Agricultural Policy, Market Barriers, and Deforestation: The Case of Mexico’s Southern Yucatán

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Summary. — This paper examines the linkages between agricultural policies and deforestation in a development frontier of Southern Mexico, focusing on support programs targeted at buffering farmers from structural reforms. We argue that local barriers to market participation condition the responsiveness of farmers to program incentives, thereby constituting a key channel through which agricultural policies impact the environment. An econometric model parameterizes the influence of two programs, PROCAMPO and Alianza para el Campo, on cultivation. Consistent with an economic environment characterized by market barriers, results suggest that program support, even when decoupled from production decisions, significantly determines land use and deforestation.

Key words — cash transfers, market barriers, farm households, deforestation, Latin America, Mexico

1. INTRODUCTION

The formulation of policies that balance human welfare against environmental stewardship is among the most pressing challenges confronting countries with tropical forests. Beyond serving as global repositories of carbon and biodiversity, tropical ecosystems are home to nearly half of the world’s 6.4 billion inhabitants, providing a critical resource base for both agricultural and extractive activities. In Latin America, where upwards of 84% of deforestation is attributable to agriculture (FAO, 1998), the political economy of environmental management has been significantly shaped by so-called structural adjustment policies (SAPs) beginning in the mid-1980s. Introduced with the aim of fostering competition and industrialization through a combination of greater openness to international trade and the removal of state interference in domestic markets, these policies have dramatically altered the set of incentives and constraints influencing land allocation decisions (Liverman & Vilas, 2006; Rudel, 2007).

Although several studies have investigated the economic effects of particular policies associated with structural adjustment on Latin America’s farming sector (Echánove & Steffen, 2003; Korten, 1993; Nadkami & Vedini, 1996), there has been relatively less research on the implications for the environment. With regard to deforestation, three principle factors have complicated attempts to understand the impacts of SAPs at the micro-level. First, the exogenous drivers associated with such policies are often experienced uniformly within a region, so that temporal data capturing conditions before and after the policy are required if effects are to be discerned. Second, farm households in rural Latin America typically apply hybrid production strategies that combine—to varying degrees—subsistence and market-oriented cultivation. This heterogeneity results from household-specific differences in the transaction costs of market participation, which in turn conditions responses to economic incentives in complex ways that make policy outcomes difficult to predict. Finally, in many cases, structural adjustment constitutes a package of “multiple and sometimes contradictory policy changes” (Liverman & Vilas, 2006), rendering it problematic to link the process as a whole to particular environmental effects. Such has been the case in Mexico, where the larger structural adjustment regime has been accompanied by support programs targeted at buffering the agricultural sector from the effects of price fluctuations on basic commodities.

Using household survey data collected from an agrarian frontier in the Southern Yucatán of Mexico, this paper addresses the question of how such ancillary programs affect crop allocation and deforestation at the farm level. The Mexican experience with structural adjustment serves as a particularly useful case study of associated environmental effects for two reasons. First, the country is widely recognized as a key player among regions in which dramatic changes in land cover are precipitating systemic climate change (Cairns, Haggerty, Alvarez, De Jong, & Olimsted, 2000; Liverman, 1990). During 1990–2000, Mexico lost roughly 1.1% of its forests annually (FAO, 2001), over half of which was attributable to agricultural expansion (Cairns et al., 2000). Second, the Mexican...
government’s embrace of structural adjustment policies beginning in the mid-1980s was far reaching, involving the abolition of trade barriers under the General Agreement on Tariffs and Trade (GATT) and later the North American Free Trade Agreement (NAFTA), tenure reform, and, more recently, the implementation of various support programs designed to promote commercialized production while countering the austerity associated with economic liberalization. The focus of the present paper is on the effects of two such programs—PROCAMPO (Program of Direct Payments to the Countryside) and Alianza para el Campo (Alliance for the countryside, hereafter Alianza). Although both programs support farm households through financial and—in the case of Alianza—technical support, they are distinguished by their aims and the conditions attached to participating. PROCAMPO places no restrictions on how aid monies are spent, though it does attach conditions on land use pursuant to an array of environmental objectives, including the avoidance of agrochemicals, the abatement of soil erosion, and the promotion of conservation. Aid from Alianza, by contrast, is directed to particular agricultural activities that the recipient has agreed to implement, but the implementation itself is subject to no restrictions other than a perfunctory commitment to avoid environmental damage.

Our point of departure in analyzing the effects of these programs focuses on how barriers to market participation, such as those caused by high transportation costs, affect the adjustment of cropping patterns to changing economic conditions and policy incentives. We suggest that the in situ market structures emerging from such barriers may be one of the key channels through which centralized agricultural policies impact the environment, but one which has received relatively spare treatment in the related literature. To throw light on this issue, the analysis pursues three questions: (1) what are the comparative effects of Mexico’s reform program on the area cultivated in subsistence and commercialized crops, (2) to what extent do these effects vary according to the costs of market access, and (3) what are the associated implications for forest cover at the parcel level? Results from an econometric model of the region’s principle land uses indicate that while both PROCAMPO and Alianza positively impact the area cultivated, particularly in pasture, PROCAMPO alone has a negative impact on the area under forest. The environmental safeguards built into the program, thus appear to have failed in abating clearance, a finding from which we draw more general conclusions concerning the importance of considering both economic and environmental contexts in program design.

2. THE STUDY REGION: POLICY CONTEXT AND LAND USE

The history of structural adjustment in Mexico has been characterized by a continual tension between the pursuits of free-market strategies on the one hand and populist measures to mitigate associated economic hardships, particularly in the agricultural sector, on the other hand. This tension has been evident in the Southern Yucatán since Mexico’s debt crisis in 1982, when fiscal constraints caused by falling prices for petroleum forced the government to scale back a decade long effort to colonize and develop the region. During the 1970s and early 1980s, the Southern Yucatán received massive inflows of state-financed investment, beginning with the construction of a highway through its center in 1972 (Figure 1). The highway instigated the first influx of agricultural colonists, whose settlement was further encouraged by the extension of ejido land grants, a communal form of tenure that was created by the land reform following the Mexican Revolution (1910–17) (Klepeis, 2004; Turner et al., 2001).

The provision of road infrastructure was accompanied by other measures to encourage the establishment of an export-oriented agricultural economy, including a comprehensive system of subsidies and credits to promote the commercial production of staples, as well as state financing of agricultural projects for rice cultivation and cattle breeding. Despite these interventions, most of the initial settlers were subsistence-oriented farmers, whose settlement along the highway was primarily driven by subsidized access to land. Confronted with a five-month dry season, extreme climatic variability, modest agronomic potential, and costly access to markets, farmers typically cultivated on an extensive basis using a system known as milpa, a centuries-old Mayan form of agriculture that involves the intercropping of maize, squash, and legumes within a rotation of forest fallow. As noted by Eakin (2005), this system has served to enhance livelihood stability and, in deed, has proved more resilient than the government-supported schemes: by 1982, many of the rice and cattle projects had failed primarily due to inadequate water management and weed infestation (Klepeis, 2003).

Beginning in the mid-1980s, a radical revision of economic policies toward greater liberalization was underway that would be bolstered by legal reforms beginning in the following decade. In 1986, Mexico entered into the GATT, the impact of which reached the agricultural sector by 1990, when tariffs on most products were dropped or drastically lowered, subsidies on inputs were withdrawn or sharply reduced, and the guaranteed price was eliminated for all crops but maize and beans (Foley, 1995). The continuation of these reforms was secured under the terms of NAFTA, effective in 1994, obligating Mexico to fully liberalize its agriculture, including maize and beans, over a fifteen-year period. On the legal front, the Mexican Constitution was amended in 1992 to terminate the continued distribution of ejido lands to peasant communities and permit lands held in usufruct under the ejido system to be bought and sold (Goldring, 1995).

Against this backdrop, state support of agriculture nevertheless continued by other means. Starting in the mid-1990s, several programs were implemented to preempt the anticipated adverse welfare effects of agricultural liberalization, the two largest of which are PROCAMPO and Alianza Para el Campo, together accounting for over half of the expenditures in the Secretary of Agriculture’s budget (USDA, 2007). The overarching aim of both programs is to increase investment and productivity in the agricultural sector without distorting production incentives, thereby facilitating the integration of agricultural producers into the market economy. In the case of PROCAMPO, farmers receive an annual lump-sum payment of roughly 867 pesos per hectare, with the total payment being based on the hectares they cultivated in each of nine staple crops in 1993, the year prior to the start of the program. As one of the central goals of PROCAMPO is to promote land use intensification (SARH, 1993), the payments are conditional on the farmer maintaining the same plot of land under some designated productive use until the scheduled termination of the program in 2008. Unlike PROCAMPO, support by Alianza is provided on a demand-driven basis, with individual farmers or collectives petitioning for financial or technical assistance to undertake particular productive investments. If financial, this assistance is usually distributed under a matching grants scheme. In 1996, the first year of the program, producers provided an average of 50% of financing,
which in the Southern Yucatán was generally directed at agricultural and livestock improvement. While PROCAMPO participation in the data is fairly extensive, covering 86% of sampled households, Alianza covers only 14% of households. These figures are roughly in line with those reported by Cord and Wodon (2001), whose data from a national survey indicate that 84% of ejidatarios participate in PROCAMPO while 11% participate in Alianza.

Despite the decades long effort of the government to promote commercialized farming, market exchange of agricultural products in the Southern Yucatán remains limited, and the majority of farmers continue to maintain a strong basis in subsistence production organized around milpa cultivation. Nevertheless, beginning in the mid-1980s, an increasing number of farmers have incorporated jalapeños, a commercial crop, and pasture into their land use portfolios. While virtually all farmers have some amount of land planted under milpa, typically for home consumption given the abolition of price supports, our survey data indicate that only half plant either jalapeños or pasture. The partial participation rate for jalapeños is explained by the risks involved; producers must invest large upfront outlays for chemicals and labor, and both prices and yields tend to be highly variable. Moreover, the majority of farmers do not have their own means of transportation and labor, and both prices and yields tend to be highly variable. The partial participation rate for jalapeños is explained by the risks involved; producers must invest large upfront outlays for chemicals and labor, and both prices and yields tend to be highly variable. Moreover, the majority of farmers do not have their own means of transportation and must, therefore, market their output via so-called coyotes (middlemen), with whom they generally have weak bargaining power (Keys, 2005; Keys & Roy Chowdhury, 2006). Pasture, by contrast, is a low risk means of increasing the value of the land with minimal labor inputs (for both sale and rental), which partly explains why only half of those planting pasture own cattle. Among owners, anecdotal evidence indicates a widespread perception that cattle fulfill both a security function in cases of emergency and as a means of accumulating savings through breeding.

3. RELATED LITERATURE

Two broad theoretical perspectives have underpinned the literature addressing the relationship between liberalized markets and environmental outcomes. One, anchored in neoclassical economic theory, emphasizes the centrality of prices as indicators of resource scarcity. Under this view, resource extraction induces price increases well before the resource is exhausted, in turn leading to investments in preservation that ensure ecosystem viability (Hyde, Amacher, & Magrath, 1996). Moreover, to the extent that liberalized markets promote economic growth and reduce poverty, proponents of this view argue that the associated increases in economic stability and welfare promote sustainable management practices. The other perspective emphasizes various forms of institutional or market failures that mask scarcity (e.g., ill-defined property rights, pollution, and extraction externalities), attributing to these a misallocation of resources that leads to excessive exploitation of the natural resource base (e.g., Chichilnisky, 1994). Rather than promoting welfare, this perspective links liberalization to increased inequities and economic hardship, often resulting in a reinforcing cycle of poverty and degradation. While neoclassical theorists would not deny the existence of market failures, their prescriptions for addressing these typically rely on policies that assign a price to non-market goods (e.g., via taxation, trading schemes, and other measures that internalize external costs). Much debate consequently focuses on the logic of ascribing monetary values to environmental goods and services (Vatn & Bromley, 1995), and, more fundamentally, on the desirability of “commodifying” resources that some, such as indigenous groups, may regard as sacrosanct (Lind & Barham, 2004; Shiva, 1997).

This debate has thus far not been taken up in the empirical literature, and there have been few, if any, attempts to monetize environmental changes associated with particular SAPs in the Latin American realm. Most studies have instead sought to establish correlations between structural adjustment and the environment using either descriptive approaches or statistical modeling. Some of these draw on national or cross-national aggregate data, often relying on temporal comparisons of macroeconomic and environmental indicators to infer the effects of changing policy regimes (De A. David, Dirven, & Vogelgesang, 2000; Kaimowitz, Thiele, & Pacheco,
studies, Liverman and Vilas (2006) conclude that on the one hand, while the evidence generated across regions and scales of aggregation has been varied. Nevertheless, based on an extensive review of the recent literature, with findings of both negative (Abizaid & Coomes, 2004; Klepeis & Vance, 2003) and positive (Reyes-Hernandez, Cortina Villar, Perales Rivera, Kauffer Michel, & Pat Fernandez, 2006; Vance & Iovanna, 2006) impacts of SAPs on forest cover, hail from across Latin America, including in Costa Rica (Chomitz, Brenes, & Constantinou, 1998), Peru (Alvarez & Naughton-Treves, 2003), El Salvador (Hecht, Kandel, Gomes, Cuellar, & Rosa, 2006), and Mexico. The case of the Mexico’s Southern Yucatan, in particular, illustrates a circumstance commonly confronted by smallholder farmers in Mexico’s ejido sector. The intersection of the supply and demand curves for an agricultural staple corresponding to two farm households, labeled one and two, which are distinguished by whether they engage the market. Both households face a price band separating the purchase and sales prices, the magnitude of which reflects the transaction costs of market participation. These costs are typically incurred from factors determining accessibility, ranging from poor transport networks to cultural practices that dictate the terms of market engagement. The higher the costs, the wider is the price band. Because the supply and demand curves for household one intersect below the sales price at point A, its valuation of the staple is less than the price it would receive from selling. The household will consequently enter the market as a seller, with the quantity sold equal to the difference between the amount it supplies at price $P_{sell}$ ($Q_{1S}$) and the amount it consumes at that price $Q_{1D}$. Household production—being determined by the market price (inclusive of transaction costs)—is separable from its consumption decision. Having made the discrete choice to enter the market, its production behavior will therefore correspond to that of a profit-maximizing farm. Although the household consumes a portion of its own production, the level of that production at $Q_{1S}$ is determined not by its consumption needs, but by the market price, just as in the case of a commercialized farm. This logic does not apply to the second household, which illustrates a circumstance commonly confronted by smallholder farmers in Mexico’s ejido sector. The intersection of its supply and demand curve at point B indicate that the

4. THEORETICAL CONSIDERATIONS

The present study aims to advance the debate about structural adjustment by making explicit connections between local market structures, exogenously given policy measures, and environmental outcomes that have hitherto received scant attention in the literature. Specifically, we propose that a large part of the explanation for the geographical variation found across studies derives from the widespread extent of select market imperfections that prevail across much of Latin America’s agrarian landscape. These imperfections originate in high transaction costs associated with market participation, which are determined by both regional characteristics (e.g., remoteness, regulatory barriers, and quality of infrastructure), as well as household-specific attributes, such as the availability of motorized transport. Their combined influence drives a wedge between the effective price a household would pay to purchase a good in the market and the relatively lower price it would receive for selling the good (de Janvry, Fatfchamps, & Sadoulet, 1991; Dyer & Taylor, 2004; Omamo, 1998). This wedge reflects the decision price faced by the household different from the observable market price. If the wedge is sufficiently large, the household may opt out of market participation, thereby restricting its responsiveness to price signals and other exogenous changes related to the structural adjustment program.

An illustration of this circumstance and its implications for the effects of a cash transfer, such as that from PROCAMPO, on agricultural production and consumption is given by Figure 2, adapted from the discussion in Sadoulet and de Janvry (1995). The figure depicts the supply and demand curves for an agricultural staple corresponding to two farm households, labeled one and two, which are distinguished by whether they engage the market. Both households face a price band separating the purchase and sales prices, the magnitude of which reflects the transaction costs of market participation. These costs are typically incurred from factors determining accessibility, ranging from poor transport networks to cultural practices that dictate the terms of market engagement. The higher are the costs, the wider is the price band. Because the supply and demand curves for household one intersect below the sales price at point A, its valuation of the staple is less than the price it would receive from selling. The household will consequently enter the market as a seller, with the quantity sold equal to the difference between the amount it supplies at price $P_{sell}$ ($Q_{1S}$) and the amount it consumes at that price $Q_{1D}$. Household production—being determined by the market price (inclusive of transaction costs)—is separable from its consumption decision. Having made the discrete choice to enter the market, its production behavior will therefore correspond to that of a profit-maximizing farm. Although the household consumes a portion of its own production, the level of that production at $Q_{1S}$ is determined not by its consumption needs, but by the market price, just as in the case of a commercialized farm. This logic does not apply to the second household, which illustrates a circumstance commonly confronted by smallholder farmers in Mexico’s ejido sector. The intersection of its supply and demand curve at point B indicate that the

![Figure 2. Impact of a cash transfer under market transaction costs.](Author's personal copy)
household’s valuation of the good is lower than the price it would pay to purchase the good, but higher than the price it would receive as a seller. As market participation confers no benefit, the household will opt for self-sufficiency, with the consequence that the quantity supplied equals the quantity demanded (at point \(Q_0\)). The production decision is thus not independent of consumption, a circumstance referred to as mismeasurement (Singh, Squire, & Swinnerton, 1986).

Now consider the effect of a cash transfer that increases the incomes of both households by an equal amount. Presuming that the agricultural staple is a normal good such as maize, the higher income will shift the two demand curves to the right, yielding two new equilibria at points A’ and B’. \(^2\) For the first household, this shift will have no bearing on the amount of the staple it produces, \(Q_{1s}\), though it will reduce its marketed surplus—and hence increase consumption—by the amount \(Q_{1d}Q_{1d}^p\). Conversely, for the second household, the absence of a market outlet induces an internal response to the demand shift: both production and consumption increase by the amount \(Q_2Q_2^p\).

While not depicted, Figure 2 can also be used to illustrate the impact of a decrease in the market price for the staple that shifts the entire band downward, as emerged from the abolition of price supports on basic staples under NAFTA. For household one, which sells the good, the shift would cause decreased production, increased consumption, and decreased marketed surplus. No behavioral response would be elicited from household two, as its production and consumption decisions are reached independently of the market price. \(^3\) Thus, on comparing the effects of the change in the price of the staple and the cash transfer, it is noted that only the market participant adjusts production in response to the former, while only the non-participant adjusts production in response to the latter.

Figure 2 is a stylized depiction of the implications of a market imperfection for a single good for which it is assumed that there is a positive income elasticity of demand. Market imperfections from high transaction costs may additionally complicate an appraisal of the household’s response to exogenous shocks. Labor market imperfections, for example, may influence land use by limiting the number of crops that can be grown by the household, or, given a surplus of family labor, by inducing farmers to cultivate their land more extensively in response to insufficient off-farm employment opportunities (Benjamin, 1992). Alternatively, missing markets for insurance may lead risk averse farmers to allocate a greater share of their land to a staple crop despite greater expected profitability of cash crop production (Hammer, 1986).

Nevertheless, the above framework serves to illustrate two general features characterizing agrarian economies, both of which have relevance for understanding the relationship between structural adjustments and the environment. First, increases (decreases) in the prices of agricultural commodities do not necessarily increase (decrease) cultivation and pressure on forests. In an extreme case, a perverse supply response from a price change may be elicited, as when a higher price for a cash crop enables lower production of that crop and expansion of a food crop in order to meet a fixed subsistence requirement (Anderson Medellin, Apedale, & Pachico, 1994). \(^4\) Second, generalizations can also not be drawn with respect to the effects of agricultural support programs, such as PROCAMPO or Alianza. Rather, both the magnitude and the direction of these effects will depend on the depth of functioning markets in the local economy, as well as the extent of heterogeneity among households with respect to their ability to overcome whatever transaction costs to market participation may exist. It is nevertheless illustrative to reiterate an extreme case that can serve as a theoretical benchmark and motivate hypothesis testing: In a context of completely functioning markets—a circumstance that rarely prevails in agricultural front regions—we would expect a cash transfer to have no effect on the production decision pertaining to either an agricultural staple or a cash crop.

5. METHODS AND DATA

To test this hypothesis, we specify four equations that relate the hectares allocated to forest, milpa, jalapenos, and pasture to the support received from PROCAMPO and Alianza in addition to a set of control variables. Given that a shock affecting the area cultivated in one land use may spill over and affect the area cultivated in others, we employ the seemingly unrelated regression (SUR) estimator to accommodate any resulting residual covariance across the equations (Perz, 2002; Roy Chowdhury & Turner, 2006). By allowing for contemporaneous correlation between the error terms in each equation, this method generates more efficient estimates of the effects of the explanatory variables. \(^5\) It bears noting that this increased efficiency is not obtained if each of the four equations includes the same set of explanatory variables. In this case, the estimates generated by SUR are identical to those produced by an ordinary least squares regression, a point that has sometimes been neglected in land use applications of the model. We therefore introduce exclusion restrictions to ensure non-nesting of the equations. The selection of included variables, discussed below, was informed by theoretical and empirical findings obtained from the previous studies from Latin America in addition to evidence garnered during the course of field work concerning which factors create demands for each of the four land uses (DeShazo & De Shazo, 1995; Georges, 1990; Godoy et al. 1997; Jokisch, 2002; Keys, 2005; Taylor, Moran-Taylor, & Rodman Ruiz, 2006). Model specifications including all the explanatory variables were also explored (but not presented) to ensure that no biases were inadvertently introduced by the exclusion of select variables from the equations. \(^6\)

We measure PROCAMPO support as the total annual payment received by the farmer in pesos. As aid from Alianza takes various forms beyond financial support, we measure its effect using a dummy variable that equals one for participation in the program and zero otherwise. Several other variables are included in the model to capture both the consumption and production sides of household decision making, the descriptive statistics for which are presented in Table 1. To control for the effects of demographic pressures and human capital, we include measures of household composition as well as the age and education of the household head. As the area cultivated in milpa is primarily dictated by the household’s subsistence requirement (Geoghegan et al., 2001), household size is included as a proxy for the total consumption intake, with children under 12 weighted by two-thirds to approximate their consumption requirement relative to adults (Pichón, 1997). Given the presence of thin markets for hired labor (Vance & Geoghegan, 2004), we additionally include household members distinguished by age and sex in the equations for jalapenos, pasture, and forest to reflect their differing roles in providing labor to various farm tasks. While the cultivation and harvesting of maize and jalapenos typically involve men, women, and children, forest clearance and pasture...
maintenance are activities usually undertaken only by men. Age of the household head and residence duration serve as controls for familiarity with local market- and agronomic conditions, which is expected to impact the area cultivated in each of the three crops. Education of the household head provides an additional control for familiarity with the local environment, and is included in the forest equation under the expectation that higher-educated farmers place less reliance on the natural resource base. Previous research suggests that education is additionally an important determinant of pasture cultivation, while having no bearing on the area cultivated in milpa or jalapenos (Klepeis & Vance, 2003; Vance & Geoghegan, 2004). With respect to farm capital, we include an indicator for chain saw ownership in the forest and jalapeno equations, recognizing the tendency for farmers to clear older vegetation to take advantage of the higher nutrient content of the soils that jalapeno cultivation requires. As most pasture is established after milpa cultivation and most milpas are established on early secondary vegetation, the chain saw variable was excluded from these two equations. An indicator for vehicle ownership is included in the equations for maize and jalapeno, as this would facilitate transport of the harvest from the parcel to the household or market outlets. The final measure of farm capital, parcel size, is included in the equations for pasture and forest, the two most extensive land allocations, as farmers generally do not face a binding constraint on land availability for the cultivation of jalapeno and milpa. The influence of market prices for the two principle crops, included in the equations for milpa and jalapeno, is captured by an index measuring the price of maize divided by the price of jalapenos, both of which are calculated as a lagged three-year moving average. The walking time from the household to the parcel is included in all the four equations given the centrality of accessibility costs in determining the land use configuration. Likewise, remittances, off-farm income, and net revenues from the sale of farm products (subtracting the costs of hired labor and chemical inputs) from the preceding year are also included in each of the equations, as liquidity is expected to affect the mix of land uses and forest cover (Radel & Schmook, 2008). Finally, dummy variables indicating the ejido in which the household resides controls for village-level influences in each of the equations.

Following from the theoretical discussion, the specification also includes a variable that is the multiple of PROCAMPO support and a dummy variable indicating whether the household’s ejido is located along the main highway. The inclusion of this interaction term allows us to test whether the impact of PROCAMPO on land use varies according to the costs of market participation. As households along the highway face lower transaction costs (i.e., a narrower band separating the sales and purchase price), they are better positioned to adjust to a cash transfer via changes in marketed surplus rather than changes in area cultivated. We therefore expect to observe an attenuated effect of the PROCAMPO support, particularly on milpa cultivation, for these households. The interaction of Alianza and the highway dummy was also explored but was excluded from the final models due to insufficient variation, as the vast majority of Alianza recipients are located away from the highway.

The data used to estimate the model are pooled from two household surveys in 1997 and 2003 in the Southern Yucatan that focused specifically on the ejido sector. 7 The total sample comprises 211 households distributed across 14 ejidos, with 164 of the households surveyed in 1997, and the remaining 47 surveyed using an identical questionnaire in 2003. 8 The ejidos were selected through a stratified two-stage cluster design that geographically divided the region into several strata, with one ejido randomly selected from each stratum. Households were then selected randomly from each ejido after an enumeration of ejidatarios was taken. The number of respondents per ejido was roughly proportional to ejidatarios’ representation in the 14-ejido population.

A standardized questionnaire, organized according to two structured interviews, was used to elicit socioeconomic and land use data from the ejidatarios. One interview was conducted with the head of household, typically male, and addressed crop and secondary vegetation management, inputs, yields, farm capital, and animal husbandry. The other interview was conducted with the spouse, typically female, and covered household composition and demographics, on-farm and off-farm activities of household members, and information on migration, remittances and household assets. This separation reflects a gendered division of labor generally present in the region, and proved useful in the interviewing process. If the male head was absent from the ejido, the entire interview was conducted with the woman, sometimes with one of her older sons present.

### Table 1. Descriptive statistics

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Units</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCAMPO</td>
<td>100s of pesos</td>
<td>30,905</td>
<td>26,583</td>
</tr>
<tr>
<td>Highway</td>
<td>1/0</td>
<td>0.287</td>
<td>0.453</td>
</tr>
<tr>
<td>Alianza para el Campo</td>
<td>1/0</td>
<td>0.139</td>
<td>0.347</td>
</tr>
<tr>
<td>Price ratio, maize/jalapeno</td>
<td>Ratio</td>
<td>45.776</td>
<td>1.349</td>
</tr>
<tr>
<td>Household size</td>
<td>Count</td>
<td>3.584</td>
<td>1.834</td>
</tr>
<tr>
<td>Children 12–17</td>
<td>Count</td>
<td>1.014</td>
<td>1.146</td>
</tr>
<tr>
<td>Males 18–64</td>
<td>Count</td>
<td>1.280</td>
<td>0.818</td>
</tr>
<tr>
<td>Females 18–64</td>
<td>Count</td>
<td>1.153</td>
<td>0.697</td>
</tr>
<tr>
<td>Age of head</td>
<td>Years</td>
<td>45.359</td>
<td>15.615</td>
</tr>
<tr>
<td>Education of head</td>
<td>Years</td>
<td>2.895</td>
<td>3.192</td>
</tr>
<tr>
<td>Residence duration</td>
<td>Years</td>
<td>18.067</td>
<td>11.071</td>
</tr>
<tr>
<td>Income, off-farm</td>
<td>100s of pesos</td>
<td>134,462</td>
<td>244,906</td>
</tr>
<tr>
<td>Income, remittances</td>
<td>100s of pesos</td>
<td>13.563</td>
<td>59.224</td>
</tr>
<tr>
<td>Income, farm</td>
<td>100s of pesos</td>
<td>92.067</td>
<td>209.78</td>
</tr>
<tr>
<td>Chain saw ownership</td>
<td>1/0</td>
<td>0.311</td>
<td>0.464</td>
</tr>
<tr>
<td>Vehicle ownership</td>
<td>1/0</td>
<td>0.129</td>
<td>0.336</td>
</tr>
<tr>
<td>Area of parcel</td>
<td>Hectares</td>
<td>70.386</td>
<td>56.354</td>
</tr>
<tr>
<td>Minutes to parcel</td>
<td>Minutes</td>
<td>59.666</td>
<td>56.021</td>
</tr>
</tbody>
</table>

8. The ejidos were selected through a stratified two-stage cluster design that geographically divided the region into several strata, with one ejido randomly selected from each stratum. Households were then selected randomly from each ejido after an enumeration of ejidatarios was taken. The number of respondents per ejido was roughly proportional to ejidatarios’ representation in the 14-ejido population.

A standardized questionnaire, organized according to two structured interviews, was used to elicit socioeconomic and land use data from the ejidatarios. One interview was conducted with the head of household, typically male, and addressed crop and secondary vegetation management, inputs, yields, farm capital, and animal husbandry. The other interview was conducted with the spouse, typically female, and covered household composition and demographics, on-farm and off-farm activities of household members, and information on migration, remittances and household assets. This separation reflects a gendered division of labor generally present in the region, and proved useful in the interviewing process. If the male head was absent from the ejido, the entire interview was conducted with the woman, sometimes with one of her older sons present.
6. RESULTS AND ANALYSIS

Consistent with an economic environment characterized by market imperfections, the cash transfer from PROCAMPO is seen to be a significant determinant in each of the equations, increasing the area under milpa, jalapenos, and pasture while decreasing the area under forest (Table 2). The program’s positive impact on milpa cultivation confirms the expectation that the cash transfer increases the demand for crops consumed by the household, which in turn results in a higher equilibrium level of output. In the case of pasture and jalapenos, neither of which are staple crops, a possible explanation for the positive effect is the relaxation of a liquidity constraint caused by missing markets for credit, which allows farmers to purchase cattle or chemical inputs. An additional reason for the promotion of pasture may be that the planting and maintenance of grasses affords a relatively inexpensive means of meeting the program’s condition that the land be kept under productive use.

In gauging the magnitude of PROCAMPO’s effects, the results show that settlement relative to the highway is an important consideration. For households located away from the highway, a 100 peso increase in the transfer is associated with a 0.084 hectare increase in the area under milpa, an effect that is roughly double that of pasture. Location along the highway, however, results in differential impacts of the program for these two land uses, as evidenced by the significant coefficients of the interaction terms. In the case of milpa cultivation, the impact of the highway is still positive but just under half that of the highway-remote households, with a unit increase resulting in a 0.040 hectare increase in area. This attenuated effect likely reflects a greater flexibility in responding to the cash transfer via adjustments in marketed surplus rather than production, a consequence of the lower costs of market access that settlement along the highway would afford. Conversely, in the case of pasture, the effect of the program is amplified by the highway. A one unit increase results in a 0.290 hectare increase in area, over six times the impact of that of the highway-remote households. To the extent that land along the highway is nutrient depleted from intensive cultivation undertaken in years past, this exacerbated effect may relate to insufficiently fertile soils for food crops.

With respect to the program’s environmental impact, the negative and significant coefficient of PROCAMPO in the forest equation suggests that a primary aim—intensiﬁcation—has not been met, with a 100 peso increase in support being associated with 0.196 less hectares under forest. As suggested by Klepeis and Vance (2003), this finding may be partly due to inconsistencies between the terms of the program and the system of forest fallow that farmers in the region typically rely on. Instead of meeting the program’s condition that the land be kept under a productive use, PROCAMPO effectively removes this land from the fallow cycle, with a possible consequence being that additional forested lands are brought into the cycle to compensate.

As with PROCAMPO, the model uncovers significant effects of Alianza support on the area cultivated under milpa and pasture, though the program’s effect on jalapeno cultivation is insignificant. On average, Alianza participants cultivate 1.63 hectares more in milpa and 5.39 hectares more in pasture than non-participants. Unlike PROCAMPO, however, these program-induced increases in the area are not associated with a corresponding loss in forest cover, as evidenced by the significant coefficient estimate in the forest equation. This may in part relate to the higher level of engagement of program administrators in the extension of the aid, especially that relating to technical assistance, which could serve to discourage farmers from encroaching older vegetation. It also bears repeating that, with respect to land use, the terms of Alianza are more ﬂexible, allowing the recipient to allocate the assistance to either plots under cultivation or those previously under fallow.

Of the remaining control variables, those that are statistically signiﬁcantly signiﬁcant have signs that are in most cases consistent with intuition. One exception is the negative coefﬁcient of males aged 18–64 on the area planted in pasture, as it would be expected that a larger pool of potential ﬁeld workers would increase the area in this and other uses. Bearing in mind that pasture requires relatively light labor outlays, it may be that whatever security function afforded by this use (along with cattle ownership) is offset by the presence of working-age men in the household, though this is an issue requiring further investigation. The other signiﬁcant measure of household size is the number of children aged 12–17. Its positive coefﬁcient in the equation of jalapeno cultivation likely reﬂects the role that young family members often play in the harvest of this crop. Increases in the age of the household head are also associated with increased jalapeno cultivation, in addition to having a positive association with milpa, evidently indicating a greater orientation of older farmers to agricultural activities. The other attribute of the household head, higher education, has positive coefﬁcients in the pasture and forest equations. Speciﬁcally, each year of schooling is associated with roughly 0.494 more hectares under pasture and 1.16 more hectares under forest.

Moving beyond the demographic variables, we ﬁnd that income, the land endowment, and the proximity of the parcel to the highway emerge as signiﬁcant determinants in at least one of the equations. The various sources of income from the year preceding the survey yield a particularly interesting pattern given the region’s increased incidence of out-migration (Radel & Schmook, 2008) and a budding labor market oriented toward the tourist industry (Torres, 2002). While off-farm labor has positive coefﬁcients in the equations for milpa and pasture and a negative coefﬁcient in the equation for forest, the coefﬁcient on remittances is signiﬁcantly positive only in the equation for pasture. Moreover, increased farm income is associated with reduced pressure of forest in the subsequent year while also increasing the area under jalapeno cultivation. By contrast, income from off-farm labor in the preceding year is negatively associated with forest cover. Drawing deﬁnitive conclusions from these ﬁndings is unwarranted given the difﬁculty of disentangling causation and correlation, but they nevertheless point to the need for further research on the strategies employed for combining non-farm income with agricultural activities, and the associated implications for forest cover.

With respect to the model, the model explains a moderate share of the variance in the dependent variable, with R2s ranging between 0.35 and 0.79. Moreover, the χ2-statistics are uniformly over 100 with at least 186 degrees of freedom, providing clear-cut evidence that the explanatory variables are jointly signiﬁcant in each of the equations. Finally, the correlations of the error terms are highly signiﬁcant, and have signs that are consistent with intuition: shocks that increase the area in one type of cultivation increase the area in the other types while decreasing the area under forest.

7. DISCUSSION

Much of the literature analyzing the linkage between structural adjustment and the environment disregards the
implications of missing markets or implicitly assumes a homogeneous market environment through which policy signals are uniformly transmitted, thereby neglecting the possibility that these signals are mediated by local economic conditions. This neglect often leads to unwarranted generalizations concerning the behavior of agricultural households, specifically by ascribing them a commercial orientation in explaining their responses to political and market interventions. Although farmers operating in a context of completely functioning markets will, according to economic theory, behave in a manner consistent with that of a commercialized enterprise, those facing high costs to market participation may instead adopt production strategies that combine a subsistence and market orientation. Such hybrid strategies can confound expectations of a straightforward response to policy incentives, and in extreme cases lead to outcomes contrary to the policy’s objectives.

This paper has analyzed the effects of two agricultural support programs—PROCAMPO and Alianza—on land use and deforestation in the Southern Yucatán, with an eye toward discerning the role of prevailing market structures in conditioning the responses of program participants. In contrast to Alianza, an explicit aim of PROCAMPO is to abate environmental degradation, the realization of which is predicated on the decoupling of cash support from the farmer’s current production (SARH, 1993). The estimated coefficients from the econometric suggest that this aim has not been attained: While both programs are positively associated with the area under cultivation, only PROCAMPO has a negative association with the area under forest.

In interpreting this discrepancy, several considerations bear highlighting. First, as shown in the theoretical discussion, the premise that the cash support from PROCAMPO is decoupled from production is unfounded, particularly when the good produced is for subsistence. Such a decoupling will only be achieved if the transaction costs of market access are sufficiently low to enable exchange, in which case the increase in demand resulting from the cash transfer can be met by either increasing the amount of the good purchased or decreasing the amount sold. If, instead, high transaction costs induce the household to forgo market exchange, as is generally true for the staples produced from milpa cultivation in Mexico’s rain fed regions, the increased demand resulting from the cash transfer can only be met by increasing production. Under such a circumstance, the PROCAMPO program’s aim of decoupling income and production will, in effect, be negated by the absence of a market outlet that would otherwise enable the household to respond to the cash transfer by adjusting marketed surplus.

Given that the assistance from PROCAMPO—as well as Alianza—creates incentives to increase cultivation, particularly in food crops, it is additionally important to consider the extent to which the conditions of the programs constrain how farmers respond. One plausible channel through which PROCAMPO negatively impacts forest cover is the requirement that runs directly counter to the system of forest fallow typically practiced (Klepeis & Vance, 2003). In lieu of affordable access to chemical inputs, the clearance of forested lands for cultivation represents a rational response to accommodating the increased demand for staples while maintaining yields. In this regard, a number of authors have suggested that the program’s payments are unlikely to provide sufficient capital to produce the kinds of improve-

### Table 2. Seemingly unrelated regression results (n = 209)

<table>
<thead>
<tr>
<th></th>
<th>Milpa</th>
<th>Jalapeño</th>
<th>Pasture</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCAMPO</td>
<td>0.084***</td>
<td>0.005*</td>
<td>0.042***</td>
<td>−0.196**</td>
</tr>
<tr>
<td>PROCAMPO + highway</td>
<td>−0.044***</td>
<td>0.001</td>
<td>0.248***</td>
<td>−0.215**</td>
</tr>
<tr>
<td>Alianza para el Campo</td>
<td>1.632***</td>
<td>−0.224</td>
<td>5.387**</td>
<td>−6.049</td>
</tr>
<tr>
<td>Price ratio, maize/jalapeño</td>
<td>0.383</td>
<td>0.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>0.066</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children 12–17</td>
<td>0.090*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males 18–64</td>
<td>−0.048</td>
<td>−2.328**</td>
<td>1.860</td>
<td></td>
</tr>
<tr>
<td>Females 18–64</td>
<td>−0.094</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of head</td>
<td>0.033**</td>
<td>0.007***</td>
<td>0.008</td>
<td>−0.205</td>
</tr>
<tr>
<td>Education of head</td>
<td></td>
<td></td>
<td>0.494*</td>
<td>1.160***</td>
</tr>
<tr>
<td>Residence duration</td>
<td>0.131</td>
<td></td>
<td>0.178</td>
<td></td>
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<tr>
<td>Income, off-farm</td>
<td>0.006***</td>
<td>0.000</td>
<td>0.020***</td>
<td>−0.017**</td>
</tr>
<tr>
<td>Income, remittances</td>
<td>0.001</td>
<td>0.000</td>
<td>0.046**</td>
<td>−0.012</td>
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<tr>
<td>Income, farm</td>
<td>0.0004</td>
<td>0.002***</td>
<td>−0.001</td>
<td>0.025**</td>
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<tr>
<td>Chain saw ownership</td>
<td>0.181</td>
<td></td>
<td></td>
<td>0.359</td>
</tr>
<tr>
<td>Vehicle ownership</td>
<td>0.091</td>
<td></td>
<td></td>
<td>−0.075</td>
</tr>
<tr>
<td>Area of parcel</td>
<td>0.105</td>
<td></td>
<td></td>
<td>−0.528**</td>
</tr>
<tr>
<td>Minutes to parcel</td>
<td>−0.002</td>
<td>0.001</td>
<td>−0.024</td>
<td>0.153***</td>
</tr>
<tr>
<td>$\chi^2$ ejido dummies</td>
<td>27.3**</td>
<td>21.2</td>
<td>34.0***</td>
<td>61.5***</td>
</tr>
<tr>
<td>$\chi^2$ equation</td>
<td>189***</td>
<td>109***</td>
<td>296.2***</td>
<td>766***</td>
</tr>
<tr>
<td>Constant</td>
<td>−18.395</td>
<td>−0.886</td>
<td>−11.185*</td>
<td>−10.709</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.488</td>
<td>0.353</td>
<td>0.592</td>
<td>0.790</td>
</tr>
</tbody>
</table>

**Correlation matrix of the residuals, $\chi^2 = 55.951***$

<table>
<thead>
<tr>
<th></th>
<th>Milpa</th>
<th>Jalapeño</th>
<th>Pasture</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milpa</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jalapeño</td>
<td>0.1693</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td>0.389</td>
<td>0.0389</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>−0.174</td>
<td>−0.1307</td>
<td>−0.2317</td>
<td>1</td>
</tr>
</tbody>
</table>

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.
ments in land that are necessary to sustain competitive commercialized production, leading them to regard the payments as, essentially, a welfare support (de Janvry, Gordillo, & Sadoulet, 1997; Myhre, 1998; Sadoulet, de Janvry, & Davis, 2001).

This interpretation appears particularly apt in the Southern Yucatán, where remoteness and environmental constraints have made commercialized production in the absence of credit resources and technical assistance difficult. As evidenced by both the failure of the government-sponsored cattle schemes and the resilience of the subsistence-oriented milpa system, the resources of the region are not so propitious that settlers can compete in the production of staples in regional markets. While jalapenos are one exception, this crop has not liberated the majority of the region’s farmers from a predominantly subsistence existence.

Three policy implications derive from these considerations. First, it is important that the conditions attached to agricultural support programs be sufficiently flexible to accommodate the production practices of participating farmers. In the case of the PROCAMPO program, this would mean relaxing the requirement that the same plot of land be maintained under production. Not only would such an alteration likely reduce the program’s administrative and enforcement costs, it would also avoid contravening the system of forest fallow employed within Mexico’s rain fed-farming sector to deal with prevailing environmental constraints. Second, it is critical that agricultural support—particularly that in the form of cash transfers—be complemented by measures that facilitate market participation. The design of these measures will depend on identifying where barriers to exchange exist. In the Southern Yucatán, poor road infrastructure and marketing networks has been one of the primary factors hindering market accessibility, though in other contexts institutional features such as legal prohibitions on certain transactions may also play a role. Finally, as suggested by Sadoulet et al. (2001), financial assistance should ideally be accompanied by technical assistance that creates opportunities to use the transfers productively. While the institutional architecture is in place for such assistance in the form of the Alianza program, its reach is relatively limited, and should be expanded beyond the roughly 11% of farmers nationwide that participate.

8. CONCLUSION

This paper has analyzed the complexities inherent in designing environmentally benign interventions targeted at economic development in regions characterized by barriers to market exchange. Although land use is driven by large-scale political and market forces (Liverman & Vilas, 2006), the impacts of these forces may vary substantially both within and across scales depending on local economic conditions. The findings of this study suggest, in particular, that agricultural policy measures are unlikely to have the intended effects in regions where market participation is limited. Such policies should therefore be accompanied by complementary measures that reduce the costs of market transactions.

NOTES

1. When adjusted for inflation, the amount of the PROCAMPO payment varies within a range of roughly 50 pesos from year to year. This figure is thus an average of the payments issued during 1994–2003.

2. The assumption that maize is a normal good is supported by the centrality of this crop in tortilla production, a staple of immense culinary and cultural significance to Mexico’s national identity (Lind & Barham, 2004). Further support is given by a nutritional survey conducted by Alayón and Gurri (2007), who found that constraints on staple consumption in the Southern Yucatan may be binding, with smallholder households experiencing seasonal food scarcity.

3. It is, however, possible that an extremely large downward shift would nudge household two into the regime as a purchaser while nudging household one into a regime of self-sufficiency.

4. Taylor and Adelman (2003), for example, speculate that the decrease in maize prices from Mexico’s agricultural reforms may have actually increased production within the country’s small-farm sector, noting the overall slight reduction in maize output despite an 18% drop in its price during 1994–97.

5. Given that jalapenos and pasture are planted by roughly half the sample, the application of the SUR estimator may generate biased estimates as a result of censoring of the dependent variables. To explore this, we estimated various censored regression models, including the Tobit and two-part models, on jalapeno and pasture cultivation. This resulted in only small differences in the magnitude of the estimates, and had no bearing on the qualitative findings.

6. The robustness of the results was also checked by removing outliers identified by leverage versus squared residual plots and re-estimating the model. This had no notable effect on the estimates.

7. The study region is also occupied by a smattering of private ranches specialized in cattle. A comparative analysis of the region’s ranchers and ejidatarios is found in Vance, Klepeis, Schmook, and Keys (2004).

8. To account for the effects of inflation over the years separating the two surveys, all variables that are expressed in pesos are deflated using the OECD’s consumer price index for Mexico (2000 = base year).

9. Baffes and Meerman (1997), for example, point to the relatively expensive administrative costs of PROCAMPO, noting that the majority of extension workers are in effect working for the program by spending their time monitoring the enforcement of restrictions on land use.

REFERENCES


