Are Remittances Insurance? Evidence from Rainfall Shocks in the Philippines

Dean Yang and HwaJung Choi

Do remittances sent by overseas migrants serve as insurance for recipient households? In a study of how remittances from overseas respond to income shocks experienced by Philippine households, changes in income are found to lead to changes in remittances in the opposite direction, consistent with an insurance motivation. Roughly 60 percent of declines in household income are replaced by remittance inflows from overseas. Because household income and remittances are jointly determined, rainfall shocks are used as instrumental variables for income changes. The hypothesis cannot be rejected that consumption in households with migrant members is unchanged in response to income shocks, whereas consumption responds strongly to income shocks in households without migrants. JEL codes: D81, F22, F32, O12, O15

Several facts motivate this study. First, life in developing countries is prone to many kinds of risk, such as crop and income loss due to natural disasters (weather, insect infestations, fire) and civil conflict. Second, international migration and remittance flows are substantial and growing. Between 1965 and 2000, individuals living outside their country of birth grew from 2.2 to 2.9 percent of the world population, totaling 175 million people in 2000.[1] The remittances that these migrants send to their countries of origin are an important but poorly understood type of international financial flow. In 2002, remittance receipts of developing countries totaled \$79 billion.[2] This amount

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1. Estimates of the number of individuals living outside their country of birth are from United Nations (2002), whereas data on world population are from United States Bureau of the Census (2002).

2. The remittance figure is the sum of the "workers' remittances," "compensation of employees," and "migrants' transfers" items in the International Monetary Fund's International Financial Statistics database for all countries not listed as high income in the World Bank's income groupings.

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exceeded the total official development aid ($51 billion) and equaled roughly 40 percent of foreign direct investment (FDI) inflows ($189 billion) received by developing countries that year.[3] Understanding the functions of remittances for recipient households is necessary for weighing the benefits to origin countries of developed country policies liberalizing inward migration [as proposed by Rodrik (2002) and Bhagwati (2003), for example].[4]

What connection, if any, is there between the pervasiveness of risk in developing countries and international remittance flows? Do remittances from overseas migrants serve as insurance for relatives back home? To shed light on this question, this article examines how income shocks experienced by households in the Philippines affect their receipt of remittances from overseas. To break the simultaneity between income and remittances, rainfall shocks are used to instrument for changes in household income. In households with members who are overseas migrants, changes in income from domestic sources lead to changes in remittances in the opposite direction of the income change: remittances fall when income rises and remittances rise when income falls. In such households, the amount of insurance is large: roughly 60 percent of exogenous declines in income are replaced by remittance inflows from overseas. In contrast, in households without overseas migrants, changes in income from domestic sources have no effect on remittance receipts. As a result, the hypothesis cannot be rejected that consumption in households with migrant members is unchanged in response to income shocks, whereas consumption responds strongly to income shocks in households without migrants.

Numerous studies have examined the mechanisms through which households in developing countries cope with risk. Among others, Townsend (1994), Udry (1994), Ligon, Thomas and Worall (2002), and Fafchamps and Lund (2003) have documented risk-pooling arrangements among households intended to smooth consumption in response to shocks. Households may also autonomously build up savings or other assets in good times and draw down these assets in hard times (Paxson 1992; Rosenzweig and Wolpin 1993; Udry 1994), increase their labor supply when shocks occur (Kochar 1999), or take steps (such as crop and plot diversification) to reduce the variation in their incomes (Morduch 1993).

This article examines a mechanism for coping with shocks ex post on which previous micro-level studies have not focused: remittances from family members overseas. At the international level, it is commonly posited that remittance flows from overseas buffer economic shocks in migrants' home countries (e.g., Ratha 2003), but there have been relatively few empirical tests of this

3. Aid and FDI figures are from World Bank (2004). Although the figures for official development aid and FDI are likely to be accurate, by most accounts national statistics on remittance receipts are considerably underreported (see, e.g., Ratha 2003), so the remittance figure may be taken as a lower bound.

4. Borjas (1999) argues that the investigation of benefits accruing to migrants' source countries is an important and virtually unexplored area in research on migration.

claim with micro-level household data.[5] Related research on the role of domestic migration in pooling risk within extended families includes Lucas and Stark (1985), Rosenzweig and Stark (1989), and Paulson (2000).

A key distinguishing facet of this article is its emphasis on credible identification of the effect of income shocks on international remittances. Studies of the impact of household income on remittance receipts use cross-sectional data, and so are subject to potentially severe biases in directions that are not obvious a priori. Reverse causation is a major concern: productive investments funded by migrant remittances can raise household income, leading to positive correlations between household income and remittances. Alternately, remittances may reduce households' need to find alternative income sources, leading to a negative relationship between remittances and domestic-source income. Even if reverse causation from remittances to income in migrants' source households were not a problem, it would be difficult to separate the cross-sectional relationship between income and remittances from the influence of unobserved third factors affecting both income and remittances (e.g., the entrepreneurial spirit of household members).

Two aspects of the empirical strategy are the key in resolving these identification problems. First, the focus is on income changes due to shocks that are credibly exogenous—changes in local rainfall—so that bias due to reverse causation is not a concern.[6] But the estimated impact of economic shocks in cross-sectional data is still likely to be biased, because the likelihood of experiencing a shock may be correlated with time-invariant household characteristics (in other words, omitted variables are still a concern). For example, if shocks occur more frequently in poorer areas, and more remittances generally flow to poor areas, estimates of the impact of income on remittances will be biased in a negative direction.

So the second crucial aspect of this article is its use of panel data, so that estimates of the impact of income shocks can be purged of the influence of unobserved time-invariant household characteristics that are jointly related to remittances and to the likelihood of experiencing a shock. Estimation of the impact of shocks focuses on how shocks are related to changes in remittances rather than on the level of remittances.

Section I considers the theoretical role of international remittance flows in sharing risk across family members in different countries. Section II describes the data used and provides empirical results. Section III discusses some of the policy implications of the findings and recommendations for future research. Further details on the household data sets are provided in the supplemental appendix, available at http://wber.oxfordjournals.org/.

5. On the international macroeconomic level, Yang (2006a) documents that international financial flows (including remittances) at the country level respond positively to economic losses due to hurricanes. For studies with micro-data, see Brown (1997) and Gubert (2002).

6. Other research using rainfall shocks as instruments includes Paxson (1992), Munshi (2003), Miguel (2005), and Maccini and Yang (2006).

I. Income Shocks and Remittances in Theory

When a household experiences a negative income shock, how should we expect remittance receipts from overseas to change? A basic theoretical result is that if there is a Pareto-efficient allocation of risk across individual entities (in this case, individual household members) in a risk-sharing arrangement, individual consumption should not be affected by idiosyncratic income shocks.

Consider households consisting of two members, indexed by $i \in \{1,2\}$. Let one household member be located in the origin household in the Philippines and the other household member be located overseas. Assume that both household members work and are able to send funds back and forth to each other.

Individuals have an uncertain income in each period t, $y^i_{s_t}$, depending on the state of nature $s_t \in S$. Household member i consumes $c^i_{s_t}$, and experiences within-period utility of $U_i(c^i_{s_t})$ at time t. Let utility be separable over time, and let instantaneous utility be twice differentiable with $U_i' > 0$ and $U_i'' < 0$. For the allocation of risk across household members to be Pareto-efficient, the ratio of marginal utilities between members in any state of nature must be equal to a constant:

$$(1) \qquad \frac{U_1'(c^1_{s_t})}{U_2'(c^2_{s_t})} = \frac{\omega_2}{\omega_1}, \quad \text{for all } s_t \text{ and } t,$$

where ω_1 and ω_2 are the Pareto weights of members 1 and 2. Household members' marginal utilities are proportional to each other, and so consumption levels between members move in tandem.

Let utility be given by the following constant absolute risk aversion function:

$$(2) \qquad U_i(c^i_{s_t}) = \frac{-\mathrm{e}^{-\theta c^i_{s_t}}}{\theta}.$$

Then, following Mace (1991), Cochrane (1991), Altonji, Hayashi, and Kotlikoff (1992), and Townsend (1994), a relationship between individual household member i's consumption and average consumption across the household members, $\bar{c}_{s_t}$, is obtained by:

$$(3) \qquad c^i_{s_t} = \bar{c}_{s_t} + \frac{\ln \omega_i - 1/2(\ln \omega_1 + \ln \omega_2)}{\theta}$$

Efficient risk sharing implies that an individual's consumption level depends here only on mean consumption in the household, $\bar{c}_{s_t}$, and an effect determined by the individual's Pareto weight relative to the other's. Because this latter term is constant over time, changes in consumption for each individual will depend only on the change in mean household consumption. Said another way, individuals face only household-level risk.

How might this within-household (but cross-country) risk sharing be carried out in practice? It is simple to imagine that an individual sends remittances to the other household member when that member experiences a negative shock.[7]

Adapting Fafchamps and Lund (2003), let consumption of individual i in state s_t be the sum of income $y^i_{s_t}$ and net inflows of remittances $r^i_{s_t}$:

$$c^i_{s_t} = y^i_{s_t} + r^i_{s_t}.$$

So then equation (3) can be rewritten as:

$$r^i_{s_t} = -y^i_{s_t} + \bar{c}_{s_t} + \frac{\ln \omega_i - 1/2(\ln \omega_1 + \ln \omega_2)}{\theta}. \tag{4}$$

This equation can be transformed into an empirically testable specification as follows. First, separate income $y^i_{s_t}$ into:

$$y^i_{S_i} = \tilde{y}^i + z^i_{S_t}, \tag{5}$$

where $\tilde{y}^i$ is the permanent component of income and $z^i_{s_t}$ is the transitory component of income. Only the transitory component depends on the state of the world.

The function of Pareto weights and the permanent income component $\tilde{y}^i$ can be captured by an individual fixed effect, γ_i. The mean household consumption level, $\bar{c}_{s_t}$, can be represented by a time effect, ϕ_t. Also, allow a random component, ε_{it}, a mean-zero error term. Then equation (4) becomes:

$$r^i_{s_t} = -Z^i_{s_t} + \gamma_i + \phi_t + \varepsilon_{it}. \tag{6}$$

The empirical test of this article is based on equation (6), where the outcome variable is remittances received from overseas. The focus is on a particular type of transitory shock, $z^i_{s_t}$, changes in income from domestic (Philippine) sources, using rainfall shocks as the instrumental variable.

There are two key questions of interest. First, is the coefficient on remittances with respect to domestic income $z^i_{s_t}$ less than zero? If yes, then this is the evidence that at least some insurance is taking place. Second, can the null hypothesis of full insurance be rejected, that is, that the coefficient on $z^i_{s_t}$ is equal to negative one?

7. Micro-economic studies among households of the insurance role of gifts and remittances include Lucas and Stark (1985), Ravallion and Dearden (1988), Rosenzweig and Stark (1989), Platteau (1991), and Cox, Eser, and Jimenez (1998).

II. Empirical Analysis

This section first describes the data and sample constructions and provides descriptive statistics on the sample households. It then discusses the regression specification and some empirical issues and presents empirical results. Finally, tests are conducted of potential violations of the instrumental variable exclusion restriction and of an important omitted variable concern.

Data and Sample Construction

The empirical analysis uses data from linked household surveys conducted by the Philippine National Statistics Office covering a nationally representative household sample: the Labor Force Survey, the Survey on Overseas Filipinos, the Family Income and Expenditure Survey, and the Annual Poverty Indicators Survey.

The Labor Force Survey is administered quarterly to inhabitants of a rotating panel of dwellings in January, April, July, and October. The other three surveys are administered with lower frequency as riders to the Labor Force Survey. Usually, one-fourth of dwellings are rotated out of the sample in each quarter, but the rotation was postponed for five quarters starting in July 1997, so that three-quarters of dwellings included in the July 1997 round were still in the sample in October 1998 (one-fourth of the dwellings had just been rotated out of the sample). The analysis here takes advantage of this postponement of the rotation schedule to examine changes in households over the 15-month period from July 1997 to October 1998.

Survey enumerators note whether the household currently living in the dwelling is the same as the household surveyed in the previous round; only dwellings inhabited continuously by the same household from July 1997 to October 1998 are included in the sample for analysis. Because the impact of domestic income shocks on remittance receipts is likely to vary according to whether households had migrant members, households that reported having one or more members overseas in June 1997 and households that did not are analyzed separately. The comparison between migrant and non-migrant households should be taken as merely suggestive because households with and without migrants differ in many ways. Thus, while differences in results between these two groups of households could be due to whether they have migrants, it could also be due to other factors such as differential access to other risk-coping mechanisms (savings, credit, informal and formal insurance).

Rainfall data used in constructing instrumental variables for household domestic income were obtained from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration. Daily rainfall data are available for 47 weather stations, often as far back as 1951. Rainfall variables are constructed by station separately for the two distinct weather seasons in the Philippines: the dry season from December through May and the wet season from June through November. Monthly rainfall is calculated by summing daily rainfall totals, with missing daily values replaced by the average daily totals in the given station-month for stations that had 20 or more daily rainfall records. For station-months with less than 20 daily rainfall records, monthly rainfall for the station is taken to be the monthly rainfall recorded in the nearest station with 20 or more daily rainfall records. Seasonal total rainfall for each station in each year is obtained by summing monthly rainfall for the months in each wet and dry season.

Rainfall shock variables for a given season are constructed as rainfall in that season (in thousands of millimeters) minus rainfall in the same season the year before. Households are assigned the rainfall data for the weather station geographically closest to their local area (specifically, the major city or town in their survey domain), using great circle distances calculated using latitude and longitude coordinates. Because some stations are never the closest station to a particular survey domain, a total of 38 stations are represented in the empirical analysis.

The supplemental appendix provides other details on the household surveys and the construction of the sample for analysis (available at http://wber.oxfordjournals.org/).

Characteristics of Sample Households

Table 1 presents summary statistics for the 27,881 households used in the empirical analysis, separately for migrant and non-migrant households. Migrant households are those with overseas workers in June 1997. The 1,655 migrant households represent 5.9 percent of the sample households.

The table also presents rainfall data to provide a sense of the instrumental variables used. The rainfall data are deviations (in thousands of millimeters) from the historical mean of each station for the dry and wet seasons. The dry season immediately before the first observation for each household (year 1, with income from January to June 1997) runs from December 1995 to May 1996, and the wet season is from June to November 1996. Correspondingly, the dry season for the second observation for each household (year 2, with income from April to September 1998) is December 1996 to May 1997, and the wet season is from June to November 1997.

For migrant households, the dry season in year 1 was on average wetter than normal, with a mean deviation across households of 0.28. In year 2, dry season rainfall was more typical, with a mean deviation of 0.03. Therefore, the mean household experienced a decline in dry season rainfall between years 1 and 2: the mean change in the dry season deviation across households is -0.25. The wet season for year 1 was only slightly wetter than normal, with a mean deviation across households of 0.07. In year 2, wet season rainfall was much dryer than normal, with a mean of -0.48. The mean household thus experienced a substantial decline in wet season rainfall between years 1 and 2 of -0.55. These declines in rainfall between the 2 years have been attributed to the 1997 El Niño weather phenomenon. The mean of the rainfall variables for the

TABLE 1. Characteristics of Sample Households, 1997

	Migrant households					Non-migrant households				
	Mean	Standard deviation	10th percentile	Median	90th percentile	Mean	Standard deviation	10th percentile	Median	90th percentile
Rainfall variables (thousands of millimeters)										
Dry season year 1	0.28	0.40	−0.04	0.10	0.55	0.38	0.50	−0.03	0.20	0.90
Dry season year 2	0.03	0.21	−0.17	0.00	0.32	−0.01	0.23	−0.33	−0.01	0.29
Change between dry season years 1 and 2	−0.25	0.56	−0.79	0.02	0.23	−0.39	0.66	−0.93	−0.28	0.23
Wet season year 1	0.07	0.47	−0.35	−0.03	1.16	0.01	0.40	−0.35	−0.03	0.54
Wet season year 2	−0.48	0.33	−0.98	−0.48	−0.12	−0.41	0.31	−0.85	−0.42	−0.05
Change between wet season years 1 and 2	−0.55	0.67	−2.00	−0.39	0.18	−0.42	0.58	−1.33	−0.23	0.18
Outcome variable										
Change in household domestic income as share of initial household income	0.03	0.64	−0.50	−0.04	0.57	0.03	1.44	−0.59	−0.13	0.68
Change in household remittance receipts as share of initial household income	0.07	0.67	−0.50	−0.02	0.71	0.01	0.22	0.00	0.00	0.00
Change in household expenditure as share of initial household expenditures	0.00	0.61	−0.55	−0.14	0.67	−0.04	1.06	−0.55	−0.16	0.55
Change in indicator for overseas worker in household	−0.38	0.49	−1.00	0.00	0.00	0.02	0.15	0.00	0.00	0.00
Household financial statistics (January–June 1997)										
Total expenditure	73,576	66,443	24,568	57,691	132,793	47,437	54,159	13,657	32,493	93,522
Total income	94,189	92,636	28,093	71,012	175,000	56,059	77,676	13,513	35,908	113,460
Total income per capita in household	20,204	21,356	5,510	15,206	39,166	11,857	15,116	2,864	7,625	24,100

Domestic income	58,067	80,815	7,971	38,310	120,317	54,170	75,912	13,076	34,800	109,760
Remittance receipts	36,122	46,752	0	26,000	87,000	1,888	13,182	0	0	0
Remittance receipts as share of total income	0.39	0.31	0.00	0.37	0.85	0.02	0.10	0.00	0.00	0.00
Household size, including overseas members, July 1997	6.2	2.4	3.0	6.0	9.0	5.2	2.3	3.0	5.0	8.0
Located in urban area	0.68					0.58				
Household head characteristics July 1997										
Age	49.9	13.9	32.0	50.0	68.0	46.7	14.1	30.0	45.0	67.0
Highest education level (indicators)										
Less than elementary	0.17					0.28				
Elementary	0.20					0.22				
Some high school	0.10					0.11				
High school	0.22					0.18				
Some college	0.16					0.11				
College or more	0.14					0.09				
Occupation (indicators)										
Agriculture	0.23					0.38				
Professional job	0.08					0.06				
Clerical job	0.13					0.11				
Service job	0.05					0.07				
Production job	0.14					0.26				
Other	0.38					0.12				
Does not work	0.00					0.00				
Marital status is single (indicator)	0.03					0.03				
Number of households	1,665					26,126				

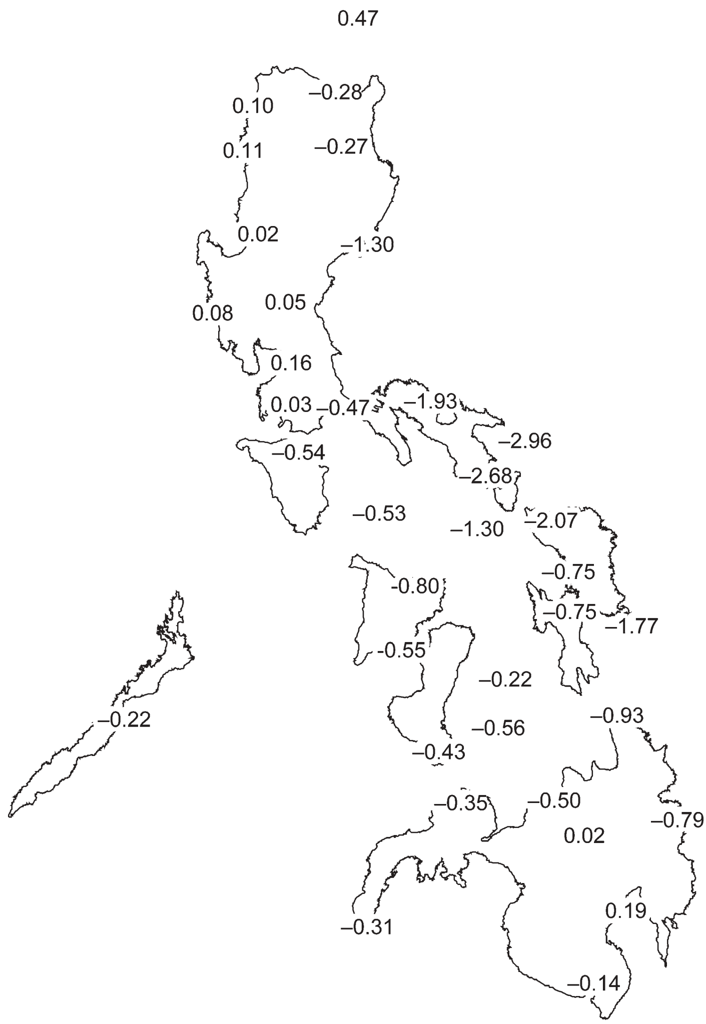
Note: Rainfall variables are deviations from historical average of each station in corresponding season. For year 1, dry season is December 1995–May 1996 and wet season is June 1996–November 1996. For year 2, dry season is December 1996–May 1997 and wet season is June 199–November 1997. Rainfall data are collected from 38 stations. Total income includes both domestic-source income and remittances from overseas. Remittance receipts are from overseas only.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

non-migrant households are generally quite similar to those for migrant households.

The changes between years 1 and 2 for the wet and dry seasons are used as the instrumental variables for the change in domestic income in the empirical analysis that follows. The geographic distribution of the rainfall shocks is depicted graphically in figures 1 and 2.

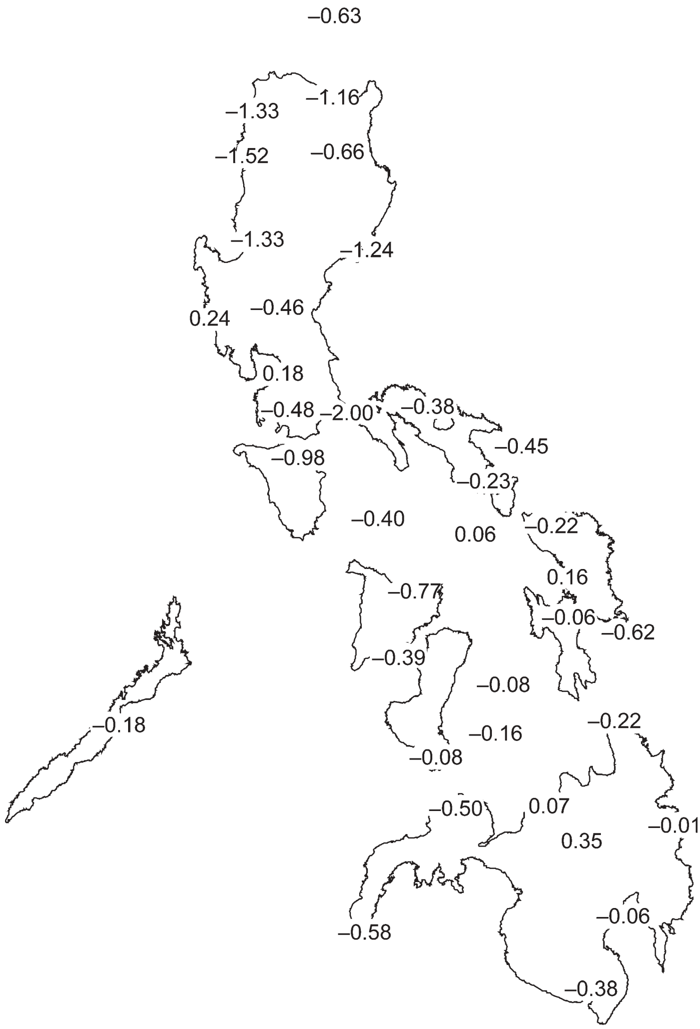
FIGURE 1. Dry Season Rainfall Shocks, Philippines



Note: Rainfall shocks are change in rainfall (in thousands of millimeters) between the December 1996–May 1996 season and the December 1996–May 1997 season. Each number in the figure is centered at coordinates of a rainfall station.

Source: Authors' calculations based on data described in the text.

FIGURE 2. Wet Season Rainfall Shocks, Philippines



Note: Rainfall shocks are changes in rainfall (in thousands of millimeters) between the June 1996–November 1996 and the June 1997–November 1997 season. Each number in the figure is centered at coordinates of a rainfall station.

Source: Authors' calculations based on data described in the text.

Total expenditure and total income in the first period (January–June 1997) are higher in migrant households than in non-migrant households. Average total expenditure is 73,576 pesos ($2,830) for migrant households and 47,437 pesos ($1,825) for non-migrant households.[8] Average total income is 94,189 pesos ($3,623) for migrant households and 56,059 pesos ($2,156) for

8. Peso figures were converted to US dollars at the January–June 1997 rate of 26 pesos per dollar.

non-migrant households. Remittances have a mean of 36,122 pesos (\$1,389) in migrant households and 1,888 pesos (\$73) in non-migrant households. Remittances amounted to 39 percent of household income for migrant households and 2 percent for non-migrant households.[9]

Average migrant household size is 6.2 members (including overseas members), whereas non-migrant household size is 5.2 members. Overall, 68 percent of migrant households are located in survey-defined urban areas, compared with 58 percent of non-migrant households.[10] Heads are more educated in migrant households than in non-migrant households: around in 30 percent of heads in migrant households have at least a college degree, compared with only 20 percent in non-migrant households. Fewer household heads worked in agriculture in 1997 in migrant households (23 percent) than in non-migrant households (38 percent). Heads in migrant households are also slightly older (mean age of 49.9) than heads of non-migrant households (46.7).

Identification Strategy

Overseas remittance responses to exogenous changes in household income from domestic sources are examined to determine whether households use remittances as insurance. The following identification strategy is used.

The remittance amount received by each household at time t is determined by household characteristics that are constant over time (such as completed education of household adults), time-variant household characteristics (such as household size), time effects common to all households (such as changes in remittance regulations or the nationwide economic situation), and time-varying household income from domestic sources. In addition, there may be time effects that vary systematically according to household characteristics, as when a nationwide economic shock has differential effects on better-educated and less-educated households. For household h at time t, the remittance equation is as follows:

$$R_{ht} = \alpha + \beta Y_{ht} + \theta' \mathbf{X}_{ht} + \delta' \mathbf{W}_h + \gamma_t + \chi_t' (T_t \mathbf{W}_h) + \varepsilon_{ht}, \tag{7}$$

where R_{ht} is the household remittance receipts from overseas, Y_{ht} the household income from domestic sources, $\mathbf{X}_{ht}$ a vector of time-variant household characteristics, $\mathbf{W}_h$ a vector of time-invariant characteristics, γ_t the time effect for period t, T_t a dummy variable for each time period, the T_t $\mathbf{W}_h$ term allows the time effect to vary systematically with household time-invariant characteristics, and $\varepsilon_{\mathrm{ht}}$ a mean-zero error term.

9. Remittance receipts of non-migrant households are not zero because households can receive remittances from non-household members (such as distant relatives or friends).

10. Although these may seem to be high urban percentages, the Philippine National Statistics Office appears to use a broad definition of an urban area, and many areas classified as "urban" are likely to be closely linked to adjacent agricultural areas.

The coefficient of interest is β, the coefficient on domestic income Y_{ht}. If remittances help insure households from losses of domestic income, this coefficient should be negative. Its magnitude represents the replacement rate of domestic income by remittances from overseas.

Although a rich variety of information is available on household characteristics that might be included in the vector $\mathbf{X}_{ht}$, serious problems remain with obtaining an unbiased estimate of β. First, there is reverse causation: domestic income can itself be a function of remittances, when remittances help fund household entrepreneurial investments. Alternately, households receiving insurance through remittances could exert less effort and thus earn lower incomes (Azam and Gubert 2005), leading to a negatively biased estimate of the effect of income on remittances. Such endogeneity concerns motivate this article's empirical strategy—the use of panel data and the use of rainfall shocks as instruments for income. In this context, the focus can be on the impact of exogenous changes in income on changes in remittances. There should therefore be no concern that the changes in income are endogenous with respect to remittance receipts due to moral hazard or other reasons.

Another concern is omitted-variable bias: unobservable household characteristics (say, the entrepreneurial spirit of household members) are likely to jointly determine domestic income and remittances. The identification strategy focuses on reducing bias generated from simultaneity and omitted variables.

With two observations for each household, first differences can be used to control for the influence of unobservable household characteristics. Rewriting equation (7) separately for each of the 2 years (1997 and 1998) yields:

$$
\begin{aligned}
R_{h97} = {} & \alpha + \beta Y_{h97} + \theta'\mathbf{X}_{h97} + \delta'\mathbf{W}_h + \gamma_{97} \\
& + \chi'_{97}(T_{97}\mathbf{W}_h) + \varepsilon_{h97}
\end{aligned}
\tag{8}
$$

$$
\begin{aligned}
R_{h98} = {} & \alpha + \beta Y_{h98} + \theta'\mathbf{X}_{h98} + \delta'\mathbf{W}_h + \gamma_{98} \\
& + \chi'_{98}(T_{98}\mathbf{W}_h) + \varepsilon_{h98}.
\end{aligned}
\tag{9}
$$

To eliminate the influence of unobservable household time-invariant characteristics, $\mathbf{W}_h$, first differences can be taken by subtracting equation (8) from equation (9), and rearranging to obtain:

$$
\begin{aligned}
\Delta R_{h98} = {} & (\gamma_{98} - \gamma_{97}) + \beta \Delta Y_{h98} + \theta' \Delta \mathbf{X}_{h98} \\
& + (\chi_{98} - \chi_{97})'\mathbf{W}_h + (\varepsilon_{h98} - \varepsilon_{h97}).
\end{aligned}
\tag{10}
$$

It still remains to deal with time-variant heterogeneity, $\Delta\mathbf{X}_{h98}$, and with reverse causation. To do so, the change in household domestic income, ΔY_{h98}, is instrumented by the change in rainfall over the study period. The change in rainfall should be a valid instrument, as it is likely to have an important effect on household income in a country such as the Philippines, where most households owe their livelihoods either directly or indirectly to agriculture. In addition, it is also plausible that rainfall affects remittances primarily through the change in household income (the instrumental variable exclusion restriction).[11] The sample is not limited to households in rural areas, since (as discussed earlier) the definition of an urban area used in the surveys is quite broad, and many households classified as urban (43 percent) do report non-zero agricultural income. Nor would it be desirable to limit the sample to households with agricultural income. Negative agricultural income shocks should reduce demand on the part of agricultural households for non-agricultural goods and services, so that negative rainfall shocks should also affect income in non-agricultural households.

The first stage regression is:

$$\begin{aligned}\Delta Y_{h98} = \pi_0 + \pi_1 \Delta RAIN\_DRY_{h98} \\ + \pi_2 \Delta RAIN\_WET_{h98} + \mu' \mathbf{W}_h + \omega_{h98},\end{aligned} \tag{11}$$

where ΔRAIN_DRY$_{h98}$ and ΔRAIN_WET$_{h98}$ are the changes in rainfall in the dry and wet seasons relevant for the change in income between 1997 and 1998, and ω_{h98} is a mean-zero error term. The inclusion of $\mathbf{W}_h$ in the regression allows for heterogeneity in the time trend from 1997 to 1998 across households depending on time-invariant characteristics.

The predicted change in income from equation (11), $\Delta \hat{Y}_{h98}$, can be substituted for ΔY_{h98} in equation (10), and various terms rewritten to obtain:

$$\Delta R_{h98} = \xi + \beta \Delta \hat{Y}_{h98} + \upsilon' \mathbf{W}_h + \eta_{h98}, \tag{12}$$

where ξ, a constant term, substitutes for the change in year effects, ν for the change in the vector of coefficients $(\chi_{98} - \chi_{97})$, and the new error term η_{h98} for the remaining terms from equation (10), $\varepsilon_{h98} - \varepsilon_{h97} + \theta' \Delta\ \mathbf{X}_{h98}$. (Now that the change in household income is instrumented by rainfall, it is plausible to assume that shocks to other household outcomes, $\Delta\ \mathbf{X}_{h98}$, are orthogonal to $\Delta \hat{Y}_{h98}$ and so can safely be included in the error term.)

Equation (12) is the estimating equation used in the regression analysis. The variables included in the vector of controls, $\mathbf{W}_h$, are a set of household characteristics in the first period (January–June 1997): an indicator for urban location; five indicators for the household head's highest level of education completed (elementary, some high school, high school, some college, and college or more; less than elementary omitted); six indicators for head's occupation (professional, clerical, service, production, other, not working; agricultural omitted); and log per capita household income.

11. Robustness checks, conducted later, examine and reject the existence of important alternative channels (other than household income) for rainfall's effects on remittances.

Regression Results

This section describes the impact of rainfall shocks on changes in household domestic income. It then presents the impact of changes in household domestic income (instrumented by rainfall shocks) on changes in household remittance receipts from overseas. It also looks at the impact of instrumented domestic income on total household expenditures and at the number of migrant members in the household.

Impact of Rainfall on Domestic Income (First-Stage Estimates)

Regression results from the first stage—predicting changes in domestic income using rainfall shocks, as in equation (11)—are presented for two specifications in table 2. The dependent variable in both regressions is the change in household income from domestic sources between the January–June 1997 and April–September 1998 reporting periods, divided by initial (January–June 1997) total household income. (For example, a change amounting to 10 percent of initial income is expressed as 0.1.[12]) The mean of the dependent variable is 0.03 for both migrant and non-migrant households, indicating that both types of households experienced increases in domestic-source income on average between the two time periods.

Spatial correlation in the outcome variables is likely to be a problem in this analysis, biasing ordinary least squares (OLS) standard error estimates downward (Moulton 1986). In particular, the concern is correlation among error terms of households associated with the same weather station, because the rainfall instrumental variables vary only at this level. So standard errors allow for an arbitrary variance–covariance structure within the coverage areas of 38 weather stations (standard errors are clustered by weather station coverage area).

The first column in table 2 presents the coefficient estimates where the rainfall shock variables are changes in rainfall in the dry and wet seasons. The coefficient on the dry season rainfall shock is positive and statistically significant at the 5% level. The coefficient on the wet season shock is negative but is not statistically significant. A decline of 500 mm of rainfall in the preceding dry season leads to a 3.3 percentage point decline in initial household domestic income. The *F*-statistic for the test of joint significance of the rainfall variables is 3.150, with a *P*-value of 0.054.

12. Dividing by pre-crisis household income achieves something similar to taking the log of an outcome: normalizing to take account of the fact that households in the sample have a wide range of income levels and allowing coefficient estimates to be interpreted as fractions of initial household income. We choose to normalize outcome variables in this way (rather than taking the log) because some second-stage outcome variables (in particular, remittances) often take on zero values. Results are robust to express the dependent variable as the level of income (in pesos) rather than as shares of initial income.

TABLE 2. Impact of Rainfall Shock on Domestic Income, 1997–98: OLS Estimates, First Stage of Instrumental Variable Regression

	Regression	
Variable	(1)	(2)
Dry season rainfall shock (thousands of millimeters)	0.065** (0.027)	0.198*** (0.054)
Square of dry season rainfall shock (thousands of millimeters)		0.065*** (0.018)
Wet season rainfall shock (thousands of millimeters)	−0.034 (0.028)	0.043 (0.066)
Square of wet season rainfall shock (thousands of millimeters)		0.059* (0.030)
Household head characteristics		
Highest education level (indicators)		
Elementary	0.030 (0.027)	0.023 (0.028)
Some high school	0.069** (0.034)	0.065* (0.034)
High school	0.100*** (0.025)	0.089*** (0.026)
Some college	0.189*** (0.036)	0.183*** (0.037)
College or more	0.381*** (0.047)	0.385*** (0.047)
Occupation (indicators)		
Professional job	0.195*** (0.037)	0.188*** (0.038)
Clerical job	0.151*** (0.033)	0.144*** (0.031)
Service job	0.115*** (0.027)	0.107*** (0.028)
Production job	0.039 (0.026)	0.032 (0.026)
Other job	0.254*** (0.029)	0.246*** (0.027)
Does not work	0.159* (0.080)	0.154** (0.074)
Household characteristics		
Log income per capita in household	−0.355*** (0.031)	−0.365*** (0.030)
Located in urban area	0.126*** (0.018)	0.115*** (0.017)
F-statistic: joint significance of rainfall shock variables	3.150	6.780
P-value	0.054	0.000
Number of observations	27,781	27,781
R^2	0.03	0.03

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Dependent variable: change in household domestic income as share of initial household income. Each column reports the results of a first-differenced regression. Numbers in parentheses are standard errors, clustered by rainfall station. Domestic income (January–June 1997/April–September 1998) is household total income excluding remittances from overseas expressed as a fraction of initial (January–June 1997) total household income. Rainfall shocks are changes in rainfall between first and second period. Omitted occupation indicator is agricultural job. Omitted education indicator is less than elementary. See table 1 for other variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

The effect of rainfall on household income may be non-linear, so column 2 of the table presents three results of a regression that also includes the square of the wet and dry season rainfall shocks. The dry season shock and its square are both now positive and statistically significantly. The wet season shock and its square are also both positive, but only the squared term is statistically significant. The four rainfall shock variables jointly appear to be quite strong as instrumental variables: the F-statistic for the test of the joint significance of the rainfall variables is 6.78, with a P-value of 0.000. In addition, the coefficients on the main effect and squared terms imply fairly substantial effects on income: a decline in dry season rainfall of 500 mm (roughly the standard deviation of the dry season change variable) leads to a 11.5 percentage point decline in household income.

Because of the relative strength of the instruments as specified in column 2, this regression is used to create the first-stage prediction of the change in household income, $\Delta\hat{Y}_{h98}$, in the instrumental variables analyses.

Instrumental Variables Estimates

The instrumental variables estimates are based on regression equation 12, using the regression results in column 2 of table 2 to generate the predicted income change. Instrumental variable standard errors are calculated using a bootstrap procedure that takes into account the variation induced by the generated regressor as well as geographic clustering of observations by rainfall station. OLS standard errors simply account for clustering of observations at the level of the rainfall station.

REMITTANCE RECEIPTS. Table 3 presents OLS and instrumental variable regression results where the outcome variable is the change in household remittance receipts from overseas between the January–June 1997 and April–September 1998 reporting periods, expressed as a share of initial (January–June 1997) household income. On average, both migrant and non-migrant households saw increases in remittances: the mean of the dependent variable was 0.07 for migrant households and 0.01 for non-migrant households.

For migrant households, the OLS estimate of the impact of the change in household domestic income on the change in remittances is negative and statistically significant at the 10 percent level, but is small in magnitude (-0.080). In contrast, the corresponding instrumental variable estimate is negative, large in magnitude, and statistically significant at the 1 percent level: 62.9 percent of income declines are replaced by new inflows of remittances to the household. That said, the standard error on the -0.629 instrumental variable point estimate is large enough that the null hypothesis of full insurance (that the coefficient is equal to negative one) cannot be rejected.

The OLS and instrumental variable estimates of the impact of changes in household domestic income on changes in remittances are dramatically different, highlighting the importance of the instrumental variable approach. A number of factors are likely to help explain this difference. First, measurement error in domestic household income will attenuate the OLS coefficient (particularly as this is a regression in first differences). Second, reverse causation may be at work. For example, increases in remittances may reflect

TABLE 3. Impact of Domestic Income Shock on Remittances, 1997–98: OLS and Instrumental Variable Estimates

Variable	Migrant households: Ordinary least squares	Migrant households: Instrumental variable	Non-migrant households: Ordinary least squares	Non-migrant households: Instrumental variable
Change in domestic household income as share of initial household income	−0.080* (0.042)	−0.629** (0.216)	−0.003 (0.002)	0.056** (0.022)
Household head characteristics				
Highest education level (indicators)				
Elementary	0.034 (0.048)	0.055 (0.046)	0.007** (0.003)	0.005** (0.002)
Some high school	0.045 (0.063)	0.079 (0.066)	0.003 (0.003)	−0.001(0.003)
High school	0.105** (0.048)	0.170*** (0.046)	0.013** (0.004)	0.007* (0.004)
Some college	0.159*** (0.046)	0.271*** (0.061)	0.019*** (0.007)	0.008 (0.008)
College or more	0.291*** (0.088)	0.514*** (0.130)	0.025*** (0.007)	0.003 (0.010)
Occupation (indicators)				
Professional job	0.003 (0.076)	0.115 (0.082)	0.006 (0.009)	−0.005 (0.010)
Clerical job	−0.064 (0.063)	0.018 (0.057)	0.008 (0.005)	−0.001 (0.004)
Service job	−0.003 (0.054)	0.053 (0.063)	−0.001 (0.005)	−0.007 (0.005)
Production job	−0.028 (0.061)	−0.003 (0.061)	0.006 (0.004)	0.004 (0.004)
Other job	0.018 (0.049)	0.155** (0.064)	0.010 (0.008)	−0.005 (0.008)
Does not work	0.538 (0.639)	0.632 (0.673)	−0.182* (0.103)	−0.192** (0.094)
Household characteristics				
Log income per capita in household	−0.282*** (0.028)	−0.490*** (0.075)	−0.014*** (0.003)	0.006 (0.007)
Located in urban area	0.068 (0.046)	0.148*** (0.051)	0.007** (0.003)	−0.001 (0.004)
Number of observations	1,655	1,655	26,126	26,126

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Dependent variable: change in household remittance receipts as share of initial household income. Each column reports results of a separate first-differenced regression. Instrumental variables for change in domestic household income are rainfall shocks in dry and wet seasons (first stage is column 2, table 2). Numbers in parentheses are standard errors. OLS standard errors are clustered by rainfall station; instrumental variable standard errors are bootstrapped. Migrant households are defined as those with an overseas worker in June 1997. See table 2 for other notes and table 1 for variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

increased investment in household entrepreneurial enterprises, leading to increased domestic income. This would lead the OLS coefficient to be biased in a positive direction. Finally, there may be omitted variables positively correlated with both the change in remittances and the change in income. For example, a need to accumulate resources for a large household purchase (such as a vehicle) or some other lump-sum payment (tuition, medical expenses) might lead to both increased remittances, increased domestic labor supply, and increased domestic income. Omitted variable stories such as these would also cause positive bias in the OLS coefficient compared with the instrumental variable.

The contrast with the results for the non-migrant households (the last two columns of table 3) is striking. The OLS coefficient is essentially zero, whereas the instrumental variable coefficient is positive (0.056). Although the instrumental variable coefficient is small, it is statistically significantly at the 5 percent level: exogenous increases in household income *raise* remittance receipts from overseas. Further analyses (described later) provide an explanation for this result.

How valuable is the insurance provided by remittances for Philippine households? One way to gage the welfare gain is to ask what fraction of income households would be willing to give up to reduce rainfall-driven income shocks, both positive and negative, by the amount indicated in column 2 of table 3 (62.9 percent). The actual distribution of rainfall shocks observed in the data is used to calculate predicted 1998 income due solely to this rainfall variation for all households in the data set (only dry season shocks are used because wet season shocks are not statistically significant in table 2). The distribution of predicted 1998 income shocks (relative to 1997 income) observed across households is then used to represent the underlying risk to be insured. The calculation assumes constant relative risk aversion utility, $U(c) = c^{1-\gamma}/(1-\gamma)$.[13] A household with a reasonable risk aversion parameter ($\gamma = 1.5$) should be willing to give up 0.24 percent of income to achieve income with this degree of smoothness. Although this number may seem small, it is large relative to the fraction of income such a household would be willing to give up to achieve complete smoothness, which is 0.28 percent under the same assumptions.[14]

HOUSEHOLD EXPENDITURES. If remittances serve as insurance for migrant households, changes in household expenditures should be relatively unresponsive to changes in household domestic income, because remittances respond so strongly (and in the opposite direction) to changes in household domestic

13. The theoretical section assumed constant absolute risk aversion utility for tractability of the empirical derivation, but constant relative risk aversion is typically thought to better characterize individual behavior under uncertainty.

14. In an analogous calculation, Lucas (1987) finds relatively small welfare gains from elimination of aggregate consumption risk in the United States.

income. It is also of interest to explore whether expenditures are smoother in migrant households than in non-migrant households in the face of domestic income shocks.

Table 4 presents the results from OLS and instrumental variable regressions where the outcome variable is the change in household expenditures between the January–June 1997 and April–September 1998 reporting periods, expressed as a share of initial (January–June 1997) household expenditures. The mean of the dependent variable is 0.00 for migrant households and −0.04 for non-migrant households (on average, expenditures are roughly stable or slightly declining between the periods). The regression specifications are otherwise the same as those reported in table 3.

The OLS results indicate that household domestic income is highly positively correlated with total expenditures for both migrant and non-migrant households. For example, for migrant households, a 10 percentage point increase in domestic household income is associated with a 5.0 percentage point increase in total expenditure; the magnitude of the OLS coefficient is similar for non-migrant households.

In the instrumental variable specification, however, the income coefficient for migrant households declines by roughly half (from 0.499 to 0.248) and also declines somewhat for non-migrant households (from 0.623 to 0.508). That the coefficient on the change in domestic income in the migrant regression declines substantially in the instrumental variable specification (and is not statistically significant) is consistent with remittances playing an important role in helping these households maintain their expenditure levels when they experience income shocks. That said, standard errors in the instrumental variable regressions are quite large (the equality of the OLS and instrumental variable coefficients cannot be rejected), so these results should be taken only as suggestive.

The relative decline in the coefficient on the change in domestic income is larger for migrant households than for non-migrant households, although again standard errors are too large to allow strong conclusions. This is most appropriately taken as merely suggestive evidence that migrant households are better able to smooth expenditures in the face of exogenous income shocks.

The comparison between migrant and non-migrant households should be taken as suggestive because households with and without migrants differ across many observed and unobserved characteristics. Differences in results between these two groups of households could be due to the presence or absence of migrants, but it could also be due to other differences such as variations in access to other risk-coping mechanisms (savings, credit, other types of informal and formal insurance).

Effect of Shock on Overseas Migration from the Household. Do exogenous income shocks driven by rainfall also affect whether a household has a member working overseas? Part of the insurance provided by migrants could

Table 4. Impact of Domestic Income Shock on Total Expenditure, 1997–98: OLS and Instrumental Variable Estimates

Variable	Migrant households: Ordinary least squares	Migrant households: Instrumental variable	Non-migrant households: Ordinary least squares	Non-migrant households: Instrumental variable
Change in domestic household income (as share of initial household income)	0.499*** (0.071)	0.248 (0.171)	0.623*** (0.087)	0.508*** (0.156)
Household head characteristics				
Highest education level (indicators)				
Elementary	−0.084* (0.046)	−0.111*** (0.043)	−0.008 (0.010)	−0.003 (0.021)
Some high school	−0.069 (0.054)	−0.070 (0.055)	−0.012 (0.013)	−0.004 (0.033)
High school	−0.019 (0.042)	−0.022 (0.064)	−0.026* (0.015)	−0.013 (0.027)
Some college	0.009 (0.047)	0.002 (0.062)	−0.041* (0.022)	−0.016 (0.046)
College or more	0.065 (0.054)	0.030 (0.097)	−0.146*** (0.052)	−0.090 (0.065)
Occupation (indicators)				
Professional job	−0.042 (0.058)	−0.052 (0.059)	−0.055** (0.024)	−0.028 (0.036)
Clerical job	0.004 (0.045)	−0.002 (0.050)	−0.033 (0.024)	−0.012 (0.032)
Service job	0.053 (0.057)	0.060 (0.063)	−0.038* (0.020)	−0.020 (0.026)
Production job	0.066 (0.061)	0.042 (0.067)	−0.020 (0.014)	−0.010 (0.018)
Other job	0.045 (0.048)	0.063 (0.064)	−0.020 (0.025)	0.008 (0.047)
Does not work	0.015 (0.150)	−0.076 (0.165)	−0.226* (0.083)	−0.144* (0.078)
Household characteristics				
Log income per capita in household	−0.113*** (0.026)	−0.110* (0.064)	0.069** (0.034)	0.019 (0.053)
Located in urban area	0.033 (0.034)	0.044 (0.037)	−0.012 (0.015)	0.006 (0.027)
Number of observations	1,655	1,655	26,126	26,126

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Dependent variable: change in household expenditure as share of initial household expenditures. Each column of table is a separate first-differenced regression. Instrumental variables for change in domestic household income are rainfall shocks in dry and wet seasons (see table 2 for first-stage regression). Numbers in parentheses are standard errors. OLS standard errors are clustered by rainfall station; instrumental variable standard errors are bootstrapped. See table 2 for other notes and table 1 for variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

take the form of delayed return and extended periods of high overseas earnings if their origin households experience negative income shocks.

This section shows whether income shocks affect whether a household has a member working overseas. The outcome variable is the change in an indicator for a household having an overseas worker between the July 1997 and October 1998 surveys. For migrant households, this indicator was equal to 1 in the first period and could equal 0 or 1 in the second period. The mean of the outcome variable is -0.38 for migrant households, meaning that in 38 percent of households with a migrant member in July 1997, all migrant members had returned by October 1998. For non-migrant households, this indicator was equal to 0 in the first period. The mean of the outcome variable for non-migrant households is 0.02, meaning that 2 percent of initially non-migrant households had become migrant households by the second period.

Table 5 presents the results from OLS and instrumental variables regressions. Specifications are the same as in tables 3 and 4. For migrant households, both the OLS and instrumental variable coefficients on the change in domestic income are negative, but neither is statistically significant at conventional levels. There is no indication for migrant households that remittance responses to income shocks are in part explained by migrants' changing their return decisions.

For non-migrant households, the OLS coefficient is close to zero and is not statistically significant. The instrumental variable coefficient is positive and statistically significant. The instrumental variable coefficient (0.075) indicates that a 10 percent increase in domestic income leads to a 0.75 percentage point increase of in the household's likelihood of having an overseas migrant. This is a large effect, given that the mean of the outcome variable among all initially non-migrant households is 2.0 percentage points.

This positive causal impact of income on overseas migration among initially non-migrant households helps explain the positive impact of income on remittances in these households (table 3, last column). This may reflect the fact that international migration requires fixed up-front costs (such as fees to recruitment agencies), so that households facing credit and savings constraints become more willing or able to pay the fixed costs when current income increases.

Robustness Checks

This section discusses the evidence against alternative channels to income for rainfall's effects and against an important potential confounding factor—exchange rate changes in migrants' overseas locations.

POTENTIAL VIOLATIONS OF EXCLUSION RESTRICTION. An important concern when instrumenting for changes in household income using rainfall variation is that rainfall shocks affect all households in a local area. Because of this, at least part of the effects found may be due to changes in locality-level economic

Table 5. Impact of Domestic Income Shock on Indicator for Overseas Worker in Household, 1997–98: OLS and Instrumental Variable Estimates

	Migrant households		Non-migrant households	
Variable	Ordinary least squares	Instrumental variable	Ordinary least squares	Instrumental variable
Change in domestic household income as share of initial household income	−0.031 (0.021)	−0.068 (0.178)	−0.001 (0.001)	0.075** (0.020)
Household head characteristics				
Highest education level (indicators)				
Elementary	0.048 (0.047)	0.051 (0.054)	0.002 (0.002)	−0.000 (0.002)
Some high school	0.079 (0.057)	0.082 (0.054)	0.006*** (0.003)	0.001 (0.004)
High school	0.037 (0.049)	0.043 (0.051)	0.006*** (0.003)	−0.002 (0.004)
Some college	0.066 (0.043)	0.076 (0.054)	0.013** (0.005)	−0.001 (0.006)
College or more	0.017 (0.066)	0.038 (0.100)	0.004 (0.007)	−0.024*** (0.011)
Occupation (indicators)				
Professional job	−0.112* (0.066)	−0.102 (0.065)	−0.006 (0.007)	−0.020** (0.006)
Clerical job	−0.170*** (0.061)	−0.163** (0.062)	−0.004 (0.004)	−0.015** (0.005)
Service job	−0.045 (0.070)	−0.040 (0.075)	−0.008** (0.003)	−0.017** (0.004)
Production job	−0.108* (0.059)	−0.104* (0.054)	−0.003 (0.003)	−0.006*** (0.003)
Other job	−0.037 (0.050)	−0.025 (0.062)	0.020** (0.004)	0.001 (0.006)
Does not work	−0.082 (0.225)	−0.070 (0.253)	0.236* (0.139)	0.224 (0.144)
Household characteristics				
Log income per capita in household	0.010 (0.023)	−0.008 (0.072)	0.014** (0.001)	0.040** (0.007)
Located in urban area	−0.013 (0.034)	−0.006 (0.044)	−0.001 (0.002)	−0.011** (0.003)
Number of observations	1,655	1,655	26,126	26,126

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Dependent variable: change in indicator for overseas worker in household. Each column is a separate first-differenced regression. Instrumental variables for change in domestic household income are rainfall shocks in dry and wet seasons (see table 2 for first-stage regression). Numbers in parentheses are standard errors. OLS standard errors are clustered by rainfall station; instrumental variable standard errors are bootstrapped. See table 2 for other notes and table 1 for variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

conditions (such as wage rates), rather than merely to changes in household income.[15] This would be a violation of the instrumental variable exclusion restriction, the assumption that the rainfall instruments affect household remittances only through their effect on household income.

This section tests for potential violations of the exclusion restriction. One way in which rainfall might affect remittances is through changes in the relative returns to various types of work, which could induce households to change their labor supply. This could be problematic if changes in household labor supply lead to changes in remittances independent of their effects on household income. For example, if adults in the household spend more time working, households may hire maids or nannies to provide child care, and remittances may rise to help pay for such help. Or households may invite older relatives to live with them and look after children, and remittances may rise to help support the larger number of household members. If such responses are empirically important, the instrumental variable regression estimates of the impact of the change in domestic income on the change in remittances will be biased in directions that cannot be predicted in advance.

To test whether such concerns have any basis, it is useful to test the stability of the instrumental variable regression coefficients to the inclusion of control variables for the change in various alternative channels. In particular, control variables are included for the change in total household hours worked and for the change in household size.[16] Any substantial change in the instrumental variable estimates when these control variables are included would cast doubt on the assumption that the effects of rainfall variability work primarily through changes in domestic income.

Table 6 presents the results of this exercise. The coefficient estimates for regressions where the outcome variable is the change in remittances are very similar to those in table 3. For example, the coefficient in the instrumental variable specification for migrant households is -0.569 in table 6 (and is statistically significant at the 1 percent level), compared with -0.629 in table 3. There appears to be little reason for concern that rainfall affects remittances through changes in household labor supply or household size independently of rainfall's effects on income. The results for the change in household expenditure (row 1) and for the change in the indicator for having an overseas migrant (row 3) are not substantially different from the previous results (tables 4 and 5). The same is true for non-migrant households.

An Omitted Variable Concern: Changes in Exchange Rates. Another general identification concern arises because 1997–98 was a time of substantial

15. Rosenzweig and Wolpin (2000) raise concerns from using weather events as instrumental variables.

16. Hours worked in the past week are reported for all household members above the age of 10. The change is from July 1997 to October 1998. The change in household size is over the same time period and includes overseas members.

TABLE 6. Impact of Domestic Income Shock on All Outcomes, 1997–98: Fixed Effect OLS and Instrumental Variable Estimates, Controlling for Change in Household Size and Labor Supply

	Migrant households		Non-migrant households	
Outcome	Ordinary least squares	Instrumental variable	Ordinary least squares	Instrumental variable
Total remittance	−0.084* (0.043)	−0.562** (0.204)	−0.003 (0.002)	0.063** (0.022)
Total expenditure	0.480*** (0.083)	0.305 (0.160)	0.621*** (0.090)	0.521** (0.160)
Overseas worker indicator	−0.030 (0.021)	−0.006 (0.172)	−0.001 (0.001)	0.079*** (0.018)
Number of observations	1,655	1,655	26,126	26,126

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Each cell presents coefficient estimate on change in domestic household income in a separate regression. Instrumental variables for change in domestic household income are rainfall shocks in dry and wet seasons (see table 2 for first-stage regression). Each regression includes control variables for the change in number of household members and the change in hours worked by household members between 1997 and 1998, as well as other control variables included in tables 3–5 (coefficients not shown). Numbers in parentheses are standard errors. OLS standard errors are clustered by rainfall station; instrumental variable standard errors are bootstrapped. See table 2 for other notes and table 1 for variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

economic fluctuation in the Philippines (and in other Asian countries) due to the Asian financial crisis. The Philippine economy experienced a decline in economic growth after the onset of the crisis in mid-1997. Annual real GDP contracted by 0.8 percent in 1998, following growth of 5.2 percent in 1997 and 5.8 percent in 1996 (World Bank 2004). The urban unemployment rate (unemployed as a share of total labor force) rose from 9.5 percent in 1999 to 10.8 percent in 1998, whereas the rural unemployment rate went from 5.2 percent to 6.9 percent (Philippine Yearbook 2001, table 15.1).

Of course, any effects of the domestic economic downturn common to all households are not an issue, because the regressions here use first-differenced variables, so that common economic shocks are captured in the constant term. In addition, the control variables for households' 1997 characteristics included in all regressions (education, occupation, income, and urban indicator) will help account for any differential effects of the 1997–98 crisis that differ across households by socioeconomic status.

However, there is another important dimension of heterogeneity that is particularly relevant for migrant households: fluctuations in the exchange rates faced by migrant members. The devaluation of the Thai baht in June 1997 set off a wave of speculative attacks on national currencies, primarily in East and Southeast Asia. Overseas Filipinos work in dozens of foreign countries, including many countries most affected by exchange rate shocks due to the 1997 Asian financial crisis, such as the Republic of Korea and Malaysia and, to a lesser extent, Taiwan, China, Singapore, and Japan.[17]

An omitted variable concern arises if the 1997–98 exchange rate shocks experienced by households in particular areas happen to be correlated with the rainfall shocks in the same areas over the same period. If, for example, areas with greater declines in dry season rainfall (and thus greater declines in income) also had exchange rate shocks that allowed migrants to send more remittances, then the negative relationship between income and remittances would be overstated.

To test whether such concerns are empirically important, the main regressions are repeated for migrant households with the change in the exchange rate (Philippine pesos per unit of foreign currency) experienced by the households' migrants included as a control variable (table 7). The change in the exchange rate is the average of the 12 months leading to October 1998 minus the average of the 12 months leading to June 1997, divided by the second number.[18] None of the coefficients is substantially different from the corresponding coefficients in tables 3–5. The exchange rate shocks experienced by household migrants appear to be orthogonal to the rainfall shocks experienced by their origin households. There is no evidence that omitted variables bias due to correlation between exchange rate and rainfall shocks is a cause for concern.

III. Conclusion

The incomes of households in developing countries are often highly exposed to environmental risk factors such as weather. At the same time, government-sponsored social insurance is generally poor or non-existent. How do households in poor countries shield themselves from environmental risk? This article documents empirically that some households are able to insure themselves without direct government involvement by sending members to work overseas. Their remittances serve as insurance in times of negative income shocks.

In households with overseas migrants, exogenous changes in income lead to changes in remittances of the opposite sign, consistent with an insurance motivation for remittances. In such households, the results show a replacement rate of household domestic income by remittances of roughly 60 percent. The null hypothesis of full insurance cannot be rejected. In contrast, changes in

17. Yang (2006b), examines the impact of these heterogeneous exchange rate shocks on return migration and on investment behavior in migrants' origin households.

18. For further discussion of the exchange rate shock measure, see Yang (forthcoming).

TABLE 7. Impact of Domestic Income Shock on All Outcomes, 1997–98: Fixed Effect OLS and Instrumental Variable Estimates, Controlling for Exchange Rate Shock, Migrant Households Only

	Migrant households	
Outcome	Ordinary least squares	Instrumental variable
Total remittance	−0.080* (0.042)	−0.639** (0.219)
Total expenditure	0.500*** (0.071)	0.256 (0.169)
Overseas worker indicator	−0.032 (0.021)	−0.107 (0.176)
Number of observations	1,655	1,655

*Significant at 10 percent level; **Significant at 5 percent level; ***Significant at 1 percent level.

Note: Each cell presents coefficient estimate on change in domestic household income in a separate regression. Instrumental variables for change in domestic household income are rainfall shocks in dry and wet seasons (see table 2 for first-stage regression). Each regression includes control variable for the exchange rate shock experienced by migrant members between 1997 and 1998, as well as other control variables included in tables 3–5 (coefficients not shown). Numbers in parentheses are standard errors. OLS standard errors are clustered by rainfall station; instrumental variable standard errors are bootstrapped. See table 2 for other notes and table 1 for variable definitions.

Source: Authors' analysis based on Philippine National Statistics Office surveys described in text.

household income have no effect on remittance receipts in households without overseas migrants.

A key question is whether remittance responses to income shocks depend on the performance or availability of alternative methods of coping with risk, such as asset sales, credit markets, and reciprocal transfer networks. In particular, the availability of other risk-coping mechanisms may depend on whether shocks are aggregate (shared by other households) or idiosyncratic (on average uncorrelated with other households).

By focusing on income shocks driven by local weather changes, this article assesses the role of remittances as insurance in the face of aggregate shocks to local areas. One reason for the finding of such large responses of remittances to rainfall-driven income shocks could be that such shared shocks make it more difficult to access credit or interhousehold assistance networks that normally help households cope with risk. For example, when a large fraction of households in a local area experiences a negative shock, the demand for credit may rise, pushing up local interest rates. Some substantial fraction of households needing loans may thus be priced out of the credit market. In addition, there may be difficulties in smoothing consumption through asset sales when there are aggregate shocks, because other households simultaneously seek to sell their assets, driving down prices.[19] If local risk-coping mechanisms break down under aggregate shocks, remittance inflows from migrant household members may be used more heavily as a smoothing device.

Whether remittances exhibit such large responses to income shocks when the shocks are idiosyncratic, or specific to given households, is therefore an important avenue for future research. An idiosyncratic shock to a given household, if truly uncorrelated on average with shocks experienced by other households, should have negligible effects on the quality of local risk-coping mechanisms, and so households should be better able to use such mechanisms than if the shock were aggregate. Remittances might not respond nearly as much to idiosyncratic shocks precisely because households should still have access to alternative local risk-pooling arrangements.

These results provide additional justification for government policies facilitating international migration and remittance flows. For migration-origin countries, greater opportunities for international migration and improvements in the ease of sending remittances should expand the extent to which remittances can serve as social insurance. Policies to ease international migration include provision of information and social services for migrants and their families left behind and oversight of recruitment agencies for overseas jobs. Policies to facilitate remittances include strengthening financial infrastructure and payment systems to lower the cost and broaden the reach of formal remittance channels. Migration destination countries also have numerous policy options, such as expanding immigration quotas and loosening restrictions on formal remittance flows to developing countries. To the extent that immigration policies in the rich world remain relatively restrictive, however, in most countries, remittances will be an important source of insurance for only a small minority of households. Thus, the results reported here do not support the wholesale dismantling of existing systems of social protection in migration origin countries, which will remain important for the majority of households.

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19. This point has been made by Rosenzweig and Wolpin (1993), Fafchamps, Udry, and Czukas (1998), and Lim and Townsend (1998).

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