Discussion Paper Series

RIEB

Kobe University

DP2016-06

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February 25, 2016

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*I am grateful to Takahiro Sato, Nobuaki Hamaguchi, and Shoji Nishijima for their feedback and support. I also thank Yuriko Takahashi, Yoshiaki Hisamatsu, Tomokazu Nomura, and the floor participants at the 50th Annual Conference of the Japan Society of Social Science on Latin America at IDE-JETRO on November 16, 2013, for their helpful comments. This research is supported by JSPS KAKENHI (grant no: 26·40002). The author is responsible for all remaining errors.

Abstract

This study empirically analyzes risk-sharing functioning in rural Mexico. It also aims to examine the vulnerability of rural households and whether the conditional cash transfer (CCT) program will reduce the vulnerability within the risk-sharing framework. I adopt the two most recent Mexican rural household panel data for 2003 and 2007—although rich in information, the data have not been fully utilized given the lack of pure control groups. Drawing on Townsend's (1994) risk sharing model, the empirical results reject the hypothesis of full risk sharing but confirm that risk-sharing functions serve better in securing basic needs such as food. In addition, the risk-sharing function, reinforced by longer exposures to the CCT program, serves to mitigate the liquidity constraints or vulnerability of poor households.

JEL Classification: O12, D12, O54

Keywords: risk sharing, household vulnerability, CCT

1. Introduction

Mexico is known as a middle income country, being the second largest country in Latin America and the Caribbean (LAC) in terms of population as well as economy size after Brazil. Its GDP per capita amounted to US$10,130 in 2011 (ECLAC, 2012) and its HDI was 0.775 (UNDP, 2013), ranked 61st among 187 countries in 2012 (Uchiyama, 2013b). It is widely recognized that the LAC has achieved a steady macroeconomic situation in the 2000s after 20 years of the so-called "lost decades" accompanied by the controversial economic crises and adjustments. For the first time ever, the number of people belonging to the middle class surpassed the number of poor people, a sign that LAC countries are progressing toward becoming components of a middle-class region. Despite the impressive gains of the past decade, the region remains unequal, with some 82 million people living on less than $2.5 per day (World Bank, 2013). World Bank (2013) warns that creating opportunities for vulnerable people is the priority issue to be addressed. Mexico is not the exception with more than half of the population being classified as poor in 2010 at the national level according to the national poverty line[i]. It is an unignorable fact that the poverty ratio reaches more than 60 percent in rural areas in the same year (Uchiyama, 2013b).

The term "vulnerability" is now used in many different literatures. However, its definition varies according to the contexts and thus to the researchers. A general idea of vulnerability in economics should be "the probability of falling below a certain poverty line in the future." (World Bank, 2000) The importance of measuring vulnerability is increasing in a sense that "vulnerability" is a dynamic concept closely related to poverty and encapsulating changes between different points in time whereas "poverty" is a static concept representing a condition at a particular point in time.

According to Dercon (2005), vulnerability can be explained by the sum of the welfare loss from deviations of mean consumption relative to an agreed level (*the cost of poverty*) plus a measure of *the cost of risk*—the difference of expected utility from the utility related to expected consumption. In this respect, based on the theory of expected utility, Kamanou and Morduch (2005) argue that the expected utility of risk-averse individuals falls as the variability of consumption rises. In addition, Dercon (2005) describes two strategies such households exposed to income fluctuations use to reduce the impacts of shocks: *risk-management* strategies and *risk-coping* strategies. Risk-management strategies attempt to reduce the riskiness of the income process *ex ante* (*income smoothing*) through, in most cases, diversification of income sources by combining different income generating activities, including cultivation of various crops to reduce the harvest risk, even if the crops have a lower average yield. In contrast, risk-coping strategies consist of self-insurance (through precautionary savings) and informal group-based risk sharing. They deal with the consequences of income risk (*consumption smoothing*). Households can insure themselves by building up assets in good years, which they can deplete in bad years. Also, informal arrangements can be made among members of a group or village to support each other in case of hardship, for example, among extended families, ethnic groups or neighborhoods.

When looking at rural areas of developing countries where poverty and vulnerability are generally concentrated, it is widely known that rural people must often cope not only with severe consumption poverty but also with extremely variable incomes, such as natural disasters, illness, injury, involuntary unemployment and market price changes (Bardhan and Udry, 1999). Thus they have to rely on the above mentioned income and consumption smoothing strategies, however, they are often hardly insured against these risks. Income fluctuations can present an acute threat to people's livelihoods even if, on average, incomes are high enough to maintain a minimal standard of living (Bardhan and Udry, 1999).

It is important to recall that the main obstacles to consumption smoothing should be the liquidity constraints caused by the market imperfection especially in rural areas. Bardhan and

Udry (1999) argue that liquidity constraints are more likely to be binding particularly among poor farmers, so that (agricultural) production and consumption cannot be financed from savings, and the costs (in terms of utility, health and even survival) of fluctuations in an already low level of consumption are extreme. The poor farmers need to consume before harvest, which depends on climate and many other external factors. Thus, when production is risky and insurance markets are incomplete, credit transactions are required to play a key role by permitting people to smooth consumption. However, it is quite usual that famers also face credit constraints and thus fail to smooth their consumption, which inevitably forces them to fall into a poverty trap.

Among various econometric methods of measuring household vulnerability, the one that has a theoretical foundation is the risk sharing model proposed by Townsend (1994) as is argued in Kurosaki (2009). Townsend (1994) proposes a general equilibrium model of jointly evaluating the actual risk-coping institutions of any kind at a time: in other words, to empirically analize how much the institutions could insure people in the villages against the risks they face, such as erratic rainfall, crop and human diseases, and severe income fluctuations, by using ten-year panel data on three high-risk villages in the semi-arid tropics of southern India[ii]. The model has been modified by Ravallion and Chaudhuri (1997) and applied to various development countries.

In this study, an empirical analysis of risk-sharing functions in rural Mexico is conducted to discuss the vulnerability of the rural poor using the most recent two periods of Mexican rural household panel data, in 2003 and 2007. In this study, vulnerability is considered the inability to smooth consumption because of liquidity constraints. First, I estimate a basic risk-sharing model defined by Townsend (1994) to examine how the risk-sharing mechanism works in rural Mexico. Continuously, I extend the model to consider the effects of Mexico's widely known poverty reduction program: the Conditional Cash Transfer (CCT) program, within the risk-sharing framework. I will also conduct the two-stage regressions with instrumental variables to deal with endogeneity problems which any of the previous literatures could not overcome successfully. The empirical results will show that there exist partial risk-sharing functions, especially for basic needs such as food, and that the risk-sharing function, reinforced by longer exposures to the CCT program, serves to mitigate the liquidity constraints or vulnerability of poor households.

The structure of this paper is as follows. Section 2 provides an overview of the poverty status of the rural households in the sample. Section 3 presents a standard risk-sharing model. Section 4 conducts empirical analyses to test the full risk-sharing hypothesis and examine the effects of CCT. Section 5 concludes the paper.

2. Panel Data and Poverty Status

2-1. Data

The series of household panel data used in this study is called *Encuestas de Evaluación de los Hogares (ENCEL)*, or *Household Evaluation Surveys*, which is designed and conducted periodically by the Social Development Secretary (*Secretaría de Desarrollo Social: SEDESOL*) assisted by the International Food Policy Research Institute (IFPRI) for the purpose of the external evaluation of the CCT program which is generally called PROGRESA-Oporunindades[iii]. Nine rounds of rural household panel data are available to date from 1997 to 2007, including a baseline survey in 1997. A unique characteristic of the ENCEL is that the randomized experiment was implemented at the beginning of the program to evaluate the effects of the program accurately. The full sample of ENCEL consists of repeated observations collected for 24,000 households from 506 localities (villages) in the 7 states of Guerrero, Hidalgo, Michoacán, Puebla, Querétaro, San Luis Potosí and Veracruz. Of those 506 localities, 320 localities were assigned to the treatment group (denominated as

“Treatment 1998” herein), and 186 localities were assigned as controls (denominated as “Treatment 2000” herein). The eligible households of the control localities could not receive PROGRESA-Oportunidades benefits until 2000 (Skoufias, 2007).

An additional comparison group of 151 localities not yet incorporated into the program was selected as a new control group using propensity score matching (PSM) for the seventh round of the survey in 2003 (denominated as “Control 2003” herein) (Todd, 2004). They became entitled to receive benefits through 2004. In total, eight rounds of surveys were conducted in the most marginal rural areas by 2007, which enables researchers to make use of a long period of micro-panel data.

I use rural samples of the two most recent rounds available: the years 2003 and 2007. ENCEL 2003 consists of 33,887 households and 205,306 individuals. ENCEL 2007 consists of 25,899 households and 176,809 individuals living in the seven sample states[iv] . When we drop households whose consumption is unreported or reported as nil, 18,942 households remain as a complete panel dataset in the case of food consumption, and 17,603 households in the case of total consumption.

2-2. Poverty Status of PROGRESA-Oportunidades’ Sample Villages

In this section, I examine the poverty trend of PROGRESA-Oportunidades’ sample villages from the seven pilot states for the years 2003 and 2007 using the household samples from ENCEL. I used the Foster–Greer–Thorbecke (FGT; Foster et al. 1984) poverty indices—the most popular indices in measuring poverty. The FGT indices are defined as

$$P_{\propto} = \frac{1}{n}\sum_{i=1}^{q}\left(1 - \frac{c_{it}}{z}\right)^{\propto}, \qquad (1)$$

where q represents the number of individuals identified by i, whose consumption, c_{it}, at time t is below a certain poverty line, z. n represents the total population. When $\alpha = 0$, 1, and 2, P_0, P_1, and P_2 represent the poverty head count ratio, poverty gap ratio, and squared poverty gap ratio, respectively.

In this study, each household's per capita weekly total consumption—the sum of reported monetary expenditures and self-consumption in the week prior to the interview—is used to estimate the FGT indices. The official rural food basket[v] (*canasta básica alimentaria rural*), published by the National Council for the Evaluation of Social Development Policy (*Consejo Nacional de Evaluación de la Política de Desarrollo Social* (*CONEVAL*)), is used as the poverty line. The per capita total consumption and poverty line are deflated by the state-level general CPI and food CPI (Banco de México).

TABLE 1

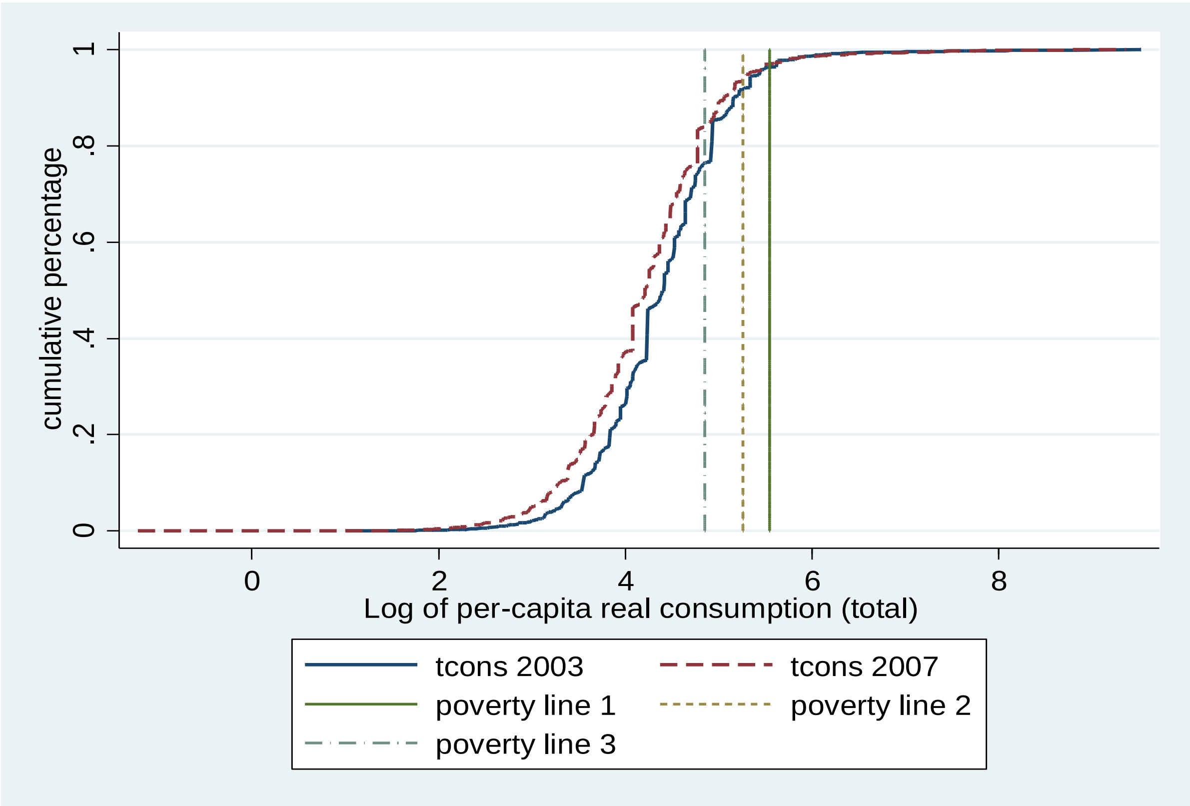
CHANGES IN FGT INDICES IN THE SAMPLE VILLAGES OF PROGRESA-OPORTUNIDADES, 2003–2007

Per-Capita Total Consumption								
Poverty Indices	Overall Sample		Treatment 1998		Treatment 2000		Control 2003	
	2003	2007	2003	2007	2003	2007	2003	2007
Headcount ratio	0.87	0.91	0.88	0.92	0.89	0.92	0.82	0.84
Poverty gap ratio	0.46	0.53	0.48	0.55	0.48	0.55	0.39	0.43
Squared poverty gap ratio	0.29	0.35	0.30	0.37	0.30	0.37	0.23	0.27
Number of obs.	17,603	17,603	8,373	8,373	5,864	5,864	3,366	3,366

Source.—Author's calculation based on ENCEL 2003 and 2007.

FIGURE 1.

STOCHASTIC DOMINANCE OF PER-CAPITA TOTAL CONSUMPTION, 2003 AND 2007



Source: Author's elaboration based on Encel 2003 and 2007.

Table 1 presents changes in the three types of FGT indices for 2003 and 2007. The indices are calculated using the overall sample and the three subsamples: original treatment groups (villages), in which the eligible households began receiving benefits in 1998 (Treatment 1998); the original control villages, accruing benefits since 2000 (Treatment 2000); and the new control villages, which were integrated into the ENCEL in 2003 and began receiving benefits by 2004 (Control 2003).

A striking result in Table 1 is that the three poverty indices in all three subsamples, which received different periods of program exposure, worsened. Both the overall poverty headcount ratio and the Treatment 1998 ratio increased by 4 percentage points, from 87 percent to 91 percent and from 88 percent to 92 percent. Treatment 2000 and Control 2003 both increased by 2–3 percentage points, from 89 percent to 92 percent and from 82 percent to 84 percent[vi]. The overall poverty gap ratio, which indicates the "depth" of poverty, worsened by 7 percentage points, that is, from 46 percent to 53 percent. Treatment 1998 and Treatment 2000 worsened by the same percentage and Control 2003 worsened by 4 percentage points. In addition, the squared poverty gap ratio, which represents the "severity" of poverty, increased by 6 percentage points in total and 4–7 percentage points in the subsamples. The aggravated poverty gap ratio and squared poverty gap ratio confirm that the distribution of poverty among the poor worsened; in other words, the poorest of the poor became even poorer than the rest of the population.

The level of poverty indices for Control 2003 is modest compared to those for the two treatment groups for 2003 and 2007, suggesting that the Control 2003 profile should be less poor, even though this group was added to serve as a new control for the original samples. Furthermore, the magnitude of changes in the FGT indices is less in the poverty gap and squared poverty gap ratios for Control 2003, again confirming the hypothesis that the most vulnerable households, which are most easily affected by unexpected shocks, should be the poorest of the poor.

I depict the cumulative distribution graph in Figure 3, with the log of per capita real consumption in ascending order on the horizontal axis, and the cumulative percentage on the vertical axis. As shown, the three vertical lines represent: the rural food basket (poverty line 1), the 75% line of the rural food basket (poverty line 2), and the 50% line of the rural food basket (poverty line 3). Since the consumption for 2007 is higher than that of 2003, at any point on the graph, it can be concluded that stochastic dominance is exhibited. In other words, we can confirm that for any level, the consumption for 2007 falls below that of 2003 (that poverty unquestionably worsened).

3. Risk-Sharing Model[vii]

3-1. General Model

We assume a village economy wherein the Pareto-efficient allocation of risk is achieved, but there is no access to credit and/or insurance markets or even storage. Now, $i = 1, \ldots, N$ indexes households in the village. There are *T* periods indexed by *t*. Further, $s = 1, \ldots, S$ indexes the states of nature with the probability of occurrence π_s. In state *s*, each household *i* receives an income of $y_{ist} > 0$[viii]. Let c_{ist} represent household *i*'s consumption if state *s* occurs in period *t*. Suppose each household has a separable utility function, then

$$U_i = \sum_{t=1}^{T} \rho^t \sum_{s=1}^{S} \pi_s u_i(c_{ist}), \qquad (2)$$

where ρ^t is a discount factor. $u(\cdot)$ is twice continuously differentiable with $u' > 0, u'' < 0$ and $\lim_{x \to 0} u'(x) = +\infty$. A Pareto-efficient allocation of risk within the village can be found by maximizing the weighted sum of utilities for each of the *N* households, where the weight of household *i* in the Pareto efficiency is λ_i, subject to the aggregated resources available in the village at each point in time in each state of nature:

$$\sum_{i=1}^{N} c_{ist} \leq \sum_{i=1}^{N} y_{ist}, \quad \forall s, t. \qquad (3)$$

$$c_{ist} \geq 0, \ \ \forall s, t.$$

We obtain the first-order conditions with respect to c_{ist} and c_{jst}

$$\frac{u'(c_{ist})}{u'(c_{jst})} = \frac{\lambda_j}{\lambda_i}, \quad \forall i, j, s, t. \qquad (4)$$

This equality extends across all *N* households in the village in any state at any point in time. The marginal utilities and, therefore, consumption levels of all the households in the village, move together.

Now, I assume that all the households in the village have an identical constant absolute risk averse utility function: $u_i(c_i) = -(1/\sigma)e^{-\sigma c_i}$. Applying this utility function to the first-order condition of equation (4), taking logs and the sum of the *N* equalities, we obtain

$$c_{ist} = \bar{c}_{st} + \frac{1}{\sigma}\left(\ln(\lambda_i) - \frac{1}{N}\sum_{j=1}^{N}\ln(\lambda_j)\right), \qquad (5)$$

where $\bar{c}_{st} = \frac{1}{N}\sum_{j=1}^{N} c_{jst}$.

Therefore, household consumption is equal to the average level of consumption in the village plus a time-invariant household fixed effect, which depends on the relative weight of the household in the Pareto program. Equation (5) implies that the change in household consumption between any two periods is equal to that in average community consumption between the two periods. After controlling for average consumption, a household's consumption is unaffected by its own income. In a Pareto-efficient allocation of risk within a community, households face only aggregate risk. Idiosyncratic income shocks are completely insured within the community.

The existence of *ex post* risk-pooling mechanisms within various communities in less developed countries suggests that some communities may have developed insurance systems that allocate risk to approach Pareto efficiency. This line of reasoning has motivated numerous quantitative studies on risk sharing[ix]. For example, Townsend (1994) and Ravallion and Chaudhuri (1997) examine consumption outcomes rather than specific risk-pooling mechanisms in ICRISAT's case villages. Within this set of villages, there is a high degree of co-movement in consumption across households, despite a substantial amount of idiosyncratic income variation. Nevertheless, a fully Pareto-efficient allocation of risk is not achieved in these villages.

3-2. Empirical Model

A reduced form of Equation (5) based on Townsend (1994) is

$$c_{it} = b_i + a_i \bar{c}_t + \beta_i y_{it} + v_{it}, \qquad (6)$$

where $\bar{c}_t$ is the average consumption in the village, y_{it} is a household's idiosyncratic variables—in this case, income—and v_{it} is an i.i.d. error term with mean zero.

We assume measurement errors in y_{it}:

$$y_{it} = y_{it}^{*} + \epsilon_{it}. \qquad (7)$$

Then, Equation (8) becomes

$$c_{it} = b_i + a_i\bar{c}_t + \beta_i y_{it} + v_{it} - \beta_i \epsilon_{it}. \qquad (8)$$

By taking first differences, we obtain

$$\Delta c_{it} = a_i \Delta\bar{c}_t + \beta_i \Delta y_{it} + u_{it}, \qquad (9)$$

$$u_{it} = \Delta v_{it} - \beta_i \Delta\epsilon_{it}, \qquad (10)$$

where Δy_{it} represents a household's idiosyncratic income shocks.

Full risk sharing can be achieved when the null hypothesis of $\beta_i = 0$ is accepted across all households within the village[x]. In other words, if the economy (e.g., village) achieves Pareto optimal risk sharing among villages, Δc_{it} should respond only to the village level shock $\Delta\bar{c}_t$ so that the size of β_i shows excess sensibility of consumption to idiosyncratic income shocks. A relatively large positive value of β_i indicates that individual *i* is less able to cope with such shocks.

Ravallion and Chaudhuri (1997) thoroughly examined Townsend's (1994) model to prove that his estimates of β_i had a downward bias. They insisted that the first term of Equation (9) ($a_i\Delta\bar{c}_t$) should be replaced with time village dummies, $\sum_t \delta_t D_t$, when assuming uniform time preference and risk aversion across households in the village. The parameter β_i can more accurately reflect the effects of idiosyncratic income shocks, Δy_{it}, because the time village dummies absorb all the aggregate shocks that occur within the village economy. In addition, restrictions on the parameters, $b_i = b,\ a_i = a,\ and\ \beta_i = \beta,\ \forall i$, are usually imposed by assuming uniform time preferences and risk aversion across households when using developing countries' panel data because the available period is typically short.

$$\Delta c_{it} = b + \sum_t \delta_t D_t + \beta \Delta y_{it} + u_{it}, \qquad (12)$$

Parameter β is also called the "excess sensitivity" parameter because it becomes positive when liquidity constraints and imperfect credit and/or insurance market mechanisms are observed. It can be argued that parameter β represents how much households in a certain group (village) are vulnerable to idiosyncratic income shocks on average, showing the extent to which consumption decreases (increases) when income marginally decreases (increases) for a household.

Since this study uses panel data for two periods (2003 and 2007), the model to be estimated takes the form of a cross-section:

$$\Delta c_i = b + a_v + \beta \Delta y_i + \gamma X_i + u_i, \ (13)$$

where a_v are village dummies, X_i is a vector of household-specific factors that affect consumption change, and u_i is an i.i.d. error term with mean zero.

4. Empirical Analyses and Results

4-1. Summary Statistics

Table 2 presents the summary statistics of variables used in this study's regression[xi]. The manner in which the variables are created is summarized in Appendix A. A significant drop in consumption and income was observed between 2003 and 2007. Weekly per capita real consumption decreased on average by 8.8 Mexican pesos for food alone and by 10.8 pesos in total. Furthermore, per capita real income decreased by 6.3 pesos on average in the same period. In contrast, per capita income between 2001 and 2002 increased by 1.2 pesos. This phenomenon can be attributed to the welfare loss in poor households owing to the increase in price for international and domestic food during the period (Valero-Gil and Valero 2008; Attanasio et al. 2009, 2013; Wood et al. 2009; Uchiyama 2013a). Table 2 shows that half of the sampled households experienced an income decline.

With respect to household characteristics in the base year (2003), 24 percent of the household heads received no education. Those with a primary education accounted for 65 percent, while 9.5 percent had a secondary education and only 2 percent received a high school or higher education. The author's calculation based on the data revealed that more than half of the household heads who enrolled in primary school did not graduate, indicating a high dropout rate. Ten percent of the households were headed by women. The average age of household heads was 46 years, and 88 percent were married and 10 percent divorced or separated. The average household size was 5.3 people and the dependency ratio was 42.7. About 31 percent of the households were indigenous, that is, the household heads speak indigenous languages. About 60 percent of the households received benefits under the CCT program in 2003. This percentage increased to 78.5 percent in 2007 because by then, the Control 2003 households began receiving benefits. About 6.3 percent households reported self-consumption during the interview week. Approximately 63 percent households owned or cultivated 4.8 hectares of land on average, but the median farming household only owned or cultivated 2 hectares of land, indicating a high number of small poor farmers and low numbers of large farmers. Land with full or partial irrigation accounted for 9.3 percent of those who owned/cultivated a land in 2003, suggesting that most of the land was rain-fed with poor yields. About 26 percent of the households received personal transfers (remittances) in cash or kind. In addition, 32 percent of the households had members older than 15 years and lived away from home (migrants). The local tortilla price increased by 2.52 pesos on average, which indicates prices in 2007 were 1.3 times higher than those in 2003[xii]. This perfectly corresponds to the Mexican national rate of increase in tortilla prices during the period, as indicated in Uchiyama (2013a).

Highly marginal pilot villages (localities) were selected from seven states of Mexico: four in Central Mexico (Hidalgo, Michoacán, Puebla, and Querétaro) and one each from the North (San Luis Potosí), the Gulf of Mexico (Veracruz), and the Southern Pacific (Guerrero). The three treatment or control groups in Table 2 correspond to the aforementioned village categories.

TABLE 2

SUMMARY STATISTICS

Variables	Obs.	Mean	Std. Dev.	Min	Max
ΔC_i: Food	12349	−8.819	47.257	−338.668	267.406
ΔC_i: Total	11483	−10.787	61.177	−391.588	487.897
ΔY_i	12349	−6.259	47.072	−378.942	137.707
ΔY_i: 2001-02	12349	1.223	21.480	−604.357	831.271
Food Consumption03	12349	71.116	43.968	10.435	391.298
Food Consumption07	12349	62.297	39.791	8.421	294.724
Total Consumption03	12349	90.736	56.469	9.885	415.187
Total Consumption07	11483	80.245	54.386	10.892	505.691
Income03	12349	28.946	43.764	0.607	392.972
Income07	12349	22.687	21.473	0.964	146.838
noedu03	12218	0.236	0.424	0	1
primary03	12218	0.649	0.477	0	1
secondary03	12218	0.095	0.293	0	1
highschool03	12218	0.011	0.105	0	1
technical03	12218	0.007	0.082	0	1
univ03	12218	0.002	0.048	0	1
female03	12240	0.100	0.300	0	1
age03	12236	46.268	14.620	3	98
married03	12349	0.877	0.329	0	1
divorced03	12349	0.099	0.299	0	1
total_member03	12349	5.246	2.315	1	19
depratio03	12349	42.678	23.848	0	100
indigenous03	12349	0.308	0.462	0	1
CCT_dum03	12349	0.592	0.492	0	1
selfcons_dum03	12349	0.063	0.244	0	1
land_dum03	12349	0.627	0.484	0	1
total_land_ha03*	8119	4.776	10.048	1	200
irrigation03**	7774	0.093	0.290	0	1
hhremit03	12349	0.256	0.437	0	1
hhmig_over15_dum03	12349	0.324	0.468	0	1
local tortilla price change03-07	12365	2.520	1.550	−1.587	7.935
State12: Guerrero	12349	0.079	0.270	0	1
State13: Hidalgo	12349	0.104	0.306	0	1
State 16: Michoacán	12349	0.168	0.373	0	1
State 21: Puebla	12349	0.146	0.353	0	1
State 22: Querétaro	12349	0.077	0.267	0	1
State 24: San Luis Potosí	12349	0.162	0.369	0	1
State 30: Veracruz	12349	0.263	0.440	0	1
Treatment 1998	12349	0.477	0.499	0	1
Treatment 2000	12349	0.335	0.472	0	1
Control 2003	12349	0.188	0.390	0	1

Source.—Author’s elaboration based on ENCEL 2003 and 2007.

Note.—Consumption and income are shown in local currency in real terms (June 2011 = 100). ΔC_i and ΔY_i denote changes in consumption and income for 2003 and 2007.

* Includes those who reported hectares of their land.

** Includes those who owned or cultivated the land in 2003.

4-2. Basic Model

I assume that the observed changes in income are endogenous in estimating Equation (13) mainly because of measurement errors. Thus, the explanatory variables are replaced by fitted values using instrumental variables. As instruments in the first stage, I use the changes in lagged income between 2001 and 2002 (*ΔY_i: 2001-02*)[xiii] based on the argument of Ravallion and Chaudhuri (1997) to correct the downward bias in Townsend's (1994) estimations, I also selected additional instrumental variables: the land holding dummy (*land_dum03*), and the migrant household dummy (*hhmig_over15_dum03*) in 2003, to complement the shortcomings of the lagged income variable as is discussed in Appendix A. These variables are expected to correlate with the income changes in 2003 and 2007, but not with the consumption variation in the same period directly. Food consumption and total consumption are used as explained variables in all models herein.

TABLE 3

REGRESSION RESULTS OF EQUATION (13)

	Model 1		Model 2	
Variables		(A) Food Consumption		
β (OLS)	0.1445***	0.1402***	0.1476***	0.1438***
	(0.0131)	(0.0131)	(0.0130)	(0.0130)
β (2SLS)	-	0.6423***	-	0.5886***
	-	(0.0834)	-	(0.0732)
		(B) Total Consumption		
β (OLS)	0.1819***	0.1816***	0.1841***	0.1837***
	(0.0163)	(0.0162)	(0.0162)	(0.0162)
β (2SLS)	-	0.7509***	-	0.6794***
	-	(0.1048)	-	(0.0925)
Tortilla price change	yes	no	yes	no
Village dummies	yes	yes	yes	yes
(A)				
No. of Obs.	12320	12349	12320	12349
R-squared (OLS)	0.1372	0.1376	0.1331	0.1335
Chi2 (2SLS)	-	216028.91	-	132799.98
(B)				
No. of Obs.	11414	11442	11414	11442
R-squared (OLS)	0.1611	0.1613	0.1589	0.1592
Chi2 (2SLS)	-	279507.62	-	923638.75

Note.—Huber–White heteroscedasticity consistent standard errors are in parentheses. Tortilla price changes were automatically omitted from the 2SLS regressions because of collinearity.

* p<0.1.

** p<0.05.

*** p<0.01.

Table 3 presents the results for both the OLS and 2SLS regressions for food consumption and total consumption. X_i includes household size; dependency ratio; age, sex, and marital status; ethnicity; education level of the household head; total hectares of land owned or cultivated by the household; and change in the local tortilla price. The instruments comprise per capita wage income changes for 2001–2002, a land dummy (1 if a household owns or cultivates land, 0 otherwise), and migrant dummy (1 if a household has any member aged 15 years or older and has migrated to another place, 0 otherwise). Different specifications are applied using irrigation (1 if a household has any irrigated land, 0 otherwise), CCT (1 if a household receives money benefits under CCT, 0 otherwise), self-consumption (1 if a household has self-consumption, 0 otherwise), and remittance (1 if a household receives personal transfers, 0 otherwise) dummies as X_i (Model 1) or not (Model 2) to check for robustness. Table 3 is limited to the present estimated coefficients of β. The complete results are provided in Appendices B and C (Tables B1, C1 and C2)[xiv].

The OLS estimation coefficients of β are about 0.14 for food consumption and about 0.18 for total consumption in both models, which is consistent with previous studies in significance and magnitude. This implies that real food and total consumption increase (decline) by about 0.14 and 0.18 Mexican pesos when real income rises (declines) by 1 Mexican peso. The null hypothesis of full risk sharing is rejected at the 1 percent level. It is noteworthy that the coefficients for food consumption are smaller than those for total consumption, which implies that food consumption is better insured than total consumption. This result is consistent with most previous studies on developing countries[xv]. To this effect, Skoufias (2007) explains that when household income increases, the demand for luxury goods (non-food) rises more than that for necessities (e.g., food), and the opposite is true in case of a decrease in household income. The 2SLS coefficients are much larger than the OLS coefficients for both food and total consumption, which confirms the downward bias in β owing to endogeneity, as the theory predicts[xvi]. The estimated values of β remain almost the same, regardless of model specifications (except in the case of 2SLS for total consumption) and controlled tortilla price change[xvii].

4-3. Model with CCT Effects

In this section, the discussion centers on whether the Mexican CCT program has contributed to reduce households' current vulnerability to poverty in the treatment villages by reinforcing the existing risk-sharing functioning through cash transfers. CCT programs in general, which are implemented in many developing countries in the world as a new targeting poverty reduction strategy, were generally undertaken with two clear objectives. First, they provide poor households with a minimum consumption floor (to reduce *current* poverty). Second, in making transfers conditional, they encourage the accumulation of human capital to break a vicious cycle whereby poverty is transmitted across generations (to reduce *future* poverty) (Fiszbein and Schady, 2009). Whether CCT can enhance the risk-sharing mechanism corresponds to the first objective (to reduce current poverty). The PROGRESA-Oportunidades which srated in 1997 and is well known for being the very first CCT program in the world. The objectives and contents are the almost same as the general CCTs mentioned above.

Fiszbein and Schady (2009) point out that income volatility can provide an additional argument for targeted cash transfer programs when fixing the credit and/or insurance markets themselves is too costly and complicated to reach many of the poor families. However, to my best knowledge, not many studies focus on the relationship between consumption smoothing and the CCT, which corresponds to the first objective, whereas there are plenty of literature regarding the second objective (the effects of human capital investments for the future poverty reduction)[xviii]. One previous study that examined risk-sharing effects of the CCT in rural Mexico is Skoufias (2007). He conducted an empirical analysis of the risk insurance model using three rounds of the ENCEL panel data for 1998–1999 and rejected full risk sharing in all the specifications. The effect of PROGRESA-Oportunidades on the improvement of pre-existing risk sharing within villages was not statistically significant in all the models, except for a few cases of subsample regressions based on household characteristics (e.g., cases where the household head had less than a primary education or was not eligible for PROGRESA). He attributed this result to the short duration (1.5 years) after the program's implementation. He also conducted regressions using shock variables as instrumental variables to deal with the attenuation bias of income variables and found the coefficients to be insignificant and the sign of the coefficient of the interaction terms (effects of PROGRESA) reversed (positive and insignificant) because of weak instruments.

To examine the CCT's effects on risk sharing, I insert the interaction terms of per capita income change with subgroup dummies in Equation (13). The model specification is as follows:

$$\Delta c_i = a_v + \delta_1 T_{1998} + \delta_2 T_{2000} + \beta \Delta y_i + \theta_1 T_{1998} \Delta y_i + \theta_2 T_{2000} \Delta y_i + \gamma X_i + u_i,$$

$$\Delta c_i = a_v + \delta T_{98\&00} + \beta \Delta y_i + \theta T_{98\&00} \Delta y_i + \gamma X_i + u_i, \quad (14)$$

where T_{1998} and T_{2000} represent the Treatment 1998 and Treatment 2000 subgroup dummies, and the $\delta T_{98\&00}$ dummy includes both the Treatment 1998 and Treatment 2000 subgroups. The parameters of the interaction terms are expected to be negative if PROGRESA-Oportunidades can improve the existing risk-sharing function, and consequently, households' vulnerability. The remainder of the variables is the same as those in Equation (13).

Table 4 presents the regression results for Equation (14). Both OLS and 2SLS estimates are shown. The coefficient of the interaction terms with Treatment 1998 becomes negative and significant only in the OLS estimates for food consumption when using Treatment 1998 and Treatment 2000 dummies separately (Panel (A)). The OLS coefficients for total consumption are negative but insignificant, while those for 2SLS are positive and insignificant. In using the Treatment 1998 and 2000 dummy to compare the first two groups with the newest Control 2003 group (Panel (B)), all coefficients for both OLS and 2SLS become negative, but only the OLS estimates for food consumption are significant at 5 percent. These results suggest that longer exposure to the program might have certain effects on the existing risk-sharing mechanism. The full results of the regression are shown in Tables D1 and D2 (Appendix D).

Subsequently, considering the possibility of different household profiles across the subgroups, I conducted separate regressions of Equation (13) for each of the three subgroups—Treatment 1998, Treatment 2000, and Control 2003—allowing different returns to household characteristics across the subsamples. The results for the estimated coefficients of β are presented in Table 5 (OLS) and Table 6 (2SLS). The full results are shown in Tables E1 and F1 (Appendices E and F). Each model's specifications are the same as those in the previous sections.

TABLE 4

REGRESSION RESULTS OF EQUATION (14)

Variables	Food Consumption				Total Consumption			
	Model 1		Model 2		Model 1		Model 2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(A): interaction with Treatment 1998 and Treatment 2000 dummies							
β	0.2036***	0.6546***	0.2057***	0.5908***	0.2155***	0.8806***	0.2168***	0.7901***
	(0.033)	(0.108)	(0.033)	(0.105)	(0.045)	(0.143)	(0.045)	(0.139)
T1998*β	−0.0785**	0.041	−0.0784**	0.051	−0.042	0.010	−0.042	0.041
	(0.037)	(0.095)	(0.037)	(0.100)	0.049	0.125	0.049	(0.129)
T2000*β	−0.063	−0.119	−0.061	−0.112	−0.041	−0.165	−0.039	−0.165
	(0.039)	(0.100)	(0.039)	(0.104)	0.052	0.132	0.052	(0.137)
	(B): interaction with Treatment1998&2000 dummy							
β	0.2036***	0.6513***	0.2057***	0.5891***	0.2155***	0.8771***	0.2168***	0.7884***
	(0.033)	(0.108)	(0.033)	(0.105)	(0.045)	(0.143)	(0.045)	(0.139)
T1998&2000 *β	−0.0723**	−0.023	−0.0713**	−0.015	-0.042	-0.060	-0.041	-0.043
	(0.036)	(0.090)	(0.036)	(0.094)	(0.048)	(0.119)	(0.048)	(0.123)
Tortilla price change	no	no	no	no	no	no	no	no
(A)								
No. of Obs.	12349	12349	12349	12349	11442	11442	11442	11442
R-squared	0.138	0.127	0.134	0.122	0.161	0.151	0.159	0.148
(B)								
No. of Obs.	12349	12349	12349	12349	11442	11442	11442	11442
R-squared	0.138	0.126	0.134	0.121	0.161	0.150	0.159	0.148

Note.—Huber–White heteroscedasticity consistent standard errors are in parentheses.

* $p<0.1$.

** $p<0.05$.

*** $p<0.01$.

Table 5 shows that coefficient β is the smallest for the Treatment 1998 groups, followed by Treatment 2000, and is the largest for the Control 2003 groups for food (0.11–0.12, 0.15–0.16, and 0.20–0.21, respectively) and total consumption (0.17, 0.19, and 0.21–0.22, respectively). The table also shows the t-values of the differences between each group's coefficients. Notably, the t-values of the differences between Treatment 1998 and Control 2003 become significant at the 5 percent level in both models of food consumption, which is the most important aspect of risk insurance. The result clearly supports the inference that longer exposure to the CCT program results in a better insured household. At the very least, the remarkable difference between the group with the longest exposure (Treatment 1998) and that with the shortest (Control 2003) supports the hypothesis that CCT mitigates poverty and vulnerability by securing a minimum income level. Moreover, the results imply that the risk-sharing function is enhanced more in food consumption than in total consumption: the differences in the magnitude of the β coefficients between food consumption and total consumption are greater in Treatment 1998 (0.12 vs. 0.17) and Treatment 2000 (0.15–0.16 vs. 0.19) than in Control 2003 (0.20–0.21 vs. 0.21–0.22). This implies that longer exposure to CCT may be more effective in securing basic needs, especially food consumption.

TABLE 5

OLS REGRESSION RESULTS OF EQUATION (13) BY SUBGROUPS

	Food Consumption			Total Consumption		
	T1998	T2000	C2003	T1998	T2000	C2003
			Model 1			
β	0.1170***	0.1512***	0.2044***	0.1651***	0.1863***	0.2109***
	(0.018)	(0.022)	(0.034)	(0.021)	(0.028)	(0.047)
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	1.21	1.32	2.27***	0.61	0.46	0.90
Tortilla price change	no	no	no	no	no	no
			Model 2			
β	0.1194***	0.1552***	0.2050***	0.1653***	0.1905***	0.2159***
	(0.018)	(0.022)	(0.034)	(0.021)	(0.028)	(0.046)
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	1.27	1.23	2.22***	0.73	0.47	1.00
Tortilla price change	no	no	no	no	no	no
(Model 1)						
No. of Obs.	5897	4130	2322	5450	3848	2144
R-squared	0.144	0.131	0.150	0.183	0.146	0.148
(Model 2)						
No. of Obs.	5897	4130	2322	5450	3848	2144
R-squared	0.140	0.126	0.147	0.179	0.144	0.147

Note.—Huber–White heteroscedasticity consistent standard errors are in parentheses. t-value represents the significance of the differences between each group's coefficients.

* p<0.1.

** p<0.05.

*** p<0.01.

TABLE 6

2SLS REGRESSION RESULTS OF EQUATION (13) BY SUBGROUPS

	Food Consumption			Total Consumption		
	T1998	T2000	C2003	T1998	T2000	C2003
			Model 1			
β	0.3746***	0.7404***	0.9217***	0.4610**'*	0.8417***	1.3914***
	(0.109)	(0.138)	(0.205)	(0.140)	(0.169)	(0.322)
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	2.08**	0.73	2.36***	1.73*	1.51	2.65***
Tortilla price change	no	no	no	no	no	no
			Model 2			
β	0.3340***	0.7643***	0.7312***	0.3926***	0.8588***	1.0717***
	(0.101)	(0.129)	(0.154)	(0.128)	(0.159)	(0.225)
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	2.63***	0.17	2.16***	2.28***	0.77	2.62***
Tortilla price change	no	no	no	no	no	no
(Model 1)						
No. of Obs.	5897	4130	2322	5450	3848	2144
Chi2	199730.55	209185.88	450.94	52926.70	778204.72	934.94
(Model 2)						
No. of Obs.	5897	4130	2322	5450	3848	2144
Chi2	46395.91	224529.67	597.06	54330.17	30893.71	1106.87

Note.—p-values are based on Huber–White heteroscedasticity consistent standard errors are provided. t-value represents the significance of the differences between each group's coefficients.

* $p < 0.1$.

** $p < 0.05$.

*** $p<0.01$.

The 2SLS regression results in Table 6 correct the downward bias of the OLS estimates and mostly confirm the OLS results by providing t-values significant at the 1 percent level for the difference in β estimates between Treatment 1998 and Control 2003 both in food and total consumptions, even though the magnitudes of coefficients vary more in 2SLS. In addition, I obtained a significant difference between Treatment 1998 and Treatment 2000 at the 10 percent level in Model 1 and at the 1 percent level in Model 2. However, the β estimates for the total consumption of Control 2003 exceeded 1, which contradicts the theory. In addition, the Model 2 estimates for food consumption are not as expected, that is, the coefficients of Treatment 2000 are higher than those of Control 2003, but the t-value shows no significant difference.

5. Concluding Remarks

In this study, I examine the risk-sharing functions and effects of the CCT program on household vulnerability in rural Mexico using the most recent two-period rural household panel data. First, I focus on testing the full risk sharing hypothesis by using the general risk-sharing model as most he the previous studies did, and the empirical results confirmed that the existing risk sharing is incomplete, which is consistent with previous studies. I also revealed that the risk-sharing functions work better for food consumption smoothing than for total consumption smoothing. Continuously, I included CCT effects on risk sharing in different specifications and confirmed that CCT reinforces the risk-sharing functions of the treatment villages, especially when a village has longer exposure to the CCT program. The CCT effects were more apparent in securing the basic needs of poor households, notably food consumption. The risk-sharing functions reinforced by CCT, in turn, could serve to mitigate the vulnerability (liquidity constraints) of rural households.

However, one should take into consideration the possibility of the downward rigidity of food demand, that is, vulnerable households living below subsistence levels cannot further decrease their consumption when hit by income shocks. Furthermore, I have not clarified the mechanism through which longer exposure to the CCT program enhances the existing risk-sharing functioning, thereby reducing household vulnerability. It is possible that securing a minimum consumption floor, which is stated as one of the CCT's main objectives, might gradually change the consumption behavior of a household. There are two possible assumptions in this respect: the ease of liquidity constraints and the increasing migration. Drawing on Angelucci and De Giorgi (2006, 2009), the exogenous positive income shocks to villages by eligible household receiving the CCT regularly should increase available resources within the village, which without doubt enables better consumption smoothing. They also argue that not only eligible but also ineligible households may be able to change their behaviors through networks within the village—a phenomenon defined as the spillover effect. Also Angelucci (2012) points out that the regular transfers are likely to be used as collaterals to increase the loan size. In addition, Angelucci (2012, 2015) and Aonuma (2009) empirically confirm the effect of PROGRESA-Oportunidades on the increasing number of migration, both international (Angelucci, 2015) and domestic (Aonuma, 2009), using ENCEL data. However, these inferences of how the CCT reinforce the risk-sharing mechanisms should yet to be carefully examined with more detailed analyses of quantitative and qualitative evidences, which remains for future study.

Finally, we should note the fact that the increase of food prices peaked in 2008 and 2011 due to the international food price crisis, which I could not cover with the ENCEL data available so far. It is required to expand the sample data to examine more thoroughly the influence of food price shocks and the Lehman shock, when new data become available.

APPENDIX A: Variables

Household real per capita food consumption: First, I construct each household's weekly food consumption by summing up the reported amount of weekly food consumption and the estimated weekly self-consumption. Then, I divide the household's weekly food consumption by the number of household members to ascertain the per capita weekly food consumption. In estimating self-consumption, I first calculate the median state price of each item using each household's reported weekly purchase and the expenditure on the item. Then, I multiply the value of reported self-consumption by the estimated unit median price of the state. Per capita food consumption is deflated by the annual average food CPI[xix].

Household real per capita total consumption: I construct a household's real per capita total consumption in the same way as food consumption, using the reported weekly total consumption of food and non-food items. Per capita total consumption is deflated by the annual average general CPI.

Household real per capita income in 2003 and 2007: This includes all household members' wages, pensions, bonuses, monetary institutional transfers (including CCT), agricultural sales, and non-agricultural sales. It excludes personal transfers (including remittances), non-labor or irregular incomes, such as the sales of assets (e.g., houses, cars, and home electronics), inheritance, lottery, gifts, and donations. Personal transfers are excluded because they are more likely to reflect *ex post* adjustments to shocks, as Skoufias (2007) argues. The reported units for each income source vary from daily, weekly, and monthly to annual. Thus, I estimate the weekly amount of each income source and sum these up to estimate weekly household income. Then, I divide the weekly total income by the number of household members and deflate it by the annual average general CPI. Households that have any type of unreported income sources are dropped from the sample.

Household real per capita income in 2001 and 2002: This consists of the sum of the household head and spouse's retrospective weekly wage income divided by the number of household members, which is deflated by the average annual general CPI.

Education dummies: *Primary, secondary*, or *highschool* refers to those who have enrolled in a primary, secondary, or high school, regardless of whether they graduated. *Technical* education refers to those who have enrolled in any technical or vocational school, including teacher's college. *University* education includes those who have enrolled for a university and higher education (including those who graduated from university and have entered into or graduated from the post-graduate level).

Household demographic variables: The total number of household members refers to the members who live in the same house. It excludes those who live separately for more than one year, whose stay is temporary, and who have expired. The dependency ratio is the proportion of household members under 14 years and over 65 years of age (non-labor force) to the number of household members aged 15–64 years (labor force).

Local tortilla price: Drawing on Attanacio et al. (2009, 2013), I first calculate the median village (locality) price of tortilla using each household's unit price (per kilogram), which is derived by applying the same method used to estimate self-consumption. I exclude median village prices above 20 pesos per kilogram for 2003 and 25 pesos for 2007. Then, I calculate the mean and standard deviation for the remaining median village tortilla prices, which are

4.7 and 2.1 for 2003 and 7.9 and 1.8 for 2007. I use each village's median price as a local price of tortilla if the median price is between the mean value ± the standard deviation (2.6–6.9 for 2003 and 6.1–9.7 for 2007). The median price of a village with less than three households reporting the purchases of tortilla is also automatically dropped. Local prices that do not meet the criteria are replaced by the corresponding upper level (municipal) median prices, which are calculated using the same method as that for the village median price. I use the state median price as the local tortilla price in case the municipal median prices do not fulfill the criteria mentioned above. Of the sample, 30 percent was replaced by municipal median prices and 17 percent by state median prices in 2003, and 24 percent and 16 percent of the sample was replaced by municipal and state median prices in 2007. The means (weighted by the number of households) of the local tortilla prices are 4.9 pesos per kilogram for 2003 and 8.1 pesos per kilogram for 2007. These estimated prices are quite reasonable since the means of the state median prices (weighted by the number of households) are 5.2 and 8.2 pesos. The local price changes for 2003 and 2007 are deflated by the food CPI.

APPENDIX B

TABLE B1

REGRESSION RESULTS OF THE FIRST STAGE OF EQUATION (13)

Variables	Food Consumption		Total Consumption	
	Model 1	Model 2	Model 1	Model 2
	Instrumented: Δy_i, t (2003–2007)			
primary03	−3.021***	−3.195***	−3.263***	−3.347***
secondary03	−2.964*	−2.565	−2.985*	−2.835
highschool03	−15.311***	−14.91***	−14.798***	−14.374***
technical03	−10.714	−9.841	−11.192	−10.241
univ03	−17.271	−17.086	−15.144	−14.896
total_member03	1.184***	1.101***	1.248***	1.112***
depratio03	0.172***	0.165***	0.166***	0.160***
female03	2.756	2.151	2.670	2.313
age03	−0.436***	−0.448***	−0.436***	−0.444***
married03	3.147	2.775	4.631	4.118
divorced03	1.400	1.535	2.868	2.622
indigenous03	4.456**	4.473**	4.269**	4.271**
total_land_ha03	−0.368***	−0.374***	−0.334***	−0.339***
irrigation03	−9.623***		−10.078***	
CCT_dum03	−4.630***		−4.490***	
selfcons_dum03	−9.907***		−9.781***	
hhremit03	−0.196		−0.049	
Instruments				
Δy_i $_{,t-1}$ (2001–2002)	−0.077**	−0.073**	−0.075**	−0.071**
land_dum03	−11.477***	−12.566***	−12.242***	−13.521***
hhmig_over15_dum03	−6.177***	−6.548***	−5.833***	−6.114***
Constant	33.554	35.341***	34.506***	35.226***
Village dummies	yes	yes	yes	yes
No. of Obs.	12349	12349	11442	11442
R-squared	0.163	0.159	0.170	0.164
F statistics	599.11	66.10	165.84	59.62

Note.—Δy_i stands for changes in income.
* p<0.1.
** p<0.05.
*** p<0.01.

APPENDIX C

TABLE C1

REGRESSION RESULTS OF EQUATION (13)

	Dependent Variable: Food Consumption					
	Model 1			Model 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	OLS	OLS	2SLS	OLS	OLS	2SLS
β	0.1445***	0.1402***	0.6423***	0.1476***	0.1438***	0.5886***
primary03	−0.9733	−1.1055	0.6891	−1.1013	−1.2637	0.4277
secondary03	−2.8077	−2.4718	−1.1952	−2.983	−2.6685	−1.5672
highschool03	−0.1772	−1.0253	6.6416	−0.3017	−1.1275	5.4696
technical03	−9.5205	−11.4713*	−6.2134	−9.4409	−11.2992*	−7.2412
univ03	−18.8005	−19.8707	−12.0768	−19.1923	−20.2393	−13.3902
total_member03	1.2951***	1.3817***	0.8856***	1.3234***	1.4000***	1.0419***
depratio03	0.1602***	0.1578***	0.0544*	0.1583***	0.1552***	0.0653**
female03	1.0167	1.1467	−0.3617	0.2389	0.2995	−0.937
age03	−0.3054***	−0.3079***	−0.0191	−0.3226***	−0.3278***	−0.0576
married03	−1.1928	−1.6523	−3.1846	−1.351	−1.837	−3.0017
divorced03	−9.537**	−10.026**	−11.294***	−9.4233**	−9.907**	−10.959***
indigenous03	−1.5942	−2.1373	−4.0437*	−1.5839	−2.1531	−3.7969*
total_land_ha03	0.0377	0.0384	0.2931***	0.0331	0.0326	0.2718***
irrigation03	1.022	0.4371	7.7785***			
CCT_dum03	1.4207	1.1779	3.7368***			
selfcons_dum03	−11.8695***	−12.9203***	−7.7668***			
hhremit03	−3.1392***	−3.4085***	−2.9343**			
tortilla price change0307	3.8972*			3.3049		
Constant	−14.2081**	1.4002	−15.6875	−13.155**	0.0378	−15.5295
Village dummies	yes	yes	yes	yes	yes	Yes
No. of Obs.	12320	12349	12349	12320	12349	12349
R-squared	0.1372	0.1376	-	0.1331	0.1389	-
F statistics	-	-	599.11	-	-	66.10
Chi2	-	-	216028.91	-	-	132799.98
Robust Durbin–Wu–Hausman test of endogeneity						
Chi2	-	-	43.8441	-	-	46.0012
F statistics	-	-	40.8796	-	-	43.3731
Weak instrument tests						
F statistics	-	-	61.5707	-	-	71.9595
Test of overidentifying restrictions						
Chi2	-	-	142.941	-	-	160.708

Note.—p-values are based on Huber–White heteroscedasticity consistent standard errors.
*p < 0.1.
**p < 0.05.
***p < 0.01.

TABLE C2

REGRESSION RESULTS OF EQUATION (13)

	Dependent Variable: Total Consumption					
	Model 1			Model 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	OLS	OLS	2SLS	OLS	OLS	2SLS
β	0.1819***	0.1816***	0.7509***	0.1841***	0.1837***	0.6794***
primary03	−3.0582**	−3.1118**	−0.9731	−3.1785**	−3.2256**	−1.2724
secondary03	−3.8574	−3.897	−2.2347	−4.0471*	−4.0774*	−2.7131
highschool03	0.6299	0.5759	8.8971	0.423	0.3853	7.4131
technical03	9.4819	9.4061	15.3861*	9.4935	9.4212	13.9712
univ03	−2.3128	−2.3921	5.2763	−2.8723	−2.9251	3.7418
total_member03	2.1314***	2.1321***	1.5756***	2.1947***	2.1950***	1.7981***
depratio03	0.2408***	0.2425***	0.1281***	0.2380***	0.2397***	0.1420***
female03	−3.7456	−3.7037	−5.7328*	−4.5651	−4.5211	−6.1791*
age03	−0.4042***	−0.4049***	−0.0774	−0.4272***	−0.4273***	−0.1258*
married03	6.5199	6.3441	3.7895	6.4929	6.3066	4.3217
divorced03	2.4235	2.1675	0.1366	2.6424	2.377	0.7203
indigenous03	1.2089	1.1975	−0.8054	1.2308	1.2078	−0.5021
total_land_ha03	0.0052	0.0051	0.2801***	−0.0001	0.0003	0.2558***
irrigation03	0.4124	0.5867	9.3690***			
CCT_dum03	2.2039	2.1764	4.9942***			
selfcons_dum03	−9.1156***	−9.0792***	−3.4248			
hhremit03	−4.2398***	−4.1940***	−3.5689**			
Tortilla price change0307	13.3782***			12.8063***		
Constant	−22.5192***	28.3717**	9.2848	−21.5963***	26.9945**	9.9755
Village dummies	yes	yes	yes	yes	yes	yes
No. of Obs.	11414	11442	11442	11414	11442	11442
R-squared	0.161082671	0.1613	-	0.1589	0.1592	-
F statistics	-	-	165.84	-	-	59.62
Chi2	-	-	279507.62	-	-	923638.75
Robust Durbin–Wu–Hausman test of endogeneity						
Chi2	-	-	38.1502	-	-	35.5103
F statistics	-	-	36.0017	-	-	33.7585
Weak instrument tests						
F statistics	-	-	61.489	-	-	74.066
Test of overidentifying restrictions						
Chi2	-	-	139.746	-	-	149.333

Note.— p-values are based on Huber–White heteroscedasticity consistent standard errors.
*p < 0.1.
**p < 0.05.
*** p < 0.01.

APPENDIX D

TABLE D1

REGRESSION RESULTS OF EQUATION (14)

	Food Consumption				Total Consumption			
	Model 1		Model 2		Model 1		Model 2	
	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) OLS	(8) 2SLS
Second-Stage Regression								
β	0.2036***	0.6546***	0.2057***	0.5908***	0.2155***	0.8806***	0.2168***	0.7901***
T1998*β	−0.0785**	0.0414	−0.0784**	0.051	−0.042	0.0102	−0.042	0.0409
T2000*β	−0.063	−0.1185	−0.0607	−0.1121	−0.0409	−0.1647	−0.0386	−0.1651
primary03	−1.0126	0.7033	−1.1356	0.431	−3.0975**	−0.8913	−3.2098**	−1.2041
secondary03	−2.7973	−1.3826	−2.9661	−1.7973	−3.8896	−2.0869	−4.0706*	−2.5882
highschool03	−0.1739	7.1924	−0.2764	5.946	0.5218	10.4327	0.3436	8.7368
technical03	−9.647	−4.5107	−9.5664	−5.6662	9.4032	15.8937*	9.4215	14.2721
univ03	−19.2515	−11.2374	−19.5971	−12.6357	−2.6017	8.1765	−3.1067	6.3015
total_member03	1.3108***	0.8395***	1.3383***	0.9961***	2.1394***	1.5392***	2.2021***	1.7722***
depratio03	0.1611***	0.0602**	0.1591***	0.0724***	0.2422***	0.1069***	0.2394***	0.1227***
female03	1.0658	−0.5978	0.2803	−1.0727	−3.666	−5.9780*	−4.4949	−6.4010*
age03	−0.307***	−0.026	−0.324***	−0.0632	−0.4053***	−0.0343	−0.428***	−0.0828
married03	−1.2943	−2.8422	−1.462	−2.679	6.3479	4.6424	6.3127	5.0317
divorced03	−9.7677**	−10.904***	−9.655**	−10.628**	2.1349	1.0326	2.3568	1.4653
indigenous03	−1.5444	−3.3000*	−1.5498	−3.0361	1.2224	−1.1183	1.2277	−0.7524
total_land_ha03	0.0377	0.2921***	0.0336	0.2706***	0.0048	0.3440***	0.0003	0.3183***
irrigation03	1.3302	8.3924***			0.7676	10.287***		
CCT_dum03	1.3563	3.7698***			2.148	5.3728***		
selfcons_dum03	−11.838***	−6.974***			−9.088***	−2.597		
hhremit03	−3.1132***	−2.5222**			−4.2110***	−3.3609**		
T1998_dum	−0.0832	40.681***	2.5813	35.812***	−99.433***	−122.51***	−94.632***	−108.82***
T2000_dum	1.218	38.782***	4.2784	34.143***	−102.19***	−128.94***	−97.149***	−115.27***
_cons	−0.2022	−15.5612	−1.5654	−15.184	27.6653**	6.4618	26.3024**	7.4518
First Stage Regression								
Instruments:								
$\Delta y_{i,t-1}$ (2001–2002)	-	−0.0774**	-	−0.0735**	-	−0.0774**	-	−0.0735**
land_dum03	-	−11.484***	-	−12.68***	-	−11.484***	-	−12.680***
hhmig_over15_dum03	-	−6.1763***	-	−6.489***	-	−6.1763***	-	−6.4892***
Tortilla price change	no	no	no	no	no	no	no	no
Village dummies	yes	yes	yes	yes	yes	yes	yes	yes
No. of Obs.	12349	12349	12349	12349	11442	11442	11442	11442
R-squared	0.138	0.127	0.134	0.122	0.161	0.151	0.159	0.148

Note.—p-values are based on Huber–White heteroscedasticity consistent standard errors.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

TABLE D2

REGRESSION RESULTS OF EQUATION (14)

	Food Consumption				Total Consumption			
	Model 1		Model 2		Model 1		Model 2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Second-Stage Regression								
β	0.2036***	0.6513***	0.2057***	0.5891***	0.2155***	0.8771***	0.2168***	0.7884***
T1998&2000*β	−0.0723**	−0.0228	−0.0713**	−0.0154	−0.0416	−0.0599	−0.0407	−0.0433
primary03	−1.0099	0.7067	−1.1324	0.4513	−3.0949**	−0.8846	−3.208**	−1.1721
secondary03	−2.7853	−1.3877	−2.9511	−1.7764	−3.8873	−2.0728	−4.0676*	−2.5423
highschool03	−0.2107	7.2171	−0.3147	5.9915	0.5291	10.5119	0.3428	8.8603
technical03	−9.6376	−4.5469	−9.5476	−5.6758	9.3964	15.8988*	9.4133	14.3167
univ03	−19.2255	−11.2742	−19.5552	−12.6442	−2.596	8.1838	−3.1027	6.3436
total_member03	1.3114***	0.8436***	1.3383***	1.0016***	2.1403***	1.5452***	2.2033***	1.7811***
depratio03	0.1613***	0.0605**	0.1592***	0.0727***	0.2422***	0.1071***	0.2393***	0.1230***
female03	1.0667	−0.5775	0.2754	−1.0372	−3.6722	−5.9671*	−4.5008	−6.3696*
age03	−0.3074***	−0.0268	−0.324***	−0.0633	−0.405***	−0.035	−0.478***	−0.0825
married03	−1.3086	−2.7467	−1.4805	−2.5713	6.3518	4.7419	6.3134	5.1589
divorced03	−9.7907**	−10.806***	−9.6791**	−10.5284**	2.142	1.1489	2.3584	1.5953
indigenous03	−1.5176	−3.3523*	−1.5173	−3.0886	1.1889	−1.2416	1.1995	−0.8863
total_land_ha03	0.0377	0.2861***	0.0337	0.2646***	0.005	0.3379***	0.0005	0.3114***
irrigation03	1.3423	8.1807***			0.7658	10.0334***		
CCT_dum03	1.3284	3.8424***			2.1603	5.4691***		
selfcons_dum03	−11.859***	−6.9437***			−9.0828***	−2.5741		
hhremit03	−3.1258***	−2.5076**			−4.208***	−3.3469**		
T1998&T2000_dum	−0.1806	−139.35***	2.4784	−129.92***	17.1275	1.5316	20.0391*	−5.6184
_cons	−0.185	−15.5857	−1.5398	−15.2992	27.6598**	6.4145	26.3004**	7.2642
First-Stage Regression								
Instruments:								
$\Delta y_{i,t-1}$ (2001–2002)	-	−0.0774**	-	−0.0734**	-	−0.0774**	-	−0.0734**

land_dum03	-	−11.477***	-	−12.672***	-	−11.477***	-	−12.672***
hhmig_over15_dum03	-	−6.1771***	-	−6.4935***	-	−6.1771***	-	−6.494***
Tortilla price change	no	no	no	no	no	no	No	no
Village dummies	yes	yes	yes	yes	yes	yes	yes	yes
No. of Obs.	12349	12349	12349	12349	11442	11442	11442	11442
R-squared	0.138	0.126	0.134	0.121	0.161	0.150	0.159	0.148

Note.—p-values are based on Huber–White heteroscedasticity consistent standard errors.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

APPENDIX E

TABLE E1

OLS REGRESSION RESULTS OF EQUATION (13) BY SUBGROUPS

	Model 1					
	Food Consumption			Total Consumption		
	T1998	T2000	C2003	T1998	T2000	C2003
β	0.1170***	0.1512***	0.2044***	0.1651***	0.1863***	0.2109***
primary03	−0.8358	0.1852	−4.4889	−1.6763	−1.9039	−10.3159***
secondary03	−2.0505	−0.9299	−7.4195*	−2.388	−1.4179	−12.1069**
highschool03	0.6689	8.436	−12.1657	−2.4082	23.0979**	−21.9068
technical03	−9.1394	−3.2761	−22.6581*	3.1413	19.4998	10.5354
univ03	−44.5793***	5.3977	−18.5092	−26.5386***	19.2509	−5.4772
total_member03	1.5690***	1.2929***	0.5903	2.4549***	2.1455***	1.1453
depratio03	0.1905***	0.0727**	0.2539***	0.2623***	0.1694***	0.3289***
female03	−1.2811	−0.1577	8.6485	−3.3514	−7.7932	4.8231
age03	−0.3682***	−0.2483***	−0.2366***	−0.4673***	−0.3237***	−0.3681***
married03	6.0826	−3.2409	−13.3277	11.0242*	2.8618	4.4769
divorced03	−0.3363	−9.8002	−29.1154***	7.4571	0.8433	−6.0789
indigenous03	−4.2316	3.2263	−3.2696	−1.2497	4.5341	4.0494
total_land_ha03	−0.0273	0.1307	0.1218	−0.0966	0.1531	0.1208
irrigation03	1.7561	−2.1177	4.4336	4.3078	−2.5239	−2.8338
CCT_dum03	0.6806	2.4346	0.333	3.7031*	1.015	−4.8429
selfcons_dum03	−13.0368***	−10.2925***	−11.6963***	−11.6666***	−6.8446**	−6.3393
hhremit03	−2.4381	−4.6840***	−2.1228	−4.3724**	−5.0816**	−2.2265
Constant	−24.8410***	31.8713***	11.2687	45.2987***	−68.3045***	35.0066*
Tortilla price change	no	no	no	no	no	no
Village dummies	yes	yes	yes	yes	yes	yes
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	1.21	1.32	2.27***	0.61	0.46	0.90
No. of Obs.	5897	4130	2322	5450	3848	2144
R-squared	0.144	0.131	0.150	0.183	0.146	0.148

Note.—p-values are based on Huber–White heteroscedasticity consistent standard errors. t-values represent the significance of the differences between each group's coefficients. The results are based on the Model 1 estimation.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

APPENDIX F

TABLE F1

2SLS REGRESSION RESULTS OF EQUATION (13) BY SUBGROUPS

	Model 1					
	Food Consumption			Total Consumption		
	T1998	T2000	C2003	T1998	T2000	C2003
β	0.3746***	0.7404***	0.9217***	0.4610***	0.8417***	1.3914***
primary03	−0.2777	2.0674	−0.4887	−0.5862	0.5533	−5.5082
secondary03	−0.3515	−1.0156	−3.7433	−1.317	−1.1584	−6.5447
highschool03	2.5279	20.1321**	−0.3112	1.1297	38.5871***	−11.2545
technical03	−8.8311	1.5847	−15.6822	6.6544	26.6087	19.2708
univ03	−38.3506**	15.2318	−19.2628	−19.1031*	31.7946	−8.4041
total_member03	1.3927***	0.505	0.7299	2.1619***	1.2205**	1.1493
depratio03	0.1355***	−0.0463	0.0711	0.2049***	0.0518	0.0366
female03	−2.1414	−2.74	8.8046	−4.9108	−10.5525*	5.2037
age03	−0.2151***	0.1231	0.0763	−0.2985***	0.0904	0.1821
married03	3.571	−3.0326	−13.8416	8.9938	2.3201	−0.5051
divorced03	−2.3942	−8.1869	−31.1108***	5.702	3.2193	−15.8834
indigenous03	−5.0532*	−0.9667	−6.9733	−1.7535	1.5854	−2.3375
total_land_ha03	0.1075	0.4481***	0.4982**	0.0304	0.5396***	0.6724**
irrigation03	3.6961	4.1138	23.0640**	8.0064*	4.1158	30.8202**
CCT_dum03	1.6031	5.9968***	11.4168	4.7985**	4.8523*	14.6747
selfcons_dum03	−12.0160***	−3.8379	−4.3927	−9.5267***	1.8502	6.5152
hhremit03	−3.0550**	−3.0107	−1.8826	−4.3533**	−2.8565	−2.7419
Constant	36.0348**	−31.4520*	−15.2295	−19.5675	−68.0234***	−3.8696
First-Stage Regression Instruments						
$\Delta y\_i_{,t-1}$ (2001–2002)	−0.1069	−0.0598	−0.0595138	−0.0977	−0.0619	−0.061
land_dum03	−12.732***	−11.105***	9.1502***	−13.226***	−11.928***	−10.119***
hhmig_over15_dum03	−3.299**	−7.0626***	−13.348***	−2.7618*	−7.1343***	−12.947***
Tortilla price change	no	no	no	no	no	no
Village dummies	yes	yes	yes	yes	yes	yes
t-value	T98 vs. T00	T00 vs. C03	T98 vs. C03	T98 vs. T00	T00 vs. C03	T98 vs. C03
	2.08**	0.73	2.36***	2.28***	0.77	2.62***
No. of Obs	5897	4130	2322	5450	3848	2144
Chi2	199730.55	209185.88	450.94	52926.70	778204.72	934.94
Robust Durbin–Wu–Hausman test of endogeneity						
Chi2	4.63	24.78	23.21	4.90	20.68	31.55
F statistics	4.31	23.37	22.52	4.55	19.57	31.79
Weak instrument tests						

F statistics	30.95	21.18	11.98	30.54	22.12	11.27
Test of overidentifying restrictions						
Chi2	83.90	57.31	7.07	61.76	55.44	12.16

Note.—p-values based on Huber–White heteroscedasticity consistent standard errors. t-values represent the significance of the differences between each group's coefficients. The results are based on the Model 1 estimation.

*p < 0.1.

**p < 0.05.

***p < 0.01.

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[i] There are three national poverty lines: the food poverty line (Pobreza alimentaria, the level that covers the minimum food basket); the human capital poverty line (Pobreza de capacidades, the level that covers the minimum necessary expenditures for food basket, education, and healthcare); and the asset poverty line (Pobreza de patrimonio, the human poverty line and the level that covers minimum expenditures pertaining to clothing, housing, and transportation) (CONEVAL, 2011). The asset poverty line is applied for this estimation.

[ii] The Indian panel data, known as ICRISAT data, is named after the institution that conducted the survey: the International Crops Research Institute for Semi-Arid Tropics.

[iii] The program was named the Education, Health and Nutrition Program (*Programa de Educación*, *Salud e Alimentación* (*PROGRESA*)) when it was firstly introduced in 1997, which replaced all other existing poverty programs and was later renamed "Oportunidades" when the government changed in 2000. Today, or since the return of the Institutional Revolutionary Party (PRI) to the government, it is called "El Programa Oportunidades" (hereinafter PROGRESA-Oportunidades). As of late 2011, the program has managed to assist 5.8 million households in the states, covering all of Mexico's municipalities (Caridad and Suárez, 2013).

[iv] ENCEL 2007 also includes new samples of 18,052 households and 77,768 individuals extracted from the original 7 states as well as from some other poor states. They are excluded from the panel data because they are cross-sectional and their profiles are very different from those of ENCEL 2003.

[v] The rural food basket used here is 23.37 Mexican pesos (approximately 1.98 US dollars) per capita, per day, as of June 2011.

[vi] The high percentage of the poverty headcount ratio is a result of the ENCEL choosing sample villages from the most marginal rural areas throughout the country. The average rural

poverty ratios at national level, measured by the same food basket but calculated by per capita income, were 20.0 percent in 2002, 13.8 percent in 2006, and 18.4 percent in 2008 (CONEVAL 2012).

[vii] This section draws on Bardhan and Udry (1999: Ch. 8) and Kurosaki (2001: Ch. 8, 2006, 2009: Ch. 9).

[viii] Here, I assume that income is exogenous.

[ix] Other representative empirical studies on risk sharing include Deaton (1992) and Grimard (1997) for Côte d'Ivoire, Udry (1994) for the rural credit market in Nigeria, and Amin et al. (2003) for microfinance in Bangladesh. All of these studies rejected the full risk-sharing hypothesis. See also Bardhan and Udry (1999: Ch. 8) and Kamanou and Morduch (2005) for a detailed literature review on empirical studies on risk sharing.

[x] An alternative hypothesis implies a complete autarky or lack of risk-sharing mechanisms.

[xi] After excluding zero or unreported income and the upper and lower one percent of the sample as outliers, the complete panel data for 2003 and 2007 comprised 12,243 households. However, I found no attrition bias in the sample upon comparing the original unbalanced samples with the balanced ones for regressions by applying the t-test to the means of the household characteristics used in the regressions. The results can be made available upon request.

[xii] Here, the price for tortilla is used as a proxy for food price changes in 2003 and 2007. ENCEL data show that notable price changes were observed mainly in corn-related products, that is, tortilla and maize grain. Prices of other food products, such as wheat, rice, beans, fruit and vegetables, meats, and even eggs and milk, remained almost unchanged. Some food prices even dropped during the period. Attanacio et al. (2009, 2013) pointed out a price rise in meat and dairy products because of the rise in the price of feed grains; however, this price increase was not felt in the marginal rural areas, suggesting that villagers in these areas are

self-sufficient in raising their own livestock. Detailed data can be made available upon request.

[xiii] Details of the income change for 2001–2002 are explained in Appendix A. The sum of the retrospective wage earnings of household heads and spouses are used as a proxy of lagged household income changes, because data for the newly added control group (Control 2003) are not available for years prior to 2003.

[xiv] We also regressed models with per capita consumption and income calculated using adult equivalent scales on the basis of Kurosaki (2009) and models without any control variables X_i, but the results did not change in any of the specifications. The results can be made available upon request.

[xv] The estimates of three ICRISAT villages conducted by Ravallion and Chaudhuri (1997) range from 0.209 to 0.462 when using flow accounting income data and from 0.120 to 0.336 when using observable transaction income data (Table IV). Kurosaki (2001: Tables 8–6) also produced results similar to those of Ravallion and Chaudhuri (1997) using the same Indian data. In the case of Côte d'Ivoire, the estimated excess sensitivity parameters range from negative (essentially zero) to 0.54. (Deaton 1993, Table 3) In addition, Grimard's (1997) estimation results using Côte d'Ivoire data are quite robust with coefficients values around 0.2 for different specifications and regression methods.

[xvi] One can infer from the 2SLS regression results that a downward bias caused by measurement errors is greater than other possible biases that can be attributed to specification errors or omitted variables.

[xvii] The coefficient of the tortilla price change was positive but insignificant in OLS estimations and was automatically omitted from 2SLS estimations, as is shown in Table 3. Since the price change is an aggregate shock to the whole village, it is possible that the effect is absorbed by the village dummies (see Appendix C for details).

[xviii] See Fiszbein and Schady (2009) for the summary of previous studies on the CCT evaluations.

[xix] Banco de México Estadísticas (http://www.banxico.org.mx/estadisticas/index.html); June 2001 = 100.