Rethinking the Supply Response to Market Reforms in Agriculture: Household Heterogeneity in Village General Equilibrium Analysis from Mexico

George A. Dyer* and J. Edward Taylor

University of California at Davis

Abstract

We present a new village general-equilibrium modeling approach to explain agricultural households' apparently perverse responses to policy and market reforms. Household characteristics influence participation in multiple markets simultaneously and generate heterogeneous micro responses to events in any single market. Household participation, in turn, shapes regional markets and makes market outcomes sensitive to local market conditions. We incorporate heterogeneous micro responses and market participation into a general-equilibrium model and offer an explanation for a positive supply response to lower maize prices in Mexico following NAFTA.

JEL classification: O12; Q11; R13

Key words: Village economies, computable general equilibrium models, agricultural supply response, NAFTA, maize.

---

* Corresponding author: George A. Dyer, Dept. Agricultural and Resource Economics, One Shields Ave., University of California, Davis, CA. 95616. email: gdyer@primal.ucdavis.edu ph: (530) 752-0231 fax: (530)752-5614.

Introduction

Governments in less developed countries (LDCs) have often been frustrated by agricultural households' apparently perverse response to policies. Economists have gone a long way towards explaining "hidden" motivations underlying household responses: Kuroda and Yotopoulos (1978) and Singh *et al.* (1986) described the effect of agricultural profits on the marketed surplus of staples; Finkelshtein and Chalfant (1991) and Fafchamps (1992) elaborated on the effects of multivariate price risk on production and consumption, and de Janvry *et al*. (1991) described the influence of transaction costs on supply response in agricultural households. However, economists have often had as much difficulty as government officials in predicting responses to agricultural policies. Recent developments in the Mexican maize sector are a case in point.

In the 1970s and early 1980s, protectionist government administrations sought to regain food self-sufficiency in Mexico by establishing incentives for small-scale staple producers in rain-fed regions (Redclift, 1983; Andrade and Blanc, 1987). Their efforts were largely unsuccessful, which earned unresponsive agricultural households a reputation as stubborn and unpredictable. A decade later, the neoliberal administration of Carlos Salinas expected (based on macroeconomic models) that those same households would abandon agriculture and the countryside in response to agricultural market liberalization. When these expectations failed to materialize, agricultural households seemed more stubborn than ever.

This paper's basic premise is that a modeling approach is required that allows for heterogeneous micro responses and general-equilibrium outcomes to predict changes in developing rural economies. Although others have suggested that heterogeneous access to staple markets among rural households can explain unresponsiveness to price changes (*e.g.*, de Janvry *et al*., 1995; Key *et al*., 2000), we believe that this alone cannot explain the apparent lack of response in the Mexican maize sector and that access to maize markets may not even be a deciding factor. Instead, we propose that numerous differences among households, including variables affecting utility from activities as well as commodities, influence participation in multiple markets simultaneously, which ultimately generates heterogeneous micro responses to events in any single market. Household participation, in turn, shapes local and regional markets and makes market and policy outcomes sensitive to local conditions. In this paper, we integrate 48 individual agricultural-household models into a village-wide computable general equilibrium (CGE) model to seek explanations for unexpected policy impacts on staple supply response and throw some light on the future of agricultural liberalization, including the role of local commodity and factor markets. In Zoatecpan, a community in East Central Mexico, we find that differences in land endowments have played a key role in determining contrasting responses to maize-price changes among households. These contrasting responses have largely cancelled one another out, leaving the impression of a lack of responsiveness to policy reforms.

We motivate our analysis by describing recent Mexican policy changes and their counter-intuitive outcomes. We then present the village-wide model and simulation findings. We conclude by discussing the implications of our findings for modeling rural-sector impacts of agricultural policy and trade reforms.

Unexpected responses to agricultural policy

In the mid 1960s, Mexico's total cultivated area in maize reached its highest level of the 20th Century. Since that time, the rising cost of inputs and the subsequent removal of subsidies eroded profitability, particularly in rain-fed areas (Hewitt, 1994; CEC, 1999). Surprisingly, in 1990, the cultivation of maize expanded across Mexico, with productivity and total output reaching record highs (INEGI, 2001). Maize production spread from its traditional stronghold in small-scale, rain-fed areas of South and Central Mexico, to the irrigated, commercial areas in the North. This expansion was a result of commercial growers turning to maize as a last resort after the government ceased to support the price of other crops (Appendini, 1994; Fritscher, 1996; Yúnez and Barceinas, 2000). It was expected to be a passing response to transitory policy and market conditions.

Fierce protection of the maize sector was a fundamental aspect of Mexican food policy and politics for many years (Austin and Esteva, 1987; Fox, 1993; Mitchell, 2001; Ochoa, 2001). Thus, despite its secular decline, maize's support price remained well above international prices in the early 1990s, benefiting surplus (*i.e.*, commercial) growers. In contrast, subsistence growers were left adrift. Government analysts of all backgrounds had long considered that subsistence agriculture sequestered land and labor, and programs were conceived over the years to use these resources more efficiently (Redclift, 1983; Montanari, 1987; Levy and van Wijnbergen, 1992). In the early 1990s, the neoliberal administration in government grew weary of the cost and inefficiency of support prices and found an opportunity to discontinue support prices and harness peasant labor in non-agricultural sectors. It planned to do so by integrating the liberalization of the maize sector with that taking place in the rest of the economy in association with the North American Free Trade Agreement (NAFTA) (Tellez, 1992).

The cornerstone of maize-sector liberalization was the phase-out of support prices (then paid through the state trading agency, CONASUPO) and simultaneous removal of trade barriers, which would allow American maize imports to fill a growing gap between domestic supply and demand. Liberalization was expected to discourage commercial maize agriculture in irrigated areas that lacked a comparative advantage for growing maize, facilitating a shift to export crops. Maize agriculture in rain-fed areas, particularly subsistence maize agriculture, was not expected to compete favorably with imports (Robinson *et al*., 1993; Levy and van Wijnbergen, 1994). Macroeconomic models predicted that Mexican maize output would decline by up to 20% (depending on the specific rules of the agreement). Commercial maize growers in rain-fed areas would be hurt but only slightly, since lower wages would partially offset lower output prices. However, subsistence growers and landless workers would suffer job losses and lower wages; many were expected to migrate to urban areas and the United States (Levy and van Wijnbergen, 1994). According to forecasts, other agricultural production on irrigated lands (*i.e.*, fruits and vegetables) would expand, benefiting growers.

The Mexican government attempted to preempt the anticipated adverse welfare effects of agricultural liberalization by compensating growers with cash transfers designed to comply with current international trade agreements (*i.e.*, NAFTA and GATT) (Appendini, 1994). Under the PROCAMPO program, per-hectare payments were based on the area cultivated by households (immediately prior to the program's implementation) in nine different crops. By offering growers a certain income, this program was intended to create incentives to increase productivity while remaining decoupled from current production (SAGARPA, 2001). PROCAMPO was scheduled to last for the duration of the liberalization process, ending in 2008.

Eight years into NAFTA and PROCAMPO, maize imports have soared, but the expected slump in domestic maize supply did not materialize. In fact, domestic supply of maize has remained above the record 1990 level since the initiation of NAFTA and PROCAMPO, and in 2001 the area cultivated in maize surpassed its 1965 historic high (INEGI, 2001). The increase in maize output can partly be attributed to commercial maize growers in irrigated areas, who were undoubtedly affected by imports but also continued to benefit from subsidies, especially through commercialization programs (ACERCA) (Puente, 2001). Subsistence growers on rain-fed lands, on the other hand, have not benefited from subsidies for commercialization, and many appear to operate with losses (Perales *et al*., 1998; Dyer, 2002). Surprisingly, the cultivated area in rain-fed maize rose steadily during the 1990s (SAGAR, 2002).

Economic analysis of the Mexican maize sector

Macroeconomic models of NAFTA and their forecasts were criticized for neglecting the microeconomics of the farm-household, its diversified economy and its market-participation decisions. According to de Janvry *et al*. (1995), heterogeneity among households implied that the effect of price declines would be felt differentially across household types: surplus growers (net sellers) would be seriously and adversely affected, but market failures (*i.e.*, transaction costs) would buffer subsistence producers (“about half of all maize producers”) from the decline in sales price. Adding up different groups' responses obtained from microeconomic estimates, de Janvry *et al*. (1995) expected rain-fed maize agriculture to contract substantially less than macroeconomic models predicted. Key *et al.* (2002) present econometric evidence that Mexican maize growers are subject to transaction costs. However, it is unclear whether high transaction costs have played a decisive role in maintaining maize production in Mexico. Sale of maize through the public DICONSA network has likely eliminated any possible transaction costs for maize buyers, which would narrow existing price bands considerably.[1] In many rural communities, there are obvious differences between sale and purchase prices, but they usually occur intertemporally: households buy maize at a high price prior to harvest and sell at a low price after it (unpublished data). Thus, few households are likely to experience a price band at any one time. Moreover, focusing on household-specific price bands for maize ignores potentially far-reaching circumstances in other markets (including changes related to recent reforms of Mexico's agrarian laws, which increased flexibility in land markets by permitting exchange and rental of *ejido* lands), as well as general-equilibrium effects.

The absence of an integrated macro- and microeconomic analysis has limited our ability to predict responses (or the lack of a response) in developing rural economies. Countrywide models capture important general-equilibrium effects, but (as pointed out by de Janvry *et al*., 1995) they necessarily neglect critical heterogeneity of rural households revealed in microeconomic models. However, microeconomic models also have limitations. To predict aggregate responses, it is not sufficient to add up household responses estimated from individual microeconomic models; it is necessary to account

[1] DICONSA is present in nearly 23,000 rural communities across Mexico (DICONSA, 2002), and in most communities between 500 and 3000 inhabitants, according to a survey conducted by UC Davis and El

for interactions among households in local or regional markets. In Mexico, for instance, a majority of land-poor, subsistence households has coexisted with a small number of land-rich, commercial growers in more or less isolated markets throughout modern history. Although last century's Agrarian Reform altered this picture, even today, widely different households interacting on an unequal basis characterize Mexican rural economies (see Bartra, 1982; Fox, 1992).

Rural households participate in factor markets based on their land and time endowments. Some of these markets are local in scope, but others, such as the labor market, can extend beyond borders. Land-poor and landless households, who most often engage in migration, integrate distant labor markets by transmitting market signals across regions. In contrast, only relatively land-rich households that produce a surplus participate in commodity markets outside their communities. These commercial growers, linked with the rest of the country through commodity markets, transmit shocks in these markets to other households in their communities. However, differences among households are not limited to participating in a market or not; they are often of a more quantitative nature. Every rural household participates in multiple markets simultaneously, and its particular way of integrating into the economy ensures a unique response to events in any single market. The interplay of households' heterogeneous responses in local and regional markets determines local responses to nation-wide policies.

We suggest that the apparent unresponsiveness of rain-fed maize agriculture in Mexico masks important microeconomic changes, largely canceled out in the aggregate by differences among households and across regions. Differences across regions (shown

---

Colegio de Mexico in August 2002.

by national statistics; see INEGI, 2001) are addressed only superficially in this paper. Instead, we focus on a single region to show how local interactions influence the local outcomes of market changes operating at the national level. Local conditions are absent from both single-household models and countrywide CGE models, but they are central to village-wide CGE models. Village-wide models describe market interactions in rural communities where trade among households is common but high transaction costs with outside markets generate local markets (see Taylor and Adelman, 1996). However, the potential of village-wide models to capture the interaction of dissimilar households has not been fully realized to date for two reasons. First, previous applications of village-wide models have incorporated differences in the source and size of households' income and in the marginal propensity of their consumption, but they have not allowed for differences in households' responses to market signals, as occur between commercial and subsistence growers. Second, village-wide models have been used to explore a variety of issues in communities with closed labor or staples markets (Taylor *et al.*, 1999a,b; 2001; Dyer *et al.*, 2001), but they have rarely been used in connection with closed local land markets. This is remarkable considering that the costs of farming distant land are likely to impose spatial limits on these markets in peasant communities.[2]

We use a village-wide model to demonstrate how market interactions among commercial and subsistence households in local markets, including land-rental markets, shape the local outcomes of a nationwide change in the price of maize and compensatory policies. Our model allows for heterogeneous household responses to market signals by incorporating household-specific shadow prices for *milpa*, the traditional activity of

[2] Despite legal restrictions on *ejido* land, rental was already common throughout rural Mexico prior to the recent reform of land tenure laws (Dewalt and Rees, 1994).

cultivating maize, beans, squash, and other crops, often in tandem, that dates back to pro-Columbian times and that is common in the rural Mexican landscape today (de Janvry *et al*., 1997). Unlike previous models, ours distinguishes between commodities (such as maize) and activities (such as *milpa*) that may generate multiple goods and services. The model is calibrated using survey data from the village of Zoatecpan in the Central Mexican state of Puebla.

The model

Households often derive non-market benefits from agricultural production, including products and product qualities for which there is no market and services such as income diversification and food security. Non-market benefits contribute to the shadow value of agricultural activity, driving a wedge between it and the value of its marketable products (Finkelshtein and Chalfant, 1991; Fafchamps, 1992). A positive difference between the shadow value of production and the value of marketable produce can explain why some households incur financial losses in agriculture.

In Mexico, the maize-based *milpa* system is renown for a diverse product that includes market as well as non-market goods. Other crops in the *milpa* (such as beans and squash) and semi-domesticated edible herbs (*quelites*) raise the value of *milpa* produce above the market value of maize alone. However, even the imputed value of the whole *milpa* harvest is often insufficient to cover its production costs, which suggests that *milpa* services are a significant part of non-market benefits (Evangelista, 1998; Dyer, 2002). Some *milpa* services are well recognized, such as income diversification and food security; others are less so, such as social standing and even personal satisfaction (Clawson, 1985; Evangelista, 1998; Faust, 1998; González, 2001).

Although some non-market benefits of *milpa* (such as grain quality) are embodied in output, others are associated with the scale of the activity during the growing season more than with the actual harvest. *Milpa* may provide insurance against food-price hikes but, by harvest time, its value is determined entirely by the market price of output. Likewise, a large *milpa* may provide social standing, irrespective of whether it is a good or poor year for maize. Households consume many of the non-market benefits of *milpa*, which are costly and must be accounted for, in part, as financial losses. Households' demand for non-market benefits of *milpa* (in a sense, their demand for *milpa*, as opposed to *milpa* crops) is bound to depend on income. Assuming diminishing marginal utility from non-market benefits of *milpa* production, one would expect the marginal shadow value of *milpa* to decrease with production scale. Marginal benefits may be substantial for subsistence households but perhaps nil for households that produce a marketed surplus: it is the buyer, not the seller, who appropriates any special qualities not accounted for in prices. If this is the case, we can expect the marginal value of *milpa* for surplus growers to be close to the market value of *milpa* output (primarily maize),[3] while for subsistence growers the non-market benefits of *milpa* should drive a wedge between the two, raising the shadow value of *milpa* above the market price of maize. Our data support this characterization of the shadow value of the *milpa* in Zoatecpan: the ratio of total production costs to market value of maize ranges from around 1.0 to more than 15. It is closest to 1.0 for surplus growers, and it attains its highest values among the smallest subsistence growers (see Fig. 1 and Dyer, 2002).

The distinction between the market price of maize (a commodity) and the shadow value of *milpa* (an activity) is instrumental in explaining heterogeneous household responses to price changes. While production decisions regarding *milpa* are based on *milpa*'s shadow value, the purchase, sale and consumption of maize depend on maize's market price. The model presented below recognizes commodities as separate from activities, distinguishing between a unique market price of maize for all households and distinct shadow values of *milpa* for each of them. Market price and shadow value are assumed identical, at the margin, if the household markets a surplus, but distinct if the household is a net buyer.[4] For net buyers, the shadow value of *milpa* is initially estimated as the ratio of total production costs to market value of output; for surplus-producing (commercial) growers, it is initially set at 1.0, which is the standardized market price of maize in our model.[5] Thus, the shadow value of *milpa* is originally endogenous for subsistence growers but exogenous and fixed by the market price of maize for commercial growers.

Rather than being aggregated into groups as in other village models, households in this model respond individually to changes in the market price of maize, in some cases switching regimes between subsistence and commercial production (*i.e.*, between an endogenous and an exogenous shadow value for *milpa*). To accommodate individual responses, the model builds on previous village-wide models. It includes the five equation blocks described by Taylor *et al.* (1999a,b; 2001): (1) a production block, (2) an

---

[3] Net of subsidies and sale costs.
[4] This differs from the transaction-costs literature, where household-specific transaction costs generate a price band (see de Janvry *et al.*, 1991). If the market price of a commodity falls within the price band for a given household, the household is self-sufficient and does not respond to changes in the market price; *i.e.*, the household has its own shadow value for the commodity. In the present model, there are no price bands since transaction costs are not addressed.
[5] The estimated ratio of costs to market value is less than 1.1 for commercial growers.

income block, (3) an expenditure block, (4) a set of general-equilibrium-closure equations, and (5) a price block. It also incorporates two new equation blocks: (6) a household-surplus block and (7) a village-supply block. Equation blocks (1) – (3) and (6) define household behavior; blocks (4) and (7) pertain to the markets. The model is presented in Tables 1 and 2.

Households

In previous village-wide models, the production block consists of one equation per activity, which determines the village's aggregate output for that activity. Given this output, the general equilibrium closure block determines the village-wide marketed surplus as the difference between village-wide production and consumption. In the present model, the production equation block allows for one equation per activity per household, so the difference between production and consumption determines the household's surplus, not the village-wide surplus. These differences between production and consumption at the household level constitute the household-surplus block.

The production block consists of a production equation and a set of factor demand equations for each household activity. Production technologies are specified as Cobb-Douglas.[6] Activities include *milpa*, other agriculture, livestock (hogs and chickens), non-agricultural goods, services and commerce. Factors include local and migratory labor, land, animal capital and other capital. Land and local labor are tradable among

[6] Although more complicated functional forms are possible, our experience with micro economy-wide models suggests that little is gained from the use of alternative functional forms—and necessary "guestimates" of accompanying elasticities. We have found the results of our policy experiments using similar models to be robust to the specification of functional forms; see Taylor *et al.*, (1999b). This is not surprising, inasmuch as the model is always calibrated at the same point given by the survey data, and policy experiments involve marginal changes in exogenous variables.

households; migratory labor, animal capital and other capital are household non-tradables. Income from household-non-tradable factors always accrues to the household that owns them; land rents and labor income are distributed among households according to their shares in the base case — a standard practice in village-wide models. Household income is the sum of factor income (including migrant remittances) and government subsidies (including PROCAMPO and PROGRESA; see *Simulations*, below). The expenditure block is defined over subsistence activities (*e.g.*, *milpa*) as well as market commodities.[7] Consumption demands are modeled using a linear expenditure system (LES) with no minimum required quantities (Deaton and Muellbauer, 1980). Prices are assumed to be endogenous for all subsistence activities, except for *milpa* among surplus growers (see above). All prices are standardized to 1, except for *milpa* among subsistence growers.

The markets

The equation blocks described in the previous section determine the behavior of 48 individual households. The remaining equation blocks aggregate these households into markets. The village-supply block aggregates household surpluses (per activity) into a village-wide commodity supply. This requires a set of commodity accounts (*i.e.*, variables) in addition to the usual production accounts of previous models. The village-supply block is similar to the commodity-production-and-allocation block used in countrywide models (see Löfgren *et al.*, 2001), transforming activity outputs into commodity surpluses using fixed coefficients. The general-equilibrium closure equations

[7] This assumes that the household spends part of its income in activities such as *milpa* in order to consume their market and non-market benefits.

determine the (net) marketed surplus of tradable commodities as the difference between village-wide supply and demand. Prices are assumed to be fixed (determined in markets outside the village) for tradables. For village nontradables, prices are endogenous, satisfying local market-clearing conditions. Land and the supply of local labor are fixed at the village level; *i.e.*, they are assumed to be village non-tradables.[8]

CGE models predict continuous changes in consumption, production and input demand. This is inadequate in the case of land, which is rented in discrete units or plots. An algorithm is used to transform continuous changes in demand for land (derived from the CGE model) into discrete changes in the number of plots managed. If the resulting changes in demand for land is greater (in absolute value) than half the size of the smallest plot under each household's management, then the number of plots changes; otherwise, it remains the same.

The relationship in the model between the value of *milpa* and the price of maize merits further discussion. For a subsistence household, the shadow value of *milpa* is endogenous (and maize surpluses are fixed at zero) as long as this value is greater than the market price of maize. Given that the non-market benefits of *milpa* are assumed to be normal goods, increases in household income result in increases in the scale of *milpa*. Although there is no a priori reason to assume that the non-market benefits of *milpa* are normal (see, *e.g.*, Finkelshtein and Chalfant, 1991), Dyer (2002) shows that households in the study region (particularly low-income households) do in fact increase the scale of *milpa* in response to increases in income. Since a larger *milpa* implies greater consumption of its goods and services, including homegrown maize, we often speak

[8] Simulation results differ quantitatively (but not qualitatively) if the supply of local labor is assumed to be perfectly elastic.

below of changes in consumption of homegrown maize vis-à-vis changes in consumption of purchased maize.[9] When a decrease in household income or an increase in the market price of maize eliminates, in our simulations, the gap between this price and the shadow value of *milpa*, the two become tied at a fixed level: the shadow value of *milpa* becomes exogenous and a marketed surplus may surface (*i.e.*, the household may sell maize in the market and prevent the shadow value of *milpa* from declining further).[10] This means that the market price of maize is effectively a lower bound for the shadow value of *milpa*; even if the marginal non-market benefits of *milpa* are nil, households can sell maize at its market price. For surplus growers, changes in the shadow value of *milpa* are tied, at the margin, to changes in the market price of maize.[11]

The study area

Zoatecpan lies in the rugged Sierra Norte de Puebla. Its indigenous population practices traditional agriculture in the form of *milpa*, a multicrop activity based on maize, often in combination with beans, squash and other edible herbs. Nearly all households in Zoatecpan own land, but endowments vary widely in size: 2% of households own 50% of the land (Fig. 2), and the average land holding is only 0.4 hectares. There is an active land rental market in the village, and in 1999 nearly half of all households participated in it. Forty six percent of households rented in land (all for *milpa*), and 5% of households rented out land. The fact that the few households that rented out land for *milpa*

[9] Note that we are not assuming different prices for homegrown and market maize, but only for *milpa* and maize.
[10] The emergence of a marketed surplus depends on the relative rates at which consumption and production change within a household in response to price and/or income changes.
[11] It is evident that if all non-market benefits embodied in the grain, such as higher-quality, the marginal value of *milpa*'s non-market benefits is nil for surplus-growers. This is not necessarily the case if non-market benefits include *milpa* services.

constituted the largest landholders in the village does not make Zoatecpan an exception; this pattern is widespread in the region. In the study area, the rental market fosters a more progressive distribution of *milpa* land among local households and nearly doubles *milpa* area for the average household.

Despite the scope of the rental market and the importance of maize agriculture, Zoatecpan, like many Mexican villages, is a net "importer" of maize. Purchases from outside markets account for approximately three fourths of total village maize consumption. Two thirds of local households produce less than 25% of their yearly maize consumption, and most other households produce less than 75% (Fig. 3). Around 94% of households are formally subsistence maize growers, and only 4% of the population can be considered commercial growers of maize (*i.e.*, households that grow maize with the intention to sell).

Quarterly household income and expenditure data were gathered over the 1999/2000 crop cycle by surveying a random sample of 48 households in Zoatecpan, representing slightly over 10% of the village's population. To increase reliability, each household in the sample was interviewed four times (three months apart), and data were collected on the previous month's consumption. Income and production data were gathered for the entire quarter during each visit.

A 1999/2000 social accounting matrix (SAM) for the village (see Dyer, 2002), provides a basis for estimation of model parameters. In accordance with first order conditions for household utility maximization, production factor shares in value added in each activity *ip* were used to estimate exponents, $\alpha_{f,ip}$, in Cobb-Douglas production functions (see Table 2). Likewise, households' observed consumption shares were used to parameterize demand functions (Table 3). This approach permits us to obtain separate parameter estimates for every household in the sample. The calibrated model reproduces every figure in the SAM in the base case.

Simulations

We use the village-wide model to explore the implications of changes in the market price of maize (reflecting recent price reforms) and two alternative cash-transfer programs that are cornerstones of Mexico's policy reforms. We consider two scenarios to highlight the importance of interactions among heterogeneous households. In the first scenario, we artificially treat all households as subsistence producers. We expect *a priori* unambiguous impacts on production and demand for a price change in this scenario. All households should adjust their demand for maize after a change in its market price but should not adjust production, which is based on an unaltered shadow value of *milpa*.[12] In the second scenario, growers that produce a maize surplus rightly treated as commercial producers (*i.e.*, they adjust production after changes in the market price of maize). Production adjustments to a price change on the part of surplus growers have important indirect effects on the economy, and the outcome must be determined empirically. This last scenario is the basis for subsequent analyses of cash-transfer programs. We simulate both a decrease and an increase in maize price. The effects are not necessarily symmetrical. A price decrease and increase motivate different sets of households (that have distinct market power) to respond, sometimes by switching into or out of production.

[12] The LES precludes the price change from having an indirect income effect on households' demand for *milpa* (see Dyer, 2002).

It is impossible to document the past effects of an integrated North American maize market in the Sierra Norte de Puebla, where records are scarce and unreliable. Alternatively, results for a simulated price **increase** will suggest what the pre-reform situation might have been in the village of Zoatecpan. Results for a price **decrease** pertain to a future scenario where the price of maize drops further.[13] Two alternative compensatory programs are simulated concurrent to a price decrease to evaluate their distributive effects. In the first, households receive a subsidy proportional to the amount of land they sowed in maize in the base case. The aggregate subsidy for the village is equal to the decrease in the value of the village's maize output resulting from a 10% decrease in price. This replicates the PROCAMPO agricultural subsidy, introduced in 1994 in the context of NAFTA to compensate rural households for the loss of revenue from declining agricultural prices (SAGARPA, 2001). In the second simulation, all household heads receive a cash payment of $161 that, aggregated across households, is also equivalent to 10% of the average base value of maize production. This latter simulation resembles the existing PROGRESA welfare program in that all rural households (not only agricultural households) are eligible for a lump-sum subsidy (see SEDESOL, 2001).[14] Reference is made to PROGRESA because the administrative infrastructure for a program of this nature exists and could be used for other purposes, but also because the current administration expressed an intention to merge the two programs. Despite their distinct goals, PROCAMPO and PROGRESA are both based on direct cash transfers to rural households, with no restrictions on the use of funds.

---

[13] See Yúnez and Barceinas (2000) for a description of recent changes in the price of maize.
[14] Under PROGRESA, adult females and students of both sexes currently receive lump sum payments (SEDESOL, 2001). In our simulations, heads of households receive lump sum payments roughly equivalent

Since there is no reason to expect households to earmark additional income (whatever the source) when deciding how to spend it, PROGRESA and PROCAMPO could have similar effects on a village's economy. However, an important difference between the programs (both in reality and in our simulations) arises from the distribution of payments. In our simulations, per-person payments are fixed under the PROGRESA-type program, but they vary under PROCAMPO in proportion to farmers' land use. Hence, we would expect PROCAMPO to accentuate differences in the distribution of income.[15] The total cost of subsidies in both simulations is the same to facilitate their comparison. In each simulation, the model yields estimated impacts of the simulated changes on every household in the sample. This distinguishes the present model from previous village-wide models and is critical for introducing switching (differential responses to staple prices across households) into the analysis. The tables, below, report village-wide aggregate impacts of the policy changes. They also report distributional effects, as measured by Gini coefficients estimated from individual-household responses.

Results

Decrease in the market price of maize

Table 4 reports results of our price experiments. In the first scenario, all households are modeled as subsistence growers; *i.e.*, the shadow value of *milpa* is endogenous for all households (see column (a) of Table 4). A 10% price increase does

---

to the current PROCAMPO payment for 0.25 hectares, which is about the average size of arable landholdings.

[15] The Gini coefficient for PROCAMPO payments in our sample (0.562) is the same as for land use; see below.

not affect the marginal returns to *milpa* directly, but it causes a contraction of the livestock sector, which uses purchased maize as its main input. As a result of this and a higher price for maize, household real incomes decline slightly, triggering a small contraction of other local activities. In equilibrium, the village's GDP contracts by only a quarter of a percentage point.[16]

The outcome is markedly different when surplus producers (4% of the total number of households) are allowed to respond to a higher market price of maize (see Table 4, column b). The increase in the price of maize is a direct incentive for all surplus growers to adjust the scale of *milpa*, but only the largest and most productive of them increases its maize output (by 27%) after local markets reach equilibrium. This grower's demand for land and labor increases substantially, forcing local rental rates and wages upward by 14.2% and 9.6%, respectively. Other households (including all subsistence growers and the remaining commercial grower) find it optimal to decrease the scale of *milpa* (by up to 10%) in response. Despite the fact that (by construction) both production factors are always fully employed, the more efficient use of land and labor by the larger commercial grower results in a 4% increase in the village's maize output. A larger surplus and a lower local demand for maize result in a 12.6% decrease in the village's maize deficit.

After an increase in maize price, higher rents and wages contribute to household incomes, increasing demand for non-maize goods and services. Since the price of village non-tradables rises, the demand for fixed-priced imports increases the most, spurring growth of the formal-commerce sector. Nonetheless, demand for non-tradables also

[16] These results contrast with those of previous general-equilibrium analyses where all households respond to either local or international maize prices (see Taylor *et al.*, 1999a).

stimulates local activities that do not use land or male labor, such as non-agricultural activities and, in some cases, livestock. As a result, the village's GDP increases by 7.3%. Although every household experiences a nominal increase in income, changes in real income range from a 12% increase to a 4% decrease; 7 out of 10 households experience a real increase. Households engaged in formal commerce experience the greatest increases, even greater than those of commercial maize growers.[17] Households with migrant members, as well as those dependent on public welfare, experience declines in real income, as they consume increasingly expensive local goods but do not benefit from the increase in local wages.

These events redistribute income in a marginally regressive fashion: the Gini coefficient for income rises from 0.356 to 0.361.[18] The redistribution of land use is also regressive: the Gini coefficient for land increases from 0.562 to 0.597. Nearly 15% of households give up land plots, which are now rented in by a commercial grower (Table 5).[19] Four percent of households give up the single plot they manage and pull out of *milpa* entirely. Due to the consolidation of land by one grower, consumption of homegrown maize drops 4.3% – more than the 3.7% drop in consumption of purchased maize. This, along with across-the-board higher nominal incomes, raises the shadow value of *milpa* for all subsistence households.

A decrease in the price of maize results in changes that for the most part are symmetrical to those described above; *i.e.*, commercial production of maize retreats in favor of subsistence production. In this case, all surplus maize growers decrease their

[17] This is true in absolute terms, but not as a percentage.
[18] See Deaton (1997) for the formula to estimate the Gini coefficient.
[19] This occurs as the landlord, who previously rented out sections of a large land plot to several households, rents the whole plot to a single household.

output.[20] A price decrease results in a more egalitarian distribution of land, as land previously used by a few commercial growers is distributed among a large number of subsistence households; the Gini coefficient for land decreases from 0.562 to 0.518 (Table 5). However, no household enters or leaves agriculture, for two reasons: first, most households were already growing *milpa* in the base case, so lower rental rates cannot entice additional households into the sector; and second, households that reduce their output after a price drop (*i.e.*, commercial maize growers) continue to manage other plots and remain in agriculture. Despite the drop in the price of maize, *milpa* is still an attractive venture for commercial growers: they continue to produce a surplus. In fact, if they ceased to do so, they would become subsistence growers and their shadow price of *milpa* could increase, halting the effect of a drop in the market price.

Two alternative compensation programs

The two simulated cash-transfer programs are remarkably similar in counteracting the effects of a decrease in the price of maize (Table 6). They effectively compensate aggregate household income, and they partially offset the contraction of local activities other than maize. On the downside, they exacerbate the contraction of the maize sector as well as the reduction in household maize surpluses, increasing the village's maize deficit. Minor differences arise from the two programs at the aggregate village level. PROCAMPO has a slightly more pronounced effect on subsistence activities: it generates a smaller contraction in maize and greater growth of the livestock sector. With a PROGRESA-type program, the contraction of commerce, non-agricultural activities and village GDP is less pronounced.

[20] A price increase motivates only one of the surplus growers to increase his output.

Differences across programs are more pronounced at the individual household level. For instance, although both programs compensate aggregate village income almost exactly, 42% of households experience a decline in real income under PROCAMPO (Gini coefficient = 0.351), but only 25% (half of them store owners) do so under a PROGRESA-type program (Gini coefficient = 0.348). The PROGRESA-type program allows greater increases in consumption of market goods (including purchased maize), while PROCAMPO results in a greater increase in consumption of homegrown maize. In both cases, households' maize surpluses decline by more than 75% in comparison with the base case (around 50% more than without subsidies), and both programs raise village maize purchases from the rest of Mexico by an additional one-third. The decline in surpluses is greater under PROCAMPO, because the largest grower consumes his previous surplus.

Both programs further the redistribution of land triggered by the drop in market price of maize (Table 7). In both cases, surplus growers scale down production and rent out land among 19% of the village's households.

Discussion

Induced changes in the village economy

Our simulation results suggest that the decline in the price of maize during the 1990s induced commercial maize growers to scale down production, reducing their demand for land and labor. Subsistence growers who are net buyers of maize (94% of the population) benefited directly from the price drop, but they suffered lower wages and fewer jobs. Although some of these households experienced increases in real income, most experienced declines. As incomes dropped, so did expenditure, which resulted in a contraction in the demand for local goods and village imports. On balance, the village became more self-reliant, as households substituted local goods for imports, which they could no longer afford, and homegrown goods for purchased goods. Thus, paradoxically, the decline in the price of maize harmed seven out of ten households in a community that purchases three quarters of the maize it demands. The sharp decline in maize price did not trigger a shift away from subsistence maize cultivation as experts predicted (Levy and van Wijnbergen, 1992). Rather, it reinforced a subsistence economy that includes not only maize but also other goods and services.

The retreat into a subsistence economy was probably associated with the unexpected recession in the national economy — the same process was observed during the chronic economic decline of the 1980s (Collier, 1999). It is also attributable to households' motivations and local economic dynamics, which could not be anticipated by macroeconomic models. As maize prices dropped and commercial growers tried to scale back their operations, local rental rates and wages fell, giving subsistence growers an incentive to take up the slack and expand the scale of their subsistence *milpa* as an alternative to migration. In Zoatecpan, the decline in rental rates was large enough to lure landless households into subsistence agriculture, allowing even households that lost real income to rent more land. Lower wages also promoted other subsistence activities within the household, including livestock, whose main input (maize) had become cheaper. Although some households with migrants managed to increase their real income through remittances, local wageworkers were hurt by the shift towards an inward looking, subsistence economy. Perhaps most adversely affected, as the subsistence economy took over, were households engaged in formal commerce that depends on trade with the rest of the country.

The simulation results presented here are generally consistent with Sadoulet *et al.*'s (2001) description of observed changes in household income among *ejidatarios* following NAFTA. This earlier analysis found that for the average *ejidatario*, the shares of wage, agricultural, and other off-farm income fell, while the shares of livestock, non-agricultural self-employment and migrant remittance income increased. Interestingly, Sadoulet *et al.* (2001) found that the average *ejidatario* household experienced a 14% increase in real income between 1994 and 1997. This may be explained by the fact that their analysis excludes landless households, who are more dependent on wage income and did not receive compensation for the adverse price effects of NAFTA and domestic agricultural reforms.

As for the maize-supply response in Zoatecpan, total output decreased (4%) even as the area in *milpa* remained constant. Although a constant maize acreage in Zoatecpan is consistent with the nation-wide pattern, reduced maize output is not. The fall in output was the result of decreases in productivity, as land was taken up by less efficient farmers unwilling or unable to purchase fertilizers. Maize consumption increased — not only consumption of cheaper purchased maize but also of more available homegrown maize. Along with the decline of commercial maize agriculture and the decrease in local market surpluses, greater consumption of maize contributed to the village's deficit, which was filled with "imported" maize. This is consistent with statistics at the national level, which show that Mexican maize imports increased sharply during the 1990s even though maize acreage and domestic production did not drop as expected (INEGI, 2001).

If our interpretation is accurate and can be generalized, it suggests that NAFTA and agricultural policy reforms made maize agriculture an increasingly subsistence activity across densely populated areas in rural Mexico. The precise implications of this transformation for rural economies depend on local market conditions and household heterogeneity. The results of our simulations for Zoatecpan reflect the village's particular land property and rental regimes. The unequal distribution of land across households and the small size of the average landholding guaranteed that many households would expand their subsistence agricultural activities in the wake of the withdrawal of commercial growers from maize production. This situation may be characteristic of indigenous communities where private land has been atomized (Heath, 1987). In *ejidos* and agrarian communities, where land is owned by the state, land distribution may be more egalitarian and the average landholding larger, diminishing the reliance on land rental markets for subsistence production. For example, in the agrarian community of Frontera Corozal, Chiapas (another community in which we are doing field work), land property among *comuneros* is highly homogeneous: every *comunero* holds a fixed 50 hectares of land. At the onset of NAFTA, Corozal households grew an average of 10 hectares of maize, produced several times more than their consumption demand, and sold surpluses to CONASUPO. Today, CONASUPO has shut down its operations, the price of maize has fallen, and the average household grows only three hectares of maize (Dyer, 2001). Nevertheless, growing populations of landless households exist in this and other *ejido* communities (*e.g.*, see Collier, 1999; Fletcher, 1999).

Also characteristic of Zoatecpan is the lack of alternative crops, which undoubtedly contributed to the retention of land in *milpa* and the conversion of *milpa* production from a commercial to a subsistence activity. In the community of Ahuacapan, Jalisco, landholders who previously grew maize commercially now rent out their land to land-poor households who grow maize for subsistence, but they also rent land to corporations that grow agave to produce tequila.[21] Undoubtedly, local conditions have produced a variety of policy and market outcomes across Mexico.

Implications for government programs

It has been mentioned before that PROCAMPO overcompensated subsistence growers, who do not sell maize and did not lose revenue when prices declined. PROCAMPO may also have overcompensated surplus growers, who adjusted production levels in response to lower prices. In contrast, PROCAMPO failed to compensate wage laborers who suffered from production cutbacks. In our simulations, more than 40% of all households experienced a net loss in real income despite PROCAMPO. PROCAMPO also discouraged the transfer of land from commercial to subsistence growers, preventing the decline in productivity associated with low-input agriculture. It did so by providing commercial maize growers the income to sustain maize production and consume surpluses within the household.[22] However, it is doubtful that this could have happened in areas where commercial operations and marketed surpluses were large. In Frontera Corozal, Chiapas, PROCAMPO transfers allowed commercial growers to simply leave land fallow (Dyer, 2001).

---

[21] M. Young (IAD, UC Davis) personal communication.

[22] Surpluses are both consumed by the household and fed to livestock.

Our simulations assume complete coverage of growers eligible for PROCAMPO. In practice, political economic considerations influence program implementation. In spite of official records (see INEGI, 1998), PROCAMPO failed to reach most eligible recipients in Zoatecpan, and it certainly does not benefit young agricultural households that did not produce a decade ago and thus never registered for PROCAMPO. It appears that PROCAMPO does reach the largest landholders in the region, who can afford the fixed costs of paperwork and bribes. However, it is unlikely that those households used PROCAMPO funds to increase agricultural productivity; most rented out their land. Moreover, it is likely that a large part of PROCAMPO funds leaked out of the region without generating an economy-wide multiplier effect, since well-off households spend a large share of their income on consumption goods produced elsewhere and "imported" into the region. Our simulation results suggest that even if they reach eligible recipients, PROCAMPO payments have a limited multiplier effect on the village economy. This would contrast with findings from other parts of Mexico that suggest that PROCAMPO funds have had an important within-household multiplier effect (see Sadoulet *et al.*, 2001). Surprisingly, PROGRESA, which has been more effective in reaching its target population in Zoatecpan, appears to match PROCAMPO's effect on all aggregate village variables and trumps it in other respects as well.

Although PROGRESA has already received high marks in achieving its own goals (Behrman and Hoddinott, 2000; Gertler, 2000; Schultz, 2001), it is likely that it has had additional benefits. In Zoatecpan, PROGRESA has been an important source of income, sustaining household expenditure and ameliorating local economic contraction as commercial maize agriculture declines. Local employers complain that PROGRESA raises agricultural wages. According to our results, 75% of households experience an increase in real income under a PROGRESA-type program, compared with 60% under PROCAMPO.[23] The distribution of income among households is also slightly more progressive under a PROGRESA-type program. It could be argued that PROCAMPO was not intended to diminish differences in household income, but rather to increase productivity and compensate losers from NAFTA. However, in Zoatecpan, PROCAMPO is not more effective at this than the alternative PROGESA-type program.

Conclusions and prospects

Few agricultural households are totally isolated from all market changes; autarchic households are a rarity. Households may be affected by changes in markets in which they do not participate, if they interact with households that do participate in those markets. Differences among households generate heterogeneous responses to market changes countrywide and also influence interactions among households in local markets. Subsistence households' interaction with commercial growers in local land and labor markets influences their responses to changes in commodity markets. The outcome may seem paradoxical at times. In Zoatecpan, Mexico, our simulations indicate that subsistence households might decrease the scale of *milpa* production in response to increases in the market price of maize. Obviously, this is not a direct response to the price change, but a result of interaction with commercial growers seeking to exploit price increases by incorporating additional land into *milpa.* A fundamental implication of this analysis is that local outcomes of changes in national policies depend upon local

[23] Households that depend on commerce inevitably experience a drop in real income, since neither program counteracts the conversion to a subsistence economy

conditions. Therefore, findings in the village of Zoatecpan cannot be easily generalized to the rest of the country. However, they illustrate how local outcomes are shaped, and they may serve as a model to understand how policy and market changes play out in other local contexts, in Mexico as well as other LDCs. This is a necessary first step in predicting the impacts of market changes at more aggregate levels.

Although the Mexican maize sector has survived NAFTA relatively unscathed, it is widely expected that, as the North American maize markets continue to integrate, small-scale maize producers in Mexico will vanish (Nadal, 2000). Our results suggest that the Mexican maize sector has already restructured, shifting from a commercial towards a subsistence mode of production. It is likely that subsistence maize production will thrive despite apparently adverse market conditions.

Bibliography

Andrade, A., and N. Blanc. 1987. SAM's cost and impact on production. In: Austin, J.E., and G. Esteva (eds.) *Food policy in Mexico: The search for self-sufficiency*. Ithaca, N.Y.: Cornell Univ. Press.

Appendini, K. 1994. Transforming food policy over a decade: The balance for Mexican corn farmers in 1993. In: Hewitt, C. (ed.) *Economic restructuring and rural subsistence in Mexico: Corn and the crisis of the 1980s.* Transformation of Rural Mexico, No. 2. Center for U.S.-Mexico Studies, San Diego: Univ. of California.

Austin, J.E., and G. Esteva. 1987. The path of exploration. In: Austin, J.E., and G. Esteva (eds.) *Food policy in Mexico: The search for self-sufficiency*. Ithaca, N.Y.: Cornell Univ. Press.

Bartra, R. 1982. *Campesinado y poder político en México.* Mexico: Ediciones Era.

Bartra, A. 2000. Sur profundo. In: Bartra, A. (ed.) *Crónicas del sur: Utopías campesinas en Guerrero*. Mexico: Ediciones Era.

Behrman, J., and J. Hoddinott. 2000. *An evaluation of the impact of PROGRESA on pre-school child height.* Washington, D.C.: IFPRI.

Cason, J., and D. Brooks. 2000. BID, FMI y BM elogian logros económicos de México: El Presidente llama a ampliar la inversión en capital humano. *La Jornada*, June 10. Mexico. <http://www.jornada.unam.mx/2000/jun00/000610/pol3.html>

Clawson, D.L. 1985. Harvest security and intraspecific diversity in traditional tropical agriculture. *Economic Botany* **39**(1):56-67.

Collier, G. 1999. *Basta!: Land and the Zapatista rebellion in Chiapas.* With E. L. Lowery Quaratiello. Oakland: Food First.

De Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. Peasant household behavior with missing markets: some paradoxes explained. *The Economic Journal* **101**:1400-1417.

De Janvry, A., E. Sadoulet, and G. Gordillo de Anda. 1995. NAFTA and Mexico's maize producers. *World Development* **23**(8):1349-1362.

De Janvry, A., G. Gordillo de Anda and E. Sadoulet. 1997. Mexico's second agrarian reform: Household and community reponses 1990-1994. Transformation of rural Mexico Series, Center for US-Mexican Studies, Univ. of California, San Diego.

Deaton, A. 1997. *The analysis of household surveys: A microeconometric approach to development policy*. Washington, D.C.: The World Bank; Baltimore: John Hopkins Univ. Press.

Dewalt, B.R., M.W. Rees. 1994. *The end of the agrarian reform in Mexico: Past lessons, future prospects.* Transformation of Rural Mexico, No. 3. Center for U.S.-Mexico Studies, San Diego: Univ. of California.

Dyer, G. 2001. *Economía y Conservación en el México Rural*, paper presented in Simposio Estudios y Perspectivas en el Manejo de los Recursos Naturales y la Conservación de Sistemas Vegetales. XV Congreso Mexicano de Botánica, Queretaro, Mexico.

Dyer, G., A. Yúnez, and J.E. Taylor. 2001. Land degradation in a diversified rural economy: a village-town CGE analysis from Mexico. In: Heerink, N., H. van Keulen, M. Kuiper (eds.) *Economic policy reforms and sustainable land use in LDCs: recent advances in quantitative analysis*. Heidelberg: Physika-Verlag.

Dyer, G. 2002. *The cost of in situ conservation of maize landraces in the Sierra Norte de Puebla, Mexico*. Ph D. diss. Univ. of California, Davis.

Evangelista Oliva, V. 1998. *Influencia de dos cultivos comerciales en el cultivo de maíz en la comunidad de Naupan, Puebla.* Master's thesis. Universidad Nacional Autónoma de México. Mexico.

Fafchamps, M. 1992. Cash crop production, food price volatility, and rural market integration in the Third World. *American Journal of Agricultural Economics* **74**:90-99.

Finkelshtein, I., and J. Chalfant. 1991. Marketed surplus under risk: do peasants agree with Sandmo? *American Journal of Agricultural Economics* **73**:557-567.

Fox, J. 1992. *The politics of food in Mexico: State power and social movillization.* Ithaca, N.Y.: Cornell Univ. Press.

Fritscher Mundt, M. 1996. El repunte maicero en tiempos de neoliberalismo. In: Lara Flores, S.M, and M. Chauvet (eds.) *La sociedad rural mexicana frente al nuevo milenio. Volumen I. La inserción de la agricultura mexicana en la economía mundial.* Mexico: INAH, UAM, UNAM, Plaza y Valdez.

Gertler, P.J. 2000. *Final report: The impact of PROGRESA on health.* November. Washington, D.C: International Food Policy Research Institute.

Heath, J.R. 1987. Constraints on peasant maize production: A case study from Michoacan. *Mexican Studies* **3**(2):263-286.

Hewitt de Alcantara, C. 1994. Introduction: Economic restructuring and rural subsistence in Mexico. In: Hewitt, C. (ed.) *Economic restructuring and rural subsistence in*

Mexico: Corn and the crisis of the 1980s. Transformation of Rural Mexico, No. 2. Center for U.S.-Mexico Studies, San Diego: Univ. of California.

INEGI. 1998. *Anuario estadístico del Estado de Puebla*. Edicion 1998. INEGI, Gobierno del Estado de Puebla. Mexico.

——. 2001. Online data base.

Key, N., E. Sadoulet, and A. de Janvry. 2000. Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics* **82**:245-259.

Levy, S., and S. van Wijnbergen. 1992. Maize and the Free Trade Agreement between Mexico and the United States. *The World Bank Economic Review* **6**(3):481-502.

Levy, S., and S. van Wijnbergen. 1994. Labor markets, migration and welfare: Agriculture in the North-American Free Trade Agreement. *Journal of Development* **43**:263-278.

Löfgren, H., R.L. Harris, and S. Robinson. 2001. A standard CGE model in GAMS. Mimeo.

Montanari, M. 1987. The conception of SAM. In: Austin, J.E., and G. Esteva (eds.) *Food policy in Mexico: The search for self-sufficiency*. Ithaca, N.Y.: Cornell Univ. Press.

Nadal, A. 1999. Maíz: Entre la guerra y la consulta. *La Jornada*, March 22. Mexico. <http://www.jornada.unam.mx/1999/mar99/990322/nadal.html>

Ochoa, E.C. 2000. *Feeding Mexico: The political uses of food since 1910*. Wilmington, Del.: SR Books

Perales R., H., S.B. Brush, and C.O. Qualset. 1998. Agronomic and economic competitiveness of maize landraces and in situ conservation in Mexico. In: Smale,

M. (ed.) *Farmers, gene banks and crop breeding: Economic analysis of diversity in wheat, maize, and rice.* Mexico: CIMMYT; Boston: Kluwer Academic Publishers.

Robinson, S., M.E. Burfisher, R. Hinojosa-Ojeda, and K.E. Thierfelder. 1993. Agricultural policies and migration in a US-Mexico Free Trade Area: A computable general equilibrium analysis. *Journal of Policy Modeling* **15**(5&6):673-701.

Sadoulet, E., A. de Janvry, and B. Davis. 2001. Cash transfer programs with income multipliers: PROCAMPO in Mexico. *World Development* **29**(6):1043-1056.

Schultz, T.P. 2001. *School subsidies for the poor: Evaluating the Mexican PROGRESA poverty program.* August. Economic Growth Center, Yale Univ., New Haven.

SEDESOL. 2001. *Programa de educación, salud y alimentación, PROGRESA.* Secretaría de Desarrollo Social. Mexico.

SEDESOL. 2002. *El cambio de Progresa en Oportunidades.* Secretaría de Desarrollo Social. Mexico. <http://www.progresa.gob.mx>

Singh, I., L. Squire, and J. Strauss. 1986. The basic model: Theory, empirical results, and policy conclusions. In: Singh, I., L. Squire, and J. Strauss (eds.) *Agricultural Household Models: extensions, applications, and policy*. Washington, D.C.: The World Bank; Baltimore: John Hopkins Univ. Press.

Taylor, J.E., and I. Adelman. 1996. *Village economies: The design, estimation, and use of villagewide economic models*. Cambridge: Cambridge Univ. Press.

Taylor, J.E., A. Yunez-Naude, and G. Dyer. 1999a. Agricultural price policy, employment, and migration in a diversified rural economy: A village-town CGE analysis from Mexico. *American Journal of Agricultural Economics* **81**:653-662.

Taylor, J.E., A. Yunez-Naude, and S. Hampton. 1999b. Agricultural policy reforms and village economies: A computable general-equilibrium analysis from Mexico. *Journal of Policy Modeling* **21**(4):453-480.

Taylor, J.E., A. Yunez-Naude, G.A. Dyer, M. Stewart and S. Ardila. In Press. *The economics of "eco-tourism": A Galapagos Islands economy-wide perspective.* Economic Development and Cultural Change <http://www.reap.ucdavis.edu>.

Tellez Kuenzler, L. 1992. Mexican agricultural policy and the Nation's modernization process. In: Carter, C., and H.O. Carter (eds.) *North American free trade Agreement: Implications for California agriculture*. Agricultural Issues Center, Univ. of California, Davis.

Yúnez Naude, A., and F. Barceinas. 2000. Efectos de la desaparición de la Conasupo en el comercio y en los precios de los cultivos básicos. *Estudios Económicos* **15**(2):189-227.

Zúñiga, D. 2000. Requiere el país política de Estado contra la pobreza: experta del BID. *La Jornada*, July 10. Mexico. <http://www.jornada.unam.mx/2000/jul00/000710/eco4.html>

Table 1. General equilibrium model: Variables

Sets of variables

ip	Activities
ic	Commodities
it	Activitites or commodities
f	Factors
h	Households

Variables

Q_{ip}	Activity *ip*'s output
$FD_{f,ip}$	Activity *ip*'s demand for factor *f*
P_{it}	Activity output/commodity *it*'s price
PVA_{it}	and price value added
W_f	Factor *f*'s wage
$WFDIST_{f,ip}$	Factor *f*'s price proportionality ratio in sector *jp*.
FVA_f	Factor *f*'s value added
EFD_f	Exogenous demand for factor *f*
MIG_f	Migration of factor *f*
Y_h	Household *h*'s income
PW_h	Government transfers to household *h*
NGT_h	Non-government transfers to household *h*
$CD_{it,h}$	Household *h*'s demand for output/commodity *it*
IN_{ic}	Aggregate intermediate demand for commodity *ic*
DD_{ic}	Aggregate demand for commodity *ic*
HAS_{ip}	Agricultural surplus of activity *ip*
HIN_{ip}	Intermediate demand for activity *ip*'s output
$HS_{ic,ip}$	Transformation coefficient of activity output *ip* into commodity *ic*
$HMSC_{ic}$	Aggregate household surplus of commodity *ic*
OPS_{ic}	Village imports of commodity *ic*
SPS_{ic}	Local purchases of commodity *ic*
EXP_{ic}	Village exports of commodity *ic*
TFD_f	Total demand for factor *f*
TFS_f	Total supply of factor *f*

Table 2. General equilibrium model: Equations

Production Block

$$Q_{ip} = \beta_{ip} \prod_{f} FD_{f,ip}^{\alpha_{f,ip}}$$

$$FD_{f,ip} = \alpha_{f,ip} \cdot PVA_{ip} \cdot Q_{ip} / W_f \cdot WFDIST_{f,ip}$$

Price block

$$PVA_{ip} = P_{ip} - \sum_{it} \sigma_{it,ip} \cdot P_{it}$$

Income block

$$FVA = W_f \cdot \left(\sum_{ip} FD_{f,ip} \cdot WFDIST_{f,ip} + EFD_f + MIG_f \right)$$

$$Y_h = \sum_{f} \alpha_{h,f} \cdot FVA_f + PW_h + NGT_h$$

$$GDP = \sum_{f} FVA_f$$

Expenditure block

$$CD_{it,h} = \sigma_{it,h} \cdot Y_h / P_{it}$$

$$IN_{ic} = \sum_{ip} \sigma_{ic,ip} \cdot Q_{ip}$$

$$DD_{ic} = \sum_{h} CD_{ic,h} + IN_{ic}$$

Household surplus block

$$Q_{ip} = HAS_{ip} + CD_{ip} + HIN_{ip}$$

(transformation equations)

$$HS_{ic,ip} = \sigma_{ic,ip} \cdot HAS_{ip}$$

Village commodity supply block

$$P_{ic} \cdot HMSC_{ic} = \sum_{ip} P_{ip} \cdot HS_{ic,ip}$$

General equilibrium block

(goods)

$$OPS_{ic} = DD_{ic} - HMSC_{ic} - SPS_{ic}$$

$$EXP_{ice} = HMSC_{ice}$$

(factors)

$$TFD_{f} = \sum_{ip} FD_{f,ip}$$

$$TFD_{f} = TFS_{f}$$

Table 3. Estimated household-budget shares

	Median	Minimum	Maximum
Milpa	0.18	0.00	0.50
All subsistence goods[1]	0.29	0.04	0.62
All food[2]	0.63	0.15	0.82
Imports[3]	0.02	0.00	0.48

1. Includes *milpa*.
2. Includes subsistence goods.
3. Household purchases outside village.

Table 4. Percentage effects of a change in the market price of maize, Zoatecpan, Mexico.

Variable	10% increase in the price of maize	
	(a) subsistence households exclusively	(b) subsistence and commercial households
production activities[1]		
Milpa	>0.01	3.95
other agriculture	0.07	-3.67
Livestock	-2.13	0.73
non-ag activities	-0.16	19.02
Commerce	-1.27	36.31
labor wage	-0.16	9.61
rental rate	-0.16	14.19
village GDP	-0.25	7.29
household income[1]	-1.25	1.64
household surplus[1]		
Maize	-	46.41,
Demand[1]		
Homegrown maize	<0.01	-4.34
market maize	-7.49	-3.69
animal products	-0.71	4.10
non-agricultural goods	-0.16	4.58
other food	-0.36	10.37
manufactured goods	-0.32	9.56
village maize imports	-7.18	-12.60

1. Village aggregate.

Table 5. Effects of a change in the market price of maize, Zoatecpan, Mexico.

Variable	original	after maize price change 10% increase	10% decrease
Gini coef. for real income	0.356	0.361	0.351
Gini coef. for land use	0.562	0.597	0.518
number of plots per hh[1]	1.60	1.48	1.73
hh giving-up plots[2]	-	14.58	2.08
hh taking-up plots[2]	-	2.08	14.58
households leaving agr. [2]	-	4.17	0.00

1. Average.
2. Percentage.

Table 6. Percentage effects of a 10% decrease in the market price of maize with compensation, Zoatecpan, Mexico.

variable	type of compensation PROCAMPO	PROGRESA[1]
production activities[2]		
milpa	-6.10	-6.26
other agriculture	4.45	4.45
livestock	0.73	0.71
non-ag activities	-12.93	-10.76
commerce	-22.62	-21.95
labor wage	-9.60	-9.60
rental rate	-14.05	-14.05
village GDP	-6.57	-6.52
household income[2]	-0.03	<0.01
household surplus[2]		
maize	-81.23	-75.98
beans	-100.62	-89.56
livestock	-4.02	-4.02
demand[1]		
home-grown maize	8.48	7.17
market maize	5.66	6.17
beans	-3.10	-2.73
animal products	-2.37	-2.56
non-agricultural goods	-3.11	-2.59
other food	-6.46	-6.26
manufactured goods	-6.16	-5.91
village maize imports	21.11	20.78

1. See text.
2. Village aggregate.

Table 7. Effects of a 10% decrease in the market price of maize with compensation, Zoatecpan, Mexico.

Variable	original	type of compensation PROCAMPO	PROGRESA[1]
Gini coef. for real income	0.356	0.351	0.348
Gini coef. for land use	0.562	0.519	0.518
number of plots per hh[2]	1.60	1.75	1.75
hh giving up plots[3]	-	4.17	4.17
hh taking up plots[3]	-	18.75	18.75
number of hh leaving agr.	-	0.00	0.00
number of varieties per hh[2]	1.60	1.68	1.68

1. See text.
2. Average.
3. Percentage.

Figure 1

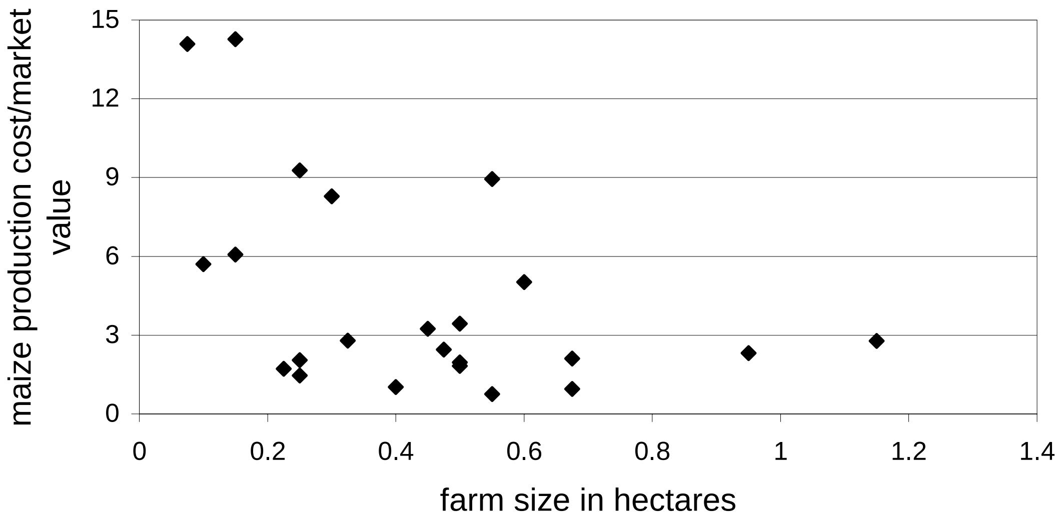

Fig. 1. Production costs/market value ratio for maize across households in Zoatecpan, Mexico.

Figure 2

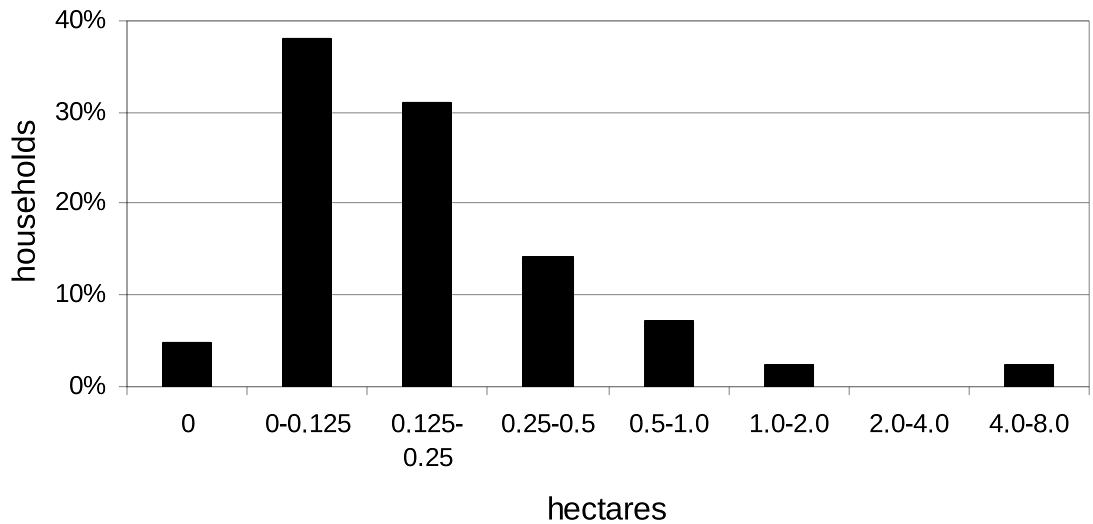

Fig. 2. Distribution of land ownership across households in Zoatecpan, Mexico.

Figure 3

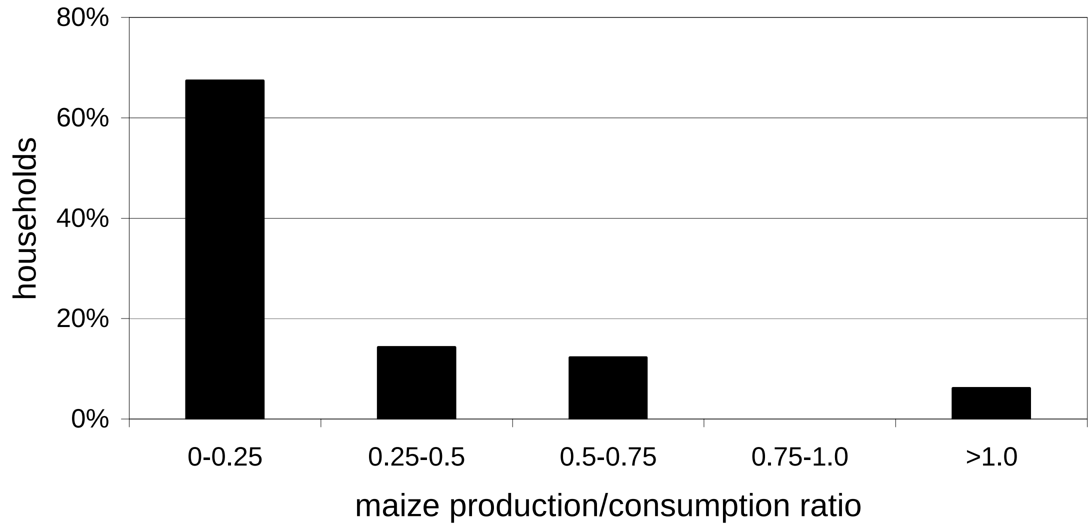

Fig. 3. Distribution of maize production/consumption ratios across households in Zoatecpan, Mexico