途上国における貧困削減と制度・市場・政策
比較経済発展論の試み
Poverty Reduction, Institutions, Markets, and Policies in Developing Countries:
Toward a Theory of Comparative Economic Development

PRIMCED Discussion Paper Series, No. 59

Impact of Human Resource Development Training on Crop Damages by Wild Animals in Developing Countries: Experimental Evidence from Rural Pakistan

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August 2014

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Abstract: Based on a four-year panel dataset of households collected in rural Pakistan, we examine the impact of an intervention on households' capacity to reduce income losses due to attacks by wild boars. A local NGO implemented the intervention as a randomized controlled trial at the beginning of the second year. We find that the intervention was highly effective in eliminating the crop-income loss in the second year, but that effects disappeared in the third and fourth years. Our finding suggests the difficulty in technology transfer through the training or the high implicit cost incurred by the households in implementing the treatment. Therefore, the intervention was not sustainable at the household level. Nevertheless, due to spillover effects, the intervention could have been cost-effective at the project level.

Key words: wild animal attack, production risk, randomized controlled trial, cost-benefit analysis, Pakistan.
JEL codes: O13, O15, Q12.

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1. Introduction

Farmers around the world face various risks when they make a decision on agricultural production. In low-income developing countries, research has been undertaken on household vulnerability to weather-related shocks, such as floods and droughts (e.g., see Sawada 2007). As an intervention to cope with weather-related risks, there is now an expanding body of economics literature on weather index insurance (e.g., see Binswanger-Mkhize 2012).

In sharp contrast, farming risk stemming from wild animal attacks in developing countries has not been well analyzed in the literature by applied economists.[1] This does not imply that such risk is not important; on the contrary, owing to the increased frequency of human–wildlife confrontation, farmers face the ever-growing risk of such attacks on their crops and subsequent income losses, as natural scientists have pointed out since the 1980s (e.g., Else and Lee 1986; Naughton-Treves 1998). Wild boars (*Susscrofa*) are universally notorious among wild animals and inflict substantial damage to crops. According to Chauhan et al. (2009), crop damages because of wild boar attacks (WBAs) have been reported for decades by farmers in the Indian subcontinent. However, the existing literature on WBAs mostly comprises technical reports, while ignoring the monetary and welfare aspects of agrarian households that have succumbed to WBAs. Furthermore, there is no economic

[1] As an exceptional work in applied economics, Sutton et al. (2008) estimate the costs of living under the threat of wild animal attacks, using Namibian farmers' willingness to pay.

research on the impact of an intervention that is specifically designed to reduce or cope with WBAs.

To fill the research gap, this study first quantifies the extent to which agricultural households in a developing country are vulnerable to WBAs; it then examines the impact of an intervention to enhance households' capacity to mitigate income loss and provides the result of cost-benefit analysis paying due attention to potential spillovers. A salient feature of this study is that it cleanly identifies the impact of the intervention through a randomized controlled trial (RCT) and the use of a four-year panel dataset of households. The RCT intervention was implemented at the beginning of the second year of the panel survey by a local nongovernmental organization (NGO) in rural Pakistan, where randomization was designed at the household level. The main component of the intervention was in human resource development (HRD) training. In the third and fourth years of the panel data, no intervention was conducted. To the best of our knowledge, none of the existing studies cleanly identifies the impact of HRD interventions on losses due to WBAs. As a result, the findings of this study are expected to add a new dimension to the existing literature on household vulnerability to the risk of wild animal attacks.

In the remainder of this paper, Section 2 describes the study area and while Section 3 provides information on our RCT intervention to reduce WBAs. Section 4 proposes an empirical strategy to econometrically identify the impact of the intervention. Section 5 quantifies the incidence of WBAs among the sample households, as well as the impact of the intervention on crop-income loss. Section 6 provides results of cost-benefit analysis, both at the household and project levels, under different spillover scenarios. Section 7 concludes the paper.

2. Study Area and Data

Pakistan is a low-income country located in South Asia. Its economy is highly dependent on agriculture: in terms of value added, approximately 21% of GDP originates in agriculture; meanwhile, in terms of employment, approximately 44% of the labor force is absorbed by agriculture (Government of Pakistan 2014). Given this dependence on agriculture, wild animal attacks pose a potential risk to the national economy and the rural population alike.

We examine an RCT implemented by an NGO called Pakistani Hoslamand Khawateen Network (PHKN), based in Haripur District, Khyber Pakhtunkhwa Province, Pakistan.[2] During September–December 2010, we implemented a baseline census survey of all villages in Haripur and a baseline sample household survey in randomly-selected villages. The randomly-sampled households numbered 583 and included both member and nonmember households of PHKN (Khan et al. 2011). The population we intend to represent with the

[2] Pakistan is a federal state comprising four provinces, with the district as the basic unit of local administration under the province. Khyber Pakhtunkhwa is one of those four provinces, known as the North-West Frontier Province until April 2010.

household data is that of rural households living in Haripur District that are potential targets of PHKN (those households excluding the rich).

Observing news of widespread crop losses owing to WBAs and carefully reviewing the data contained in the baseline survey, PHKN decided to introduce a remedial action on the pilot base, called the Anti-WBA Program (AWBAP). After AWBAP was conducted successfully as an RCT in February–March 2011, we resurveyed the same sample households in November–December 2011. The third-round survey was conducted a year after, i.e., in November–December 2012 and the fourth-round survey was conducted in December 2013. We thus have obtained a four year panel dataset of 583 households, containing detailed information of household roster, income sources, assets, consumption, farming and other shocks, coping methods, etc.

The information on wild boar attacks was collected from household respondents based on recalls. As people in the village are aware of even minute information regarding other households' farming, it was highly difficult for the household respondents to strategically misreport the damage. Furthermore, we cross-checked the reported damage with professional assessment by those who provided the HRD training. As a result, we were able to collect precise information on the crop-income loss suffered by the sample households.

To compare monetary variables measured in Pakistan rupees (PKR) across four rounds of surveys in real terms, we deflated these variables from the second to fourth surveys, using the official statistics of consumer price indices for the whole of Pakistan (Government of Pakistan 2014).[3] One US$ was equivalent to PKR 91 during the baseline survey. This is the dataset we analyze in this paper.

3. Experimental Design

As the funding was not sufficient to treat all households who reported crop losses due to WBAs, PHKN employed an RCT to ensure equal treatment ex ante. According to the household baseline survey, 197 of the 583 households had reported WBAs (henceforth referred to as “eligible households”). No attrition occurred among the 197 eligible households during the second to fourth surveys. PHKN selected 55 of the eligible households, using a random luck draw. We refer to these 55 households below as the “treatment households”; we call the remaining 142 eligible households not given treatment “control households.”

The 55 treatment households are distributed as follows: 48 member households, 3 nonmember households in villages with PHKN’s organizations, and 4 nonmember households in villages without. In typical situations, NGOs like PHKN do not allow nonmembers to be treated with any intervention. In the case of the AWBAP, however, nonmembers were also included but with a lower rate of being selected through the luck draw, owing to PHKN policies and donor restrictions.

[3] This is unsatisfactory, because the official inflation figures in Pakistan do not provide regional estimates and are notoriously underestimated. The use of more precise and disaggregated inflation rates is left for future research.

As the randomization was implemented at the household level, the number of treatment households in a village differed. Across villages, the eligible households spread over 30 villages—of which, 19 villages had at least one treatment household. Among the 19 villages with treatment households, the number of such households in the village is distributed as follows: 1 household in 8 villages; 2 households in 4 villages; 3 households in 3 villages; and 3, 6, 8, and 12 households in one village each. Village-level variation with respect to the number of treatment households will be utilized in our empirical analysis to examine the within-village spillover effects of the AWBAP. Household-level variation with respect to PHKN membership will be utilized to examine the possibly differential impact of member status.

The selected households were contacted in a telephone call about their participation in HRD training under the AWBAP. However, the theme and details of the program were not disclosed to participants until they actually attended the training sessions. The main objective of this program was to prevent WBAs and subsequent crop-income losses through HRD training focused on the awareness and prevention of WBAs. The prevention component of the program imparts information on basic techniques for scaring or trapping animals and for curtailing boar-population growth.[4] Under the program, some basic equipment and animal drugs were also provided free of charge to the treated households, upon the successful

[4] Drugs are used in the long term to control the boar population. It is claimed that female boars lose their fertility after consuming the drugs.

completion of training. The average direct cost of AWBAP treatment per household was around PKR 6,000, of which about one-third is the recurrent cost of equipment and drugs. In other words, participants were given neither income transfers nor credit. All selected households completed all training sessions, which lasted for two weeks. Hence, the AWBAP has zero noncompliance, which implies that the intent to treat impact equals the treatment on the treated impact.

We carefully compared the baseline characteristics of treatment and control households (Table 1). The comparison shows that in most cases, the difference between the means of the two sets of households is statistically insignificant. Especially when we look at variables corresponding to housing conditions, demographics, household asset indicators, cash inflows and outflows, and income loss due to WBAs, the difference is both small in terms of magnitude and statistically insignificant. Therefore, we can safely claim that the randomization process resulted in two almost similar sets of households, and that there is no systematic observable difference between them. Any difference observed in any of variables between the benchmark and later surveys can be safely attributed to the impact of the AWBAP.

One concern in Table 1 is that all five consumption measures have higher average values among control households than among treated households. The difference was statistically significant at the 5% level for food consumption and in-kind food consumption.

As we implemented the randomization strictly, we assess this finding as a chance occurrence. To be safe, we control the imbalance in benchmark observations by using a double difference, rather than a single difference, as our main empirical specification (see below).

On the other hand, although not important to the internal validity of our RCT, eligible households were not similar to noneligible households (Khan 2013). For example, eligible households' land holdings were five times larger than were those of noneligible ones; these households had an unpaid consumption level that was twice that of noneligible households and had slightly larger family sizes than did noneligible households. As expected, the set of eligible households comprises farm households only, while the whole sample includes a large number of nonfarm and/or landless households. This implies that the internal validity of our RCT applies only to the subset of eligible households, and not to the whole sample of households in our dataset. In other words, the population we intend to represent through the AWBAP impact analysis comprises agricultural households living in Haripur District that are not affluent and are (potentially) susceptible to WBAs.

4. Empirical Strategy to Identify the Household-level Impact

We first plot the distribution of crop-income loss due to WBAs differentiated by the survey year and treatment status. This allows us to undertake a graphical investigation of the AWBAP impact.

As the graphical perusal may have limited power in determining differentiated change, we turn to microeconometrics.[5] For econometric analyses, we use the subsample of eligible households, because noneligible and eligible households are systematically different, while control and treatment households within the subset of eligible households are highly comparable. The basic model is specified as:

$$Y_{it} = b_i + b_{10}T_{2011} + b_{11}T_{2011}\times X_i + b_{20}T_{2012} + b_{21}T_{2012}\times X_i + b_{30}T_{2013} + b_{31}T_{2013}\times X_i + u_{it}, \qquad (1)$$

where Y_{it} is the crop-income loss due to WBAs for household i in period t; b_i is the household fixed effect; T_t is a dummy variable for the survey in round t; X_i is a dummy variable that represents the AWBAP treatment; and u_{it} is a zero-mean error term. Three coefficients on the interaction terms, b_{11}, b_{21}, and b_{31} are the double difference (difference-in-difference, or DID) estimators for the treatment impact at the household level. If the AWBAP in early 2011 resulted in lower crop-income loss in year 2011 (2012 or 2013) than in 2010, the coefficient b_{11} (b_{21} or b_{31}) should be negative and significant. We employ DID as the main specification because it allows for potential nonrandomized elements conditional on household fixed factors.

Three coefficients on time dummies (b_{10}, b_{20}, and b_{30}) in equation (1) reflect

[5] As the household data were collected using villages as the primary sampling unit (Khan et al. 2011), we use in all regressions robust standard errors clustered at the village level.

unobservable aggregate factors that affect the crop-income loss for nontreated households. The unobservable factors reflect spillover effects from treatment households as well. To sharply identify whether the intervention had a spillover effect on neighbors who were not treated directly, the basic specification is extended to distinguish control households living in villages where some households had been treated with the AWBAP from control households living in villages where no household had been treated with the AWBAP. Using the latter as the reference category, the basic model is extended as:

$$Y_{it}= b_i + b_{10}T_{2011} + b_{11}T_{2011}\times X_i+ b_{12}T_{2011}\times X^{v}_{i}$$

$$+ b_{20}T_{2012} + b_{21}T_{2012}\times X_i+ b_{22}T_{2012}\times X^{v}_{i} + b_{30}T_{2013}+ b_{31}T_{2013}\times X_i+ b_{32}T_{2013}\times X^{v}_{i}+ u_{it}, \qquad (2)$$

where X^{v}_{i} is the dummy variable for a control household that lived in a village where there was at least one treatment household.

Theoretically, the within-village spillover effect, which can be captured by b_{12}, b_{22}, and b_{33}, could be positive or negative. If control households living in a village with treatment households learn from those treatment households (social learning) or if wild boars avoid a village where some households are implementing the AWBAP treatment (positive externality), a positive spillover effect is expected. On the other hand, if wild boars change their target plots within a village—thus going from attacking plots protected by the AWBAP treatment to unprotected plots (negative externality)—a negative spillover effect on income and consumption is expected.

In equation (2), three coefficients on time dummies (b_{10}, b_{20}, and b_{30}) now capture any unobservable factors common across villages. The unobservable factors include between-village spillover effects from villages where some households were treated to other villages. The between-village spillover effects may be positive or negative, depending on the geographic space of wild boars' habitat.

Equation (1) can be extended in other directions as well, allowing for a heterogeneous impact among treatment households. Let D_i be the dummy variable for the subcategory of treatment households. Then we estimate:

$$Y_{it} = b_i + b_{10}T_{2011} + b_{11}T_{2011}\times X_i + b'_{11}T_{2011}\times X_i\times D_i$$

$$+ b_{20}T_{2012} + b_{21}T_{2012}\times X_i + b'_{21}T_{2012}\times X_i\times D_i + b_{30}T_{2013} + b_{31}T_{2013}\times X_i + b'_{31}T_{2013}\times X_i\times D_i + u_{it}. \quad (3)$$

We will attempt to distinguish treatment households in terms of PHKN membership status (D_i = 1 if the treatment household is a nonmember of PHKN)[6] and 2010 flood damage (D_i = 1 if the treatment household was severely hit by the 2010 floods).[7] If the null hypothesis

[6] Possibly, the intervention could be more effective among treatment households that were also members of PHKN, since such households are more familiar with the intervening agency. As explained already, of 55 treatment households, 7 were nonmember households.

[7] Possibly, the intervention did not lead to an increase in welfare among treatment households that had also been hit by the 2010 floods. Of 55 treatment households, 26 had suffered from damage due to the 2010 floods.

that $b'_{11} = b'_{21} = b'_{31} = 0$ is not rejected, equation (3) is reduced to equation (1).

5. Estimation Results

Table 2 summarizes crop-income loss due to WBAs, for three types of sample households; Figure 1 shows their distribution graphically. Before the intervention, 197 of the 583 sample households suffered income losses in 2010 due to WBAs (the incidence rate at the household level was 34%). The average WBA crop-income loss in 2010 among treatment households was approximately PKR 7,300, while that among control households was PKR 8,200. Because of randomization, the difference was statistically insignificant. The average loss upon combining the two categories was PKR 7,900.

How large an amount is PKR 7,900? To put this figure into perspective, the average annual consumption expenditure among eligible households was PKR 264,000, and the average food component from the field (in-kind part) was PKR 40,300. Therefore, the income loss due to WBAs was approximately 3% of the total consumption and 20% of the self-produced food consumption. This is not a negligible amount.

Following the AWBAP treatment, the treatment households reported no income loss due to WBAs in 2011. On the other hand, control households suffered again from WBAs, with an incidence rate of 83% and an average income loss of PKR 4,370 (in 2010 prices, to ensure comparison in real terms). Since attacks by wild animals are stochastic, 17% of noneligible households suffered from WBAs in 2011. Therefore, the AWBAP was highly effective in eliminating crop-income loss due to WBAs in 2011.

Without further attempt at AWBAP interventions by PHKN, the AWBAP impact on the crop-income loss was not sustained. As Table 2 shows, 55% (60%) of treatment households again suffered income loss in 2012 (2013) due to WBAs. Their average income loss was PKR 3,170 in 2012 and PKR 2,180 in 2013, both of which were lower than the income loss in 2010. On the other hand, 73% (70%) of control households and 5.6% (9.7%) of noneligible households suffered from crop-income loss in 2012 (2013). The average income loss among the former was PKR 5,080 in 2012 and PKR 2,870 in 2013, both of which were lower than that in 2010 but the trend is very similar to the one experienced by the treatment households.

To cleanly show the impact of the AWBAP on crop-income loss, equation (1) is estimated (see column 1, Table 3). The DID impact in 2011 (coefficient on "Follow-up*Treatment") is substantial, and statistically significant at the 1% level. The treatment households were able to reduce the loss by PKR 3,473. As there was no crop-income loss among treatment households in 2011 (i.e., no statistical variation), the DID impact is likely to be an underestimate. This is because the crop-income loss cannot be negative. We will further interpret the impact estimates in Table 3 in the cost-benefit analysis section.

On the other hand, column 1, Table 3 shows that the DID impact in 2012 (coefficient on “3rd round*Treatment”) and the impact in 2013 (coefficient on “4th round*Treatment”) were no longer significant. In 2012, although its point estimate shows that each treatment household’s income loss was PKR 1,000 smaller than that of control households, this difference is statistically insignificant. In 2013, the point estimate is with the sign opposite to the expectation (statistically insignificant).

These findings seem to suggest that treatment households did not implement the AWBAP measures strictly during 2012 and 2013, in the absence of PHKN interventions. In other words, one-shot HRD training to reduce WBAs was not permanently effective. One of the reasons for this failure among treatment households could be the difficulty in obtaining the necessary drugs. However, since the nominal cost of the drugs is small, this reason is not likely to be important. Another reason could be that either there existed a nonnegligible implicit cost of implementing the AWBAP treatment, or that treatment households were not able to master the treatment technique to the extent that they could implement it without the help of PHKN. Regarding the hidden and implicit costs, we can list the opportunity cost of labor and effort in following the AWBAP directions, which could have resulted in lower wage income; the material and drug costs, whose shadow prices could be much higher than their market prices, if households are credit-constrained; the social cost of participating in human resource training organized by a women-led NGO within a male-dominated society, and the like.

Another interesting feature of column 1, Table 3 is that the coefficients on the time dummies (b_{10}, b_{20}, and b_{30}) are highly negative and statistically significant. In other words, the whole set of eligible households, regardless of their treatment status, suffered less from WBAs in 2011–2013 than in 2010. This could be due to the positive externality (spillover) of the treatment on wild boars—that is, the animals avoided the whole area because some of the villages there had been implementing the AWBAP treatments in early 2011. At the same time, a part of the negative coefficient in 2011 could be explained by the stochastic nature of wild boar behavior. As the eligible households were defined as those that had suffered from WBAs in 2010, it is possible that their loss would have been smaller without any intervention in 2011, if the animals tended to choose plots for attack in a stochastic manner.

To further examine the nature of spillover, within-village spillover effects are identified through estimating equation (2). Column 2, Table 3 shows the regression results, allowing for control households living closer to treatment households to be affected by the treatment. Coefficient estimates for b_{12}, b_{22}, and b_{32} are positive, indicating that control households tended to suffer more from WBAs if they lived in a village where other households were treated than if they lived in a village without any AWBAP treatment. This suggests negative externality within the village (i.e., the animals stop targeting plots owned by treatment households and turn to plots owned by control households), and that both positive externality and social learning were weak. However, the three coefficients have large standard errors so that the null hypothesis that $b_{12} = b_{22} = b_{32} = 0$ is not rejected (see the last row of Table 3).

Regarding potential heterogeneity among treatment households (columns 3 and 4, Table 3), the additional coefficients are small and statistically insignificant. The null hypothesis that $b'_{11} = b'_{21} = b'_{31} = 0$ is not at all rejected (see the last row of Table 3). Therefore, the AWBAP impact on crop-income loss reduction is homogenous, there being no difference regardless of the treatment household's PHKN membership or the extent of 2010 flood damage.

The results reported in Table 3 are robust to other alterations.[8] For instance, we attempted to use the dummy variable for crop loss instead of the income loss amount in PKR as the dependent variable; we also tried replacing X_{vi} in equation (2) with the number of treatment households in the village that had interacted with the control household dummy, and we tried other definitions of D_i in equation (3). The results were qualitatively similar to those reported in Table 3. Therefore, we regard column 1, Table 3 as our best estimate for the AWBAP impact. We conclude that the positive AWBAP impact at the household level occurred only in 2011 as a one-shot impact (or an impact dying very quickly), and that there was no significant spillover effect within a village, as far as crop-income losses due to WBAs are concerned.

[8] The robustness check results are available upon request from the authors.

6. Cost-Benefit Analysis

Based on the estimates in column 1, Table 3, we implement a cost-benefit analysis for the AWBAP assuming a four-year project period in Table 4. We designate as the baseline timing (t = 0) the timing when the AWBAP training was implemented and costs were paid. The crop-income loss reductions realized in years 2011–2013 are discounted by the annual real interest rate of 5% to make them in constant values evaluated at the baseline timing. As the actual months between the AWBAP training and the harvest in 2011 were around nine to ten months, slightly shorter than a full year, this is for simplicity purpose. Using a 10-month period between the baseline timing and the harvest in 2011 did not change the cost-benefit analysis results qualitatively; similarly, marginally changing the real interest rate for discounting did not change the results qualitatively.[9]

The cost-benefit analysis is conducted at the household level and at the project level. The household-level analysis attempts to assess whether the project was worth participating from individual point of view. This analysis is per-household basis and shows the average picture for the 55 treatment households. The project-level analysis attempts to assess whether the project was beneficial for the whole area from the point of view of the donor. This analysis shows the total costs and benefits for the whole panel of 569 households shown in Table 2 (55 treatment, 142 control, and 372 noneligible households).

[9] The alternative results are available upon request from the authors.

We calculate costs and benefits under four scenarios: [two scenarios for the benefits] times [two scenarios for the costs]. Regarding the benefits, our more conservative estimate is that the AWBAP reduced the crop-income loss by PKR 3,473 in 2011 among treatment households only; as all other DID impact was statistically insignificant, we treat them as zero impact; as the coefficients on time dummies (b_{10}, b_{20}, and b_{30}) may capture any unobservable factors, we assume zero positive spillover between villages. On the other hand, our less conservative estimate for the benefits assumes that a half of coefficients on time dummies was due to positive spillover of the project. This implies that the per-household benefit for the treatment households is PKR 3,473+ PKR3,787/2 in 2011, PKR 3,081/2 in 2012, and PKR 5,287/2 in 2013; the per-household benefit for the control households is PKR 3,787/2 in 2011, PKR 3,081/2 in 2012, and PKR 5,287/2 in 2013. The less conservative estimate for the benefits accounts for the cost among the noneligible households as well: a half of the crop-income loss suffered by these households shown in Table 2 is included as the reduced benefit (the increase in crop-income loss) due to the negative spillover from the project.

Regarding the costs, we simulate two scenarios corresponding to the two reasons for non-sustainability, discussed in the previous section: inability to master the technique (no implicit cost for the treatment households to implement the treatment), and substantial implicit costs (such as effort). Under the substantial implicit costs, we adopt the cost estimate at PKR 7,680, which corresponds to approximately 24 days of unskilled wage prevalent in the study area in 2011. The 24 days cover the two weeks spent on HRD trainings and the average working days in the field to conduct AWBAP treatment after the trainings. Although PHKN paid the training costs to hire the specialists as well as recurrent cost for the treatment, we attribute the recurrent cost to the cost paid by the treatment households in the cost-benefit analysis. In other words, the cost-benefit analysis assumes that PHKN gave transfers to enable treatment households to purchase the recurrent materials.

The simulation results are reported in Table 4. By construction, Scenario 2 is the least favorable to the project (low estimate for the reduction of crop-income loss and substantial implicit cost for implementing the treatment) while Scenario 3 is the most favorable to the project (high estimate for the benefit and no implicit cost for implementation). Scenarios 1 and 4 lie in between these two extreme scenarios.

At the household level, the project brought treatment households a positive benefit only under the assumption of no implicit cost of implementing the treatment. If the only benefit is the DID impact in 2011, the benefit cost ratio is 1.65 and IRR is 73.5% (Scenario 1). Both indicators become unreasonably large if the spillover effect is added (Scenario 3). It was not worth participating in the project for the treatment households if substantial implicit cost of implementing the treatment is assumed (Scenarios 2 and 4).

At the project level, as shown in the lower half of Table 4, there are three types of costs for the AWBAP: recurrent costs (such as drugs), implicit cost for implementing the treatment, and PHKN's training costs. The benefit now includes those attributable to nontreated households (due to the spillover effects).

In sharp contrast to the individual-level cost-benefit analysis, the project brought the whole area a positive benefit even under the assumption of substantial implicit cost of implementing the treatment. Under Scenario 4, the benefit cost ratio is now 1.27 and IRR is 18.3%. The three types of costs are now compared with small gross benefit to the treatment households, moderate benefit to the control households (positive spillover), and a marginally-negative benefit to the noneligible households (negative spillover). The second effect is large enough in our case so that the project was worthwhile even under Scenario 4 with substantial implicit cost. In other words, the cost-benefit analysis indicates the possibility that the AWBAP treatment was beneficial for the whole area if positive spillover effects on animals that fell on nontreated households were taken into account, even when the intervention may not have been beneficial for the treatment households' viewpoint.

7. Conclusion

In this paper, we examined household vulnerability to wild animal attacks—an unexplored source of production risk to agricultural households in developing countries—and the impact of an HRD intervention to reduce their damage on crops. Based on a four-year panel dataset of households collected in rural Pakistan, we first quantified the extent to which farmers were vulnerable to attacks by wild boars prior to the intervention. We found that the attacks affected the crop income of 34% of the sample households, with the average extent of damage equivalent to approximately 3% of the total annual consumption and 20% of the self-produced food consumption.

We then examined the impact of an RCT to enhance the households' capacity to reduce income loss. The RCT intervention was implemented in the early months of the second year. Based on the difference-in-difference identification strategy, we found that the intervention was highly effective in eliminating the crop-income loss of treated households in the second year, but that the effect on these households was not discernible in the third and fourth years. In other words, the intervention was not sustainable at the treatment household level. The finding from the last two years could be due to the high implicit cost for households to implement the treatment, in the sense that there existed a nonnegligible implicit cost of treatment implementation (such as effort), or the treatment households were unable to master the treatment technique to the extent that they could implement it without agency assistance. At the same time, the regression results suggested a possibility of positive spillover across villages, as the crop-income loss due to wild boar attacks was reduced in all villages in all three years after the intervention.

The cost-benefit analysis under different cost and benefit assumptions showed that if the disappearance of the household-level treatment impact was due to the substantial implicit cost, the intervention was not beneficial to the treatment households at the individual level. The cost-benefit analysis also showed that at the project level, the intervention could have been beneficial to the whole area even with the substantial implicit cost, if the positive spillover effects (i.e., the crop-income loss incurred by nontreated households declined after the intervention) were taken into account.

An important lesson from the findings of this paper is that an RCT methodology is a powerful tool in evaluating the impact of HRD training on reducing the crop loss due to wild animal attacks. Our case clearly shows that the one-shot HRD training in this particular case was not sustainable without further assistance, although its running cost was much smaller than the crop income loss before the intervention. Therefore, in designing HRD training interventions in developing countries, due attention should be paid to implicit and hidden costs of implementing the new technique and to potential difficulty of mastering the technique. As these are speculative interpretations, more empirical research needs to be accumulated on whether and under what conditions an HRD training intervention is effective and sustainable in reducing crop damages by wild animals. Regarding the between-village spillover effects, the interpretation given in this paper is speculative. It needs to be supported by evidence from animal science research regarding the spatial behavior of wild boars when they are faced with anti-boar treatments in a field they tried to attack. These are left for further study.

References

Binswanger-Mkhize, H. P. 2012. Is There Too Much Hype about Index-based Agricultural Insurance? *Journal of Development Studies* 48: 187–200.

Chauhan, N. P. S., K. S. Barwal, and D. Kumar. 2009. Human–Wild Pig Conflict in Selected States in India and Mitigation Strategies. *Acta Silvatica & Lignaria Hungarica* 5: 189–197.

Else, J. G. and P. C. Lee. 1986. Primate Human Conflict. In *Primate Ecology and Conservation*, , ed. J. G. Else and P. C. Lee, 213-214.Cambridge, UK: Cambridge University Press.

Government of Pakistan. 2014. *Pakistan Economic Survey 2013-14*. Islamabad: Government of Pakistan, Ministry of Finance, Economic Advisor's Wing.

Khan, H. U. 2013. Economic Analysis of Community-based Development Interventions in Rural Pakistan. Unpublished Ph.D. dissertation, Hitotsubashi University.

Khan, H. U., K. Miura, and T. Kurosaki. 2011. The Effectiveness of Community-based Development in Poverty Reduction: A Descriptive Analysis of a Women-Managed NGO in Rural Pakistan. PRIMCED Discussion Paper No.13, Hitotsubashi University.

Naughton-Treves, L. 1998. Predicting Patterns of Crop Damage by Wildlife around Kibale National Park, Uganda. *Conservation Biology* 12: 156–168.

Sawada, Y. 2007. The Impact of Natural and Manmade Disasters on Household Welfare. *Agricultural Economics* 37(s1): 59–73.

Sutton, W. R., D. M. Larson, and L. S. Jarvis. 2008. Assessing the Costs of Living with Wildlife in Developing Countries Using Willingness to Pay. *Environment and Development Economics* 13: 475–495.

Table 1. Balance check

Variable		Mean for each group: Control Household (*n*=142)	Mean for each group: Treatment Household (*n*=55)	Mean difference (standard error): Control-Treatment	
Housing conditions					
h_floor	house floor is paved (dummy)	0.11	0.05	0.06	(0.04)
h_cond	house is made of bricks (dummy)	0.52	0.45	0.07	(0.08)
h_boundry	house boundry dummy	0.89	0.87	0.01	(0.05)
room_no	number of rooms in house	3.27	3.07	0.19	(0.21)
toilet	toilet exists in house (dummy)	0.89	0.87	0.02	(0.05)
drainage	drainage availability in house (dummy)	0.42	0.36	0.05	(0.08)
Household demography					
hhsize	household size	6.95	6.38	0.57	(0.43)
fem_rate	female/male ratio	1.03	1.22	-0.19	(0.14)
hh_age	household head's age	50.97	49.22	1.75	(1.98)
hh_lite	household head' literacy dummy	0.80	0.71	0.09	(0.07)
hh_edu	household head's years of education	6.69	5.91	0.78	(0.71)
Household asset indicators					
cellphone	cellphone ownership (dummy)	0.95	0.89	0.06	(0.05)
area_hh	area of house (in Marlas)	11.08	10.89	0.19	(1.09)
tot_area_ol	total landholding (area in Kanals)	14.83	11.09	3.74	(2.17)
Household cash flow					
fulltime_no	number of fulltime employed members	1.56	1.60	-0.04	(0.15)
zu_out	zakat payment (dummy)	0.15	0.15	0.00	(0.06)
remittance	receipt of remittance (PKR 1,000)	83.27	47.31	35.96	(24.75)
Household consumption					
tot_exp	total expenditures (PKR 1,000)	272.23	241.15	31.07	(23.35)
exp_pc	per-capita expenditure (PKR 1,000)	40.61	39.72	0.89	(2.78)
exp_food	food expenditures (PKR 1,000)	190.20	163.75	26.45**	(11.09)
exp_nonfd	nonfood expenditures (PKR 1,000)	82.03	77.41	4.62	(4.62)
exp_kindfd	in-kind food expenditures imputed using village prices (PKR 1,000)	44.34	29.72	14.62***	(4.49)
Crop-income loss due to wild boar attacks					
estloss_wba	income loss due to WBAs (PKR1000)	8.16	7.26	0.90	(1.00)

Source: Prepared by the author (same as the following tables and figure).
Notes: All statistics are taken from the 2010 baseline survey data. The standard errors are reported in parentheses, estimated under the assumption that allows the unequal variance of two groups. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2. Crop-income loss by eligibility and treatment status

Survey year	Treatment households (*n*=55)	Control households (*n*=142)	Non-eligible households (*n*=372)
(A) Crop-income loss due to wild boar attacks			
2010	7.26	8.16	0.00
	(5.94)	(7.21)	(0.00)
2011	0.00	4.37	1.18
	(0.00)	(5.90)	(5.46)
2012	3.17	5.08	0.28
	(6.05)	(8.78)	(1.44)
2013	2.18	2.87	0.35
	(2.40)	(3.17)	(1.28)
(B) Crop-income loss (percentage of households attacked by wild boars)			
2010	100.0	100.0	0.0
2011	0.0	83.1	16.7
2012	54.5	72.5	5.6
2013	60.0	70.4	9.7

Notes: Figures in parentheses are standard deviations. All monetary variables are in PKR 1,000 in 2010 prices. We report summary statistics for non-eligible households that were surveyed continuously for all four survey rounds without changes in their membership status. Therefore, the number of observations (*n*) is 372.

Table 3. Impact of the AWBAP on crop-income loss

	Dependent variable: Crop-income loss (PKR 1,000 in 2010 prices)			
Explanatory variables:	(1) Basic spec.	(2) Other = Control*Village_level_treatment	(3) Other = Treatment*Non_member_dummy	(4) Other = Treatment*Flood_damage_dummy
Follow-up	-3.787***	-5.179**	-3.787***	-3.787***
	[0.847]	[2.364]	[0.849]	[0.849]
Follow-up*Treatment	-3.473***	-2.081	-3.573***	-3.688***
	[1.096]	[2.510]	[1.087]	[1.313]
Follow-up*Other		1.749	0.789	0.457
		[2.518]	[2.640]	[1.350]
3rd_round	-3.081***	-6.242**	-3.081***	-3.081***
	[0.940]	[2.363]	[0.942]	[0.942]
3rd_round*Treatment	-1.009	2.151	-1.803	-0.514
	[1.196]	[2.559]	[1.197]	[1.888]
3rd_round*Other		3.971	6.237	-1.046
		[2.548]	[5.900]	[2.252]
4th_round	-5.287***	-7.671***	-5.287***	-5.287***
	[0.926]	[2.208]	[0.928]	[0.928]
4th_round*Treatment	0.205	2.588	0.069	0.321
	[0.990]	[2.327]	[0.974]	[1.281]
4th_round*Other		2.996	1.062	-0.246
		[2.397]	[2.089]	[1.378]
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.162	0.171	0.169	0.163
F-statistics for zero slopes	15.38***	11.94***	12.19***	11.72***
F-stat. for (1) Basic spec. (F(3, 29))		1.03	0.47	0.91

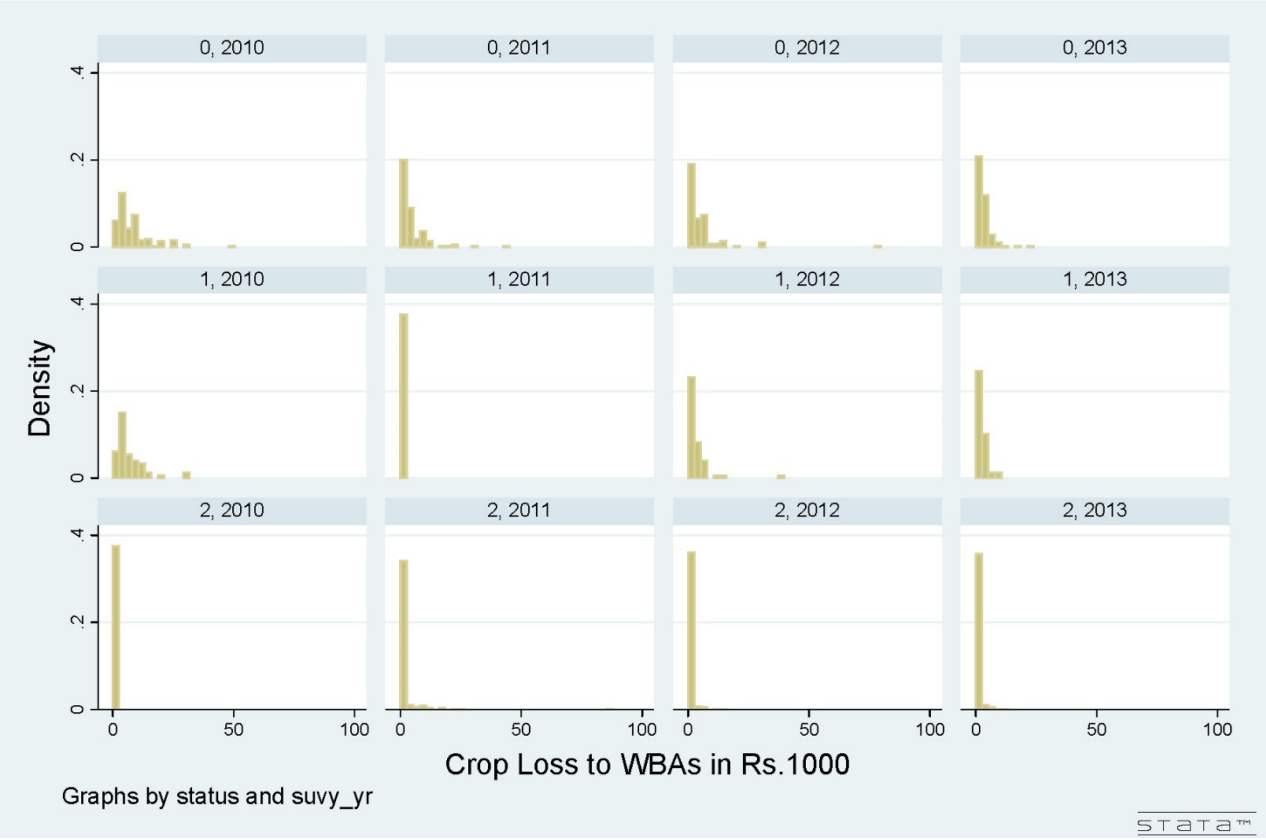
Notes: Estimated by a fixed-effect panel specification with the number of observations at 788 (4 periods x 197 eligible households). Robust standard errors clustered at the village level are shown in brackets. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 4. The cost and benefit of the AWBAP

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Low estimate for the reduction of crop-income loss		High estimate for the reduction of crop-income loss	
	No implicit cost (inability to master the technique)	Substantial implicit cost	No implicit cost (inability to master the technique)	Substantial implicit cost
At the household-level (PKR 1,000 per treatment household)				
C11. Recurrent cost for treatment	-2.00	-2.00	-2.00	-2.00
C12. Implicit cost for implementation by household	0	-7.68	0	-7.68
B11. Reduction of crop-income loss in 2011	3.47	3.47	5.37	5.37
B12. Reduction of crop-income loss in 2012	0	0	1.54	1.54
B13. Reduction of crop-income loss in 2013	0	0	2.64	2.64
Net present value, assuming real interest rate of 5%	1.30	-6.38	6.79	-0.89
Benefit cost ratio	1.65	0.34	4.40	0.91
Internal rate of return in real terms (%)	73.5	-64.2	207.5	-0.8
At the project-level (PKR 100,000 for the whole panel of 569 households)				
C21. Recurrent cost for treatment (C11*55)	-1.10	-1.10	-1.10	-1.10
C22. Implicit cost (C12*55)	0	-4.22	0	-4.22
C23. HRD training cost for 55 households	-2.20	-2.20	-2.20	-2.20
B21. Reduction of crop-income loss in 2011	1.91	1.91	3.44	3.44
B22. Reduction of crop-income loss in 2012	0	0	2.51	2.51
B23. Reduction of crop-income loss in 2013	0	0	4.56	4.56
Net present value, assuming real interest rate of 5%	-1.48	-5.71	6.19	1.97
Benefit cost ratio	0.55	0.24	2.88	1.26
Internal rate of return in real terms (%)	-42.2	-74.6	85.5	17.8

Notes: All monetary values are in PKR, 2010 prices. Net present value, Benefit cost ratio, and Internal rate of return are all calculated at the time of project initiation in early 2011, approximated as year 2010.

Figure 1. Distribution of crop-income loss by eligibility and treatment status



Notes: The first figure in the caption shows the eligibility/treatment status, while the second figure shows the survey year. For instance, the caption "0, 2010" in the top-left graph indicates the distribution of crop-income loss among control households in 2010, while the caption "2, 2013" in the bottom-right graph indicates the distribution of crop-income loss among noneligible households in 2013.