of crops produced	2.0	2.4	2.0	b	2.6*	3.3*	4.1*	b
Credit indicators:								
Credit per ha. owned[2]	0.24	1.19	1.53	b	0.53	1.06	2.38	a,c
Ask for credit	60.0	69.0	100.0		50.0	56.7	71.4	
Receive credit	30.0	46.6	75.0		31.3	50.0	57.1	
Receive who ask	50.0	67.5	75.0		62.5	88.1	80.0	
Report problems with credit	50.0%	24.1	0.0	b	50.0	56.7*	28.6	
Input usage:								
Hire labor	85.0	84.5	75.0		68.8	66.7*	100.0	
No. of workers hired	2.65	3.70	11.25		5.49*	8.30*	11.47	b
Purchase seeds	35.0%	91.4	100.0	a,b	56.3	73.3*	71.4	
Use fertilizer	70.0	96.6	100.0	b	87.5	95.0	100.0	
Use pesticides	35.0	91.4	100.0	a,b	68.8*	96.7	100.0	b
Irrigate	10.0	93.1	75.0	a,b	56.3*	86.7	85.7	b
Use machinery in harvest	10.0	78.9	100.0	a,b	50.0*	88.3	100.0	a,b
Use tractor to prepare soil	60.0	100.0	100.0	b	75.0	96.7	100.0	b
Intercrop	35.0	5.2	25.0	b	25.0	21.7*	28.6	
Farm Assets:								
Own tractor	10.0	50.0	75.0	a,b	18.8	45.0	100.0	a,c
Own farm implements	10.0	50.0	75.0	a,b	18.8	45.0	100.0	a,c
Own vehicles	10.0	31.0	75.0	a	37.5*	30.0	57.1	
Km to purchase seeds	11.1	9.9	18.0		5.3	10.3	4.9	b,c
Km to purchase fertilizer	14.9	10.1	5.8	a,b	9.9	9.4	5.4	c
Education of principal:								
No education	60.0%	58.6	50.0		73.3	49.2	42.9	
Up to completed primary	40.0	39.6	0.0		20.0	50.9	28.6	b
Up to completed secondary	0.0	0.0	0.0		0.0	0.0	0.0	
Beyond secondary	0.0	0.0	50.0	a,c	6.7	0.0	28.6	c
Income-related Characteristics:								
Households with Off-farm income	45.0%	32.8	75.0		31.3	56.7*	85.7	a
No. of family members with off-farm jobs	0.70	0.50	1.75	a,c	0.44	1.17*	1.86	a,b

[1] Principal Crop refers to the crop which the farmer reports as being his most important.
[2] Credit is reported in millions of 1991 pesos.
Test codes:
a: low and high groups are significantly different at least 10% confidence level,
b: low and medium
c: medium and high
* 1993 value is significantly different from 1991 value.

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