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MUTUAL CROP INSURANCE AND MORAL HAZARD: THE CASE OF MEXICAN FONDOS

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1 Introduction

Improving access to capital for smallholders is an important task in developing countries. To ensure the people's liquidity risk management strategies do not only complement credits but they also prevent the rural poor from reducing their consumption, or even nutrition, in case of bad years. While there are many informal mechanisms in developing countries market-driven mechanisms seem to be limited. Especially, one major source of uncertainty for a rural society agricultural crop yield risk is even hard to mitigate in developed countries.

A positive exception may be the Mexican Fondos. They are mutual insurance groups providing crop insurance based on named perils exclusively to their members. Based on sustainable loss ratios, low subsidy rates and a market share over 50% since regulation allowed their operation the Fondo system seems to be a story of success. KNIGHT and COBLE as well as MOSCHINI and HENNESSY survey empirical studies indicating problems of asymmetric information in crop insurance. In general, partially self-selected group reduce problems of asymmetric information. In contrast to Fondos, crop insurance schemes analyzed in the literature are not based on named perils but on crop yield in general.

In this article, we aim (1) to test empirically for moral hazard in a multiple peril crop insurance, (2) to show theoretically that certain institutions in a mutual insurance can reduce incentives for moral hazard, and (3) to test empirically if such an institution in the Mexican Fondos reduces moral hazard in the real world. We, first, present the system of the Mexican Fondos and one of its specialties, i.e. the so-called Social Fund. We show that incentive mechanisms within the Fondo system may influence moral hazard behavior. Afterwards we develop our testing procedure for moral hazard before showing and discussing the empirical results that confirm both moral hazard behavior as well as the potential of the so called Social Fund to reduce moral hazard behavior.

2 The Fondos System

This section is heavily based on IBARRA and MAHUL. It is divided into two parts. First, we explain the Fondos' operating and, second, why moral hazard may exist in the Fondo system.

2.1 Operating of Fondos

According to Mexican laws, Fondos are non-profit organizations constituted by the farmers as civil associations without the need to provide any capital endowment, except their willingness to associate between themselves. The Fondos are not allowed to sell insurance to third parties other than its own members. The regulation requests an unlimited stop loss reinsurance treaty implicitly. The regulation empowers the reinsurer to cancel the reinsurance contract, and if it is the case, to negate any pending indemnities, when the Fondo violates any of its contractual obligations. The Mexican system makes the reinsurers responsible for pricing the premiums also within a Fondo because of their superior knowledge on risk pricing and their access to

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broader databases. Risks are covered for named perils, e.g. hail, drought, flooding, heat waves, frosts.

Reserve requirements for the Fondo are defined in relation to the actuarially fair insurance premium and surpluses from each production cycle. The surplus remains from the Current Risk Reserve (CCR which is premiums paid by farmers (including subsidies) minus administrative costs and reinsurance premiums) minus indemnities (see Figure). 30% of the surplus (light gray areas) go into the Special (Contingency) Reserves which serve for paying indemnities in future periods (see period 4). The remaining 70% (dark gray areas) are paid into a so-called Social Fund (see Figure on the bottom, e.g. in period 5). This money can be spent by the Fondo's members on joint investments after democratic voting as has been done at the beginning of period 7 inFigure . If the Special Reserves exceed 15% of the insured value (equivalently to SCR^* in Figure) the surplus flows into the Social Fund completely (period 7). The reinsurance company pays out for indemnities that are not covered by the CCR and the Special Reserves (black areas, e.g. in period 1).

2.2 Moral hazard in the Fondos System

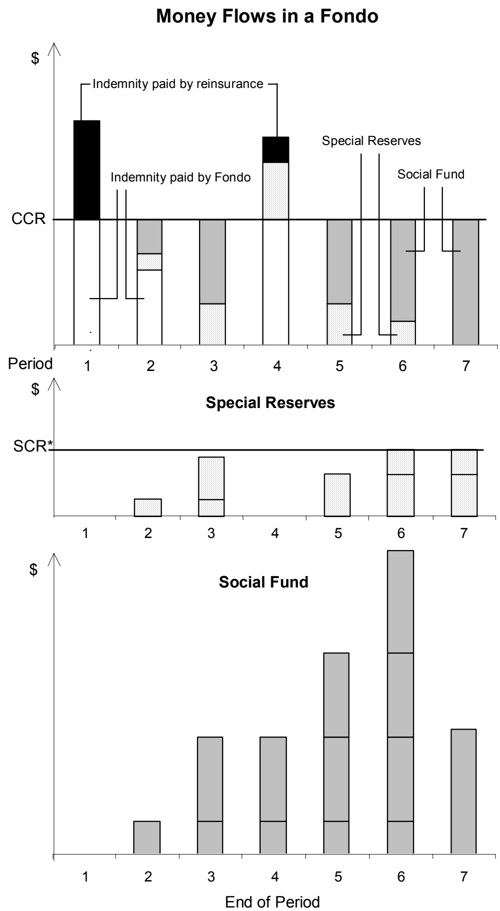
The insurance is based on two steps, the mutual insurance among the members and the reinsurance between the Fondo and the reinsurance company. A member pays a premium at the beginning of each production cycle for purchasing the guarantee that losses defined in the insurance contract minus coinsurance are fully compensated to him. At the first step the Fondo pays the indemnities for losses by means of the CCR and the Special Reserves. Consequently, if the Fondo cannot cover all indemnities in the first step the reinsurance pays the remaining money in the second step (see period 1 and 4 in Figure).

Moral hazard can evolve on two different stages, within the Fondo as well as between the Fondo and the reinsurance. Within a Fondo a farmer might reduce his costly care in production resulting in higher or more probable damages if a peril occurs. As a consequence of this moral hazard behavior the farmer can expect more indemnities while other farmers who take more care receive reduced benefits from the Social Fund. However, because a Fondo has not more than 300 members in common and because they are located in nearby communities the farmers know each other. Thus, the farmers have high incentives and relatively low costs to monitor each other to control moral hazard behavior. On the other hand, if farmers act strategically by agreeing on no moral hazard controls every farmer can be better off because the reinsurance pays higher indemnities than expected. This is especially true if the reinsurance company adjusts the premiums only slightly between sequent periods and if farmers only have a short time horizon about their insurance decisions.

Within the Fondo moral hazard is reduced due to the coinsurance, by social enforcement and by a farmer's risk to be excluded from the Fondo or at least loosing the insurance guarantee for the current production cycle. There are not any systematic premium adjustments differentiating between the farmers' different loss histories. However on the Fondo level, a common loss memory is partially incorporated in the Special Reserves. Beyond the reinsurance company's right to cancel a Fondo's reinsurance contract if the Fondo violates its obligations the Special Reserves are an important moral hazard reducing mechanism between the Fondo and the reinsurance company. The expected future payments into the Social Fund increase when the reserves of a Fondo – everything equal – increase and vice versa.

Consequently, the farmers' incentive for moral hazard behavior and for monitoring each other depends partially on the amount of reserves that the Fondo has accumulated. This dependence is empirically tested in section 4 of the paper. The dependence is driven by the different portions of a period's surplus that go into the Social Fund. If the upper bound of reserves (15% of the insured value) is reached total surpluses go into the Social Fund, below that bound only 70% of the surplus go into the Social Fund (see Figure). Thus, avoiding a neighbor's loss by monitoring has a higher benefit for a farmer when reserves are at the upper bound or when a farmer can expect that the reserves will be at the upper bound in the near future.

Figure 1: Money Flows in a Fondo



3 Model

We model a dynamic stochastic control problem similar to an approach of ABBRING, CHIAPPORI, and PINQUET extending it to a moral hazard game. We show the optimal response functions for a farmer under no-cooperation and under cooperation among farmers, respectively. GHATAK and GUINNANE present a similar but static game about the joint liability for loans in developing countries, such as the case of the famous Indian GRAMEEN bank.

3.1 Assumptions

Farmers maximize their individual expected income V_T over their planning horizon that may cover several consecutive production periods. Agents are risk-neutral. This is not in contrast to the insurance decision because major incentives for Fondo members to insure are reducing liquidity problems and substituting for loan collaterals. Insurance decision, insurance premium q, and amount of loss L are assumed to be exogenous where $(L – D) > 2q$ is assumed. D is an absolute deductible, the coverage for loss L minus deductible D is 100%. Administration costs for the insurance are exogenous, too. Only two states of nature with loss 0 or loss L can occur. Probability of no loss p can be chosen by the individual farmer i. The cost function for no loss probability is $0.5\ \gamma p^2$ for all farmers, $\gamma > L$ is assumed to ensure that some loss probability would be optimal in the absence of any insurance.

A portion b of a period's surplus goes into the Social Fund. The money of the Social Fund is equally distributed among the farmers. (Investments of the social fund that may have public good character are not allowed in the model.) Therefore, a farmer's optimal decision depends on other farmers' decisions. We will reduce this game to two farmers as in GHATAK and GUINNANE. In this case, the payment out of the social fund amounts to $2bq$ because it is only paid in t if no loss occurs to both farmers in t. b equals b^{max} if reserves are at the upper bound of the Special Reserves sr, $b = b^{min} < b^{max} < 1$ if reserves are below the upper bound sr^{max}. The second farmer is called j and his no loss probability is o. The risks (loss probabilities) of the farmers are independent for the game. The systemic component of the crop yield risk is captured by the reinsurance which is assumed to act exogenously. Farmers are assumed to be unable to affect the systemic risk by their individual no loss probability.

Agricultural production decisions and outcome minus production costs in period t are separated into two components, a non-stochastic one consisting of the non-stochastic income Y minus premium q minus costs for no loss probabilities $0.5\ \gamma\ p^2$. The second component is deductible D occurring in period t with loss probability $(1 – p_t)$. Then, we get for period t

$$z(p_t) = Y_t - q - [1 - p_t]D - \frac{1}{2}\gamma p_t^2 \qquad (1)$$

3.2 Dynamic Model

The dynamic value function for farmer i at the first decicion date (i.e. beginning of the first period) is

$$V_T = z(p_1) + b_1 q p_1 o_1 + \sum_{t=2}^{T} \delta^t \left[U_t^{\min} + prob_t(sr_{t-1}) \Delta_t^U \right] \qquad (2)$$

T is the last period of the farmer's decision horizon. $0 < \delta < 1$ is a discount factor. $U_{t\text{-}}^{\ min} = z(p_t)+b^{min}\ q\ p_t\ o_t$. $\Delta^U{}_t = [b^{max} – b^{min}]q\ p_t\ o_t$. The term $prob_t$ represents the probability at the decision date that $b_t = b^{max}$. The farmer's value is his certain income minus premium minus expected economic loss due to the deductible minus costs from risk reducing actions plus expected payouts from the Social Fund plus the discounted expected value from future periods which is the sum of a certain minimum future value and an expected difference to higher future values.

Under no cooperation the optimal no loss probability for farmer *i* becomes

$$p_1^* = \frac{1}{\gamma}\left[D + b_1 q o_1 + \delta \frac{\partial prob_2}{\partial p_1}\Delta_2^U + \delta^2 \frac{\partial prob_3}{\partial p_1}\Delta_3^U + \ldots + \delta^T \frac{\partial prob_T}{\partial p_1}\Delta_T^U \right] \tag{3}$$

While for the partial derivatives of the probabilities several cases apply all of them are non-negative and independent of the first period's optimal no loss probability. The cases depend on the level of Special Reserves at the beginning of the first period and there are more possible cases in future than in nearby periods. Now, it can be shown that the optimal no loss probability increases with the level of Special Reserves (see the Appendix, too). If Special Reserves in future periods are sufficiently high the corresponding b equals b^{max} and $\Delta^U{}_t > 0$ resulting in a higher p_1^*. In addition, that $b_1 = b^{max}$ holds for the first period increases with the level of Special Reserves, too. The optimal no loss probability for farmer *i* also increases with a higher no loss probability chosen by farmer *j*.

The optimal no loss probabilities under cooperation, i.e. $p_{t+k} = o_{t+k}$ for all $k \in \mathbb{N} < T$, are presented in the appendix. Again, it can be shown that the optimal no loss probability increases or stays constant with the level of Special Reserves. Thus, the second objective of our analysis mentioned in the introduction is fulfilled. The institutions in the Fondos can reduce moral hazard theoretically. We test this result in the following section empirically.

4 Empirical Application

4.1 Empirical Model

The test procedure is based on the simple idea that the loss probability is influenced by the behavior of the Fondo members. Therefore, we estimate the loss probability under the hypothesis of symmetric information and compare it with the loss probability conditioned on additional variables that reflect incentives for the farmers to change the loss probability, in particular the Special Reserves. If the Special Reserves decrease the loss probability we have shown empirically that the rule of different portions of a period's surplus going into the Social Fund decrease moral hazard as well as the existence of moral hazard in this multiple peril crop insurance. Since we do not have the same information the insurance company uses to calculate the premiums and risks we have to restrict ourselves to observable variables that we combine in a heuristic way to estimate the loss probability. Our reduced form equation is

$$\pi = \beta_0 + \beta_1 q + X_1\beta'_{2-6} + X_2\beta'_{7-21} + X_3\beta'_{22-23} + \beta_{24}SCR + u \tag{4}$$

$$X_1 = \left[q\left[1-R\right] \quad q*dummy \quad q*v^n \quad q\left[\frac{v}{A}\right]^n \quad q*age \right]$$

$$X_3 = \left[A \quad period\_lossratio \right]$$

where π is a column vector with z rows (z = number of all observations included in the estimation across Fondos and periods). The endogenous variable π is a binary variable amounting to one if a Fondo faces at least one claim in a period and zero otherwise. X_1 is a $z \times 5$ matrix, X_2 is a $z \times 15$ matrix capturing the squares and cross products of the variables in X_1, X_3 is a $z \times 2$ matrix, and u is the disturbance. β_0 is a constant and the remaining βs are appropriately dimensioned column vectors. The superscript n represents normalized variables. Thus, it is assumed that the variables insured value v and insured value per hectare v / A have impact only by their deviations from its mean as well as the loss ratio R only corrects the net premium rate q if it deviates from 1.

We explain the variables which are supposed to represent the loss probability under symmetric information and afterwards we explain the variables standing for problems of asymmetric information.

Loss probability under symmetric information

A latent variable π^* shall represent the probability that at least one loss (claim) occurs in the Fondo in a period. The insurance company forms expectations about π^* which we call $E[\pi^*]$. We do not have this information. However, we observe the net premium rate (premium per hectare minus administrative costs per hectare) which represents the probability $E[\pi^*]$ at least partially. Since π^* cannot be observed we use the binary variable π for the estimation.

Consequently, to get an estimate for the loss probability π^* we start with the net premium rate q. To account for the rate-making error of the insurance we add the product of the net premium rate and the historic loss ratio R (the relation between the accumulated premiums and indemnities of a Fondo) that had been observed for a Fondo until an observation's period. This product equals an expected value for π for period t if period t is a random draw from the previous periods and if only no loss or a fixed loss occurs. To account for heterogeneous losses we include the observed loss occurrence which is the portion of periods that faced at least one loss in relation to all observed former periods. For example, if the loss ratio is one a premium rate of 10% would imply a 10% probability of losses if we have the simple loss distribution of no or a fixed loss. However, the true occurrence probability might be less because the loss distribution is significantly skewed with extremely high, but very rare losses. We will incorporate the observed loss occurrence by a *dummy* variable indicating whether the observed loss occurrence exceeds the net premium rate or not.

The variable v "insured value" is supposed to reflect an incentive for the insurance company to avoid an underrating of the premium. This is especially true for Fondos with a high insured value because the total economic loss for the reinsurance would be high in case of underrating the premium. Since underestimating the risk of a total loss of a highly per hectare valued crop would also cause higher economic losses for the insurance compared to underestimating the same risk for a crop with a low value per hectare one can expect a tendency of the insurance to overrate the premium of high value crops (safety loading). Therefore, we include also the variable v / A "insured value per hectare" evaluated on the Fondo level. We assume that both value variables adjust the premium multiplicatively to become an appropriate measure for the loss probability. We incorporate the total insured area of a Fondo A which is supposed to account for a Fondo's regional expansion. The probability that a specific weather event touches at least one plot of the Fondo increases with the Fondo's total area. The variable *period_lossratio* equals a period's total indemnities in relation to the insured value for the aggregate of all Fondos to account for different weather conditions among the observed production periods.

Incorporating asymmetric information

Under asymmetric information we have to include factors that may have an impact on the loss probability because the insurance company has less information than farmers and because the insurance company has to pay for collecting information or coping with the informational advantage of the farmers. Characteristics of the Fondo are important for the aspect of adverse selection. The *age* of a Fondo may explain differences in the loss probability among Fondos because older Fondos had more time to self-select their members and the insurance company had more time to adjust premiums, i.e. reduce a hypothetical safety loading. Since we assume that the *age* variable mainly affects the safety loading of premiums it enters the model multiplicatively with the premium. However, an additive component due to self-selection mechanisms might exist, too. The *age* variable counts previous periods a Fondo has operated.

The most important incentive for farmers for moral hazard is examined in the economic model above, i.e. the level of Special Reserves. However, the continuous variable in the theoretical model is transformed into a discrete variable *SCR* with classes 1, 2, and 3 indicating special reserves below 10%, above 10% and below 20%, and above 20%, respectively. We do not assume a continuous impact of the Special Reserves on the loss probability because farmers' impact on changing the probability reaching the upper bound of reserves in the future may be too low compared to the stochastic component of the loss occurrence when the Special Reserves are significantly below the upper bound of 15% of the insured value or significantly above the upper bound.

4.2 Pure Heterogeneity

As ABBRING, CHIAPPORI, and PINQUET point out a main challenge in analyzing the behavior of insured is the "distinction between pure heterogeneity and state dependence" (p. 770). We apply three strategies to overcome the distinction problem. First, since we have (unbalanced) panel data we can capture much of the pure and unobserved heterogeneity among Fondos by means of fixed or random effects specifications. Second, we control for production cycles by means of a period's total indemnities in relation to the insured value (*period_lossratio*) to capture heterogeneity among periods.

Third, we include information from observed variables that probably do not affect farmers' moral hazard behavior, such as loss ratio, the total insured value of a Fondo, and the number of cycles with at least one loss in relation to the age of a Fondo. Since the variable of interest, the Special Reserves variable *SCR* represents a portion of the accumulated surpluses in relation to the insured value we argue that the *SCR* variable does not add new information about the Fondo itself and its exposure to risk to the analysis. Moreover, there are two reasons that *SCR* contains less information about the loss probability than the combination of loss ratio, the relation of loss cycles compared to total insured cycles and the insured value of a Fondo. First, the portion of the surplus going into the Special Reserves varies depending whether the upper bound of reserves is reached or not and, second, the reserves can drop to zero after a period with a high loss. Thus, the variability in the reserves among periods does not reflect changes in the loss probability. Differences among Fondos that may occur from wrong rate-making should be captured by the Fondo specific individual effects. However, the effect of wrong rate making may change over time when the insurance company changes coinsurance conditions for some crops or premiums for some Fondos.

4.3 Specifications and Results

We estimate (4) as an unbalanced panel. The standard procedures to account for individual effects in panel data cannot be applied for limited dependent variables (see e.g. BALTAGI). We use a random effects logistic and a conditional fixed effects logistic estimation procedure for limited dependent variables implemented in Stata 8.2. The disturbance term in the estimations is assumed to be normally distributed.

For the random effects estimation, 248 different Fondos are included resulting in 2176 observations between the winter production cycle 1991/92 and the winter production cycle 2000/01. The three first production cycles in 1990 and 1991 are omitted (151 observations) because these are the first years of Fondos operating in Mexico. Table displays the results of the random effects regression after restricting insignificant variables jointly. The joint restriction is only significant on the 12%-level, signs do not change. Variable x5 becomes significant because its square is excluded. The remaining results are unchanged by excluding eight variables (e.g. the *period_lossratio* variable). The *special reserves* variable is significant on the 10% level with the expected negative sign.

Table 1: Results of the logistic random effects regression

n = 2176

Log Likelihood = -553.8

Variable			Coefficient	Standard Error	z-value
net premium	x1	%	82.5 ***	10.00	8.3
loss ratio	x2		52.3 ***	7.17	7.3
loss occurrence	x3		-23.9 ***	6.31	-3.8
insured value	x4	normalised	8.47 ***	1.77	4.8
insured value per hectare	x5	multiplied by 10^3, normalised	-0.29 ***	0.11	-2.7
age of fond	x6		-8.09 ***	1.28	-6.3
x2 x2	x7		-17.5 ***	2.47	-7.1
x2 x3	x8		-27.7 ***	5.34	-5.2
x2 x6	x9		-3.25 ***	0.77	-4.2
x3 x5	x10	multiplied by 10^3	1.30 ***	0.42	3.1
x3 x6	x11		3.96 ***	0.54	7.3
x6 x6	x12		0.16 ***	0.052	3.0
area insured	x13	multiplied by 10^3	0.20 ***	0.07	2.9
special reserves	x14	3 classes	-0.30 *	0.17	-1.8
constant	x15		0.18	0.38	0.5

*, **, *** represent significance on the 10%, 5%, 1% level, respectively.

In the conditional fixed effect estimation the endogenous variable is conditioned on the sum of the endogenous variable in a specific group, i.e. Fondo, over all periods. Thus, all groups are excluded that have either only losses or only no losses in all periods, i.e. cycles, because the value of the endogenous variable for such groups is unambiguously set for all of its observations adding nothing new to the conditional likelihood function. Consequently, 1350 observations of 138 Fondos are included in the conditional fixed effect regression. After restricting 12 insignificant variables the log likelihood is around -239 and the *special reserves* variable is significant again on the 10% level with the expected sign. For both specifications, Hausman's specification test rejects the null hypothesis of no individual effects.

The result about the *special reserves* is stable in that sense that we receive equivalent results when (1) using dummy variables for different levels of Special Reserves instead of the classified variable, (2) using shorter time series, and (3) using random or fixed effect specifications. Summing up, although we have a multiple peril crop insurance moral hazard can be detected in the Mexican Fondos empirically and the rule of different surpluses going into the Social Fund reduces moral hazard empirically. However, the level of significance is only 10%.

5 Concluding Remarks

We have presented a system of Mexican mutual crop insurance groups, i.e. Fondos. We show from a theoretical point of view that some institutions in the system have impact on the farmers' behaviour to avoid or reduce losses. Thus, if farmers can influence the level of losses or the loss probability technologically the institutions can be used to restrict the incentives for moral hazard. In the empirical analysis we have shown that the rule of different portions of a period's monetary surplus going into a common so called Social Fund reduces the loss probability in a Fondo. Thus, we have empirically shown both that an institution of the Fondos can reduce moral hazard and that moral hazard exists in this insurance system of a multiple peril crop insurance. To the author's best knowledge the latter is the first empirical evidence for moral hazard in multiple peril crop insurance.

Further analysis empirically and theoretically should follow up because this insurance institution might serve as a blue print for other developing countries to cope efficiently with crop yield risk, reduce income fluctuations and substitute for loan collaterals. Also, the theoretical model can be used to identify theoretically optimal designed insurance contracts to improve the Fondos' institutions because the rules today are mainly set be the Mexican government and a quasi-monopolistic reinsurance company.

References

ABBRING, CHIAPPORI, and PINQUET (2003). Moral Hazard and Dynamic Insurance Data. Journal of the European Economic Association 1 (4), pp 767-820.

BALTAGI, B. H. (2001). Econometric Analysis of Panel Data. Second Edition.

IBARRA, H., MAHUL, O. 2004. Self-Insurance Funds as Agriculture Insurance Providers: the Case of Fondos in Mexico. Worldbank. Mimeo. November 2004.

GHATAK, M., GUINNANE, T. W. (1999). The economics of lending with joint liability: theory and practice. Journal of Development Economics 60, pp 195-228.

KNIGHT, T. O., COBLE, K. H. (1997). Survey of U.S. Multiple Crop Insurance Literature Since 1980. Review of Agricultural Economics 19(1), pp 128-156.

MOSCHINI, G., HENNESSY, D. A. (2001). Uncertainty, Risk Aversion, and Risk Management for Agricultural Producers. Handbook of Agricultural Economics, Vol. 1 A, pp 87-153.

Appendix

$$p_1^{**} = \begin{cases} \left[\gamma - 2b^{\min} q\right]^{-1} D \quad \text{if } \; sr^{\max} - sr_0 > 2\left[T-1\right] q \left[1 - b^{\min}\right] \\ \left[\gamma - 2b^{\min} q - 2\delta^{T} \prod_{t=2}^{T-1} p_t^2 \Delta_T^U\right]^{-1} D \\ \qquad \text{if } \; 2\left[T-2\right] q\left[1-b^{\min}\right] < sr^{\max} - sr_0 \le 2\left[T-1\right] q \left[1-b^{\min}\right] \\ \left[\gamma - 2b^{\min} q - 2\delta^{T-1} \prod_{t=2}^{T-2} p_t^2 \Delta_{T-1}^U - \sum_{t=T}^{T} \delta^t p_{t-1}^2 \frac{\partial prob_{t-2}^{sr}}{\partial p_1} p_1^{-1} \Delta_t^U\right]^{-1} D \\ \qquad \text{if } \; 2\left[T-3\right] q\left[1-b^{\min}\right] < sr^{\max} - sr_0 \le 2\left[T-2\right] q \left[1-b^{\min}\right] \\ \vdots \\ \vdots \\ \left[\gamma - 2b^{\min} q - 2\delta^{2} \prod_{t=2}^{2} p_t^2 \Delta_3^U - \sum_{t=4}^{T} \delta^t p_{t-1}^2 \frac{\partial prob_{t-2}^{sr}}{\partial p_1} p_1^{-1} \Delta_t^U\right]^{-1} D \\ \qquad \text{if } \; 2q\left[1-b^{\min}\right] < sr^{\max} - sr_0 \le 2*2q \left[1-b^{\min}\right] \\ \left[\gamma - 2b^{\min} q - 2\delta \Delta_2^U - \sum_{t=3}^{T} \delta^t p_{t-1}^2 \frac{\partial prob_{t-2}^{sr}}{\partial p_1} p_1^{-1} \Delta_t^U\right]^{-1} D \\ \qquad \text{if } \; 0 < sr^{\max} - sr_0 \le 2q\left[1-b^{\min}\right] \\ \left[\gamma - 2b^{\max} q - 2\delta \Delta_2^U - \sum_{t=3}^{T} \delta^t p_{t-1}^2 \frac{\partial prob_{t-2}^{sr}}{\partial p_1} p_1^{-1} \Delta_t^U\right]^{-1} D \\ \qquad \text{if } \; sr^{\max} - sr_0 = 0 \end{cases} \tag{5}$$

We define $prob_t^{sr}$ to represent the probability that the special reserves at the end of period t are sufficiently small that $sr^{max} - sr_t < 2q[1 - b^{min}]$ holds. For the case of cooperation follows that the probability that b^{max} applies in $t+2$ becomes p^2_{t+1}. It is straightforward that $prob_t^{sr}$ is a function of both the Special Reserves at the beginning of period 1 sr_0 and the losses occurring until period t. Probability $prob_t^{sr}$ represents the sum of probabilities for single combinations of outcomes (losses and no losses) in future periods. Each combination must ensure that that b^{max} can be applied in period $t+2$. It follows that the partial derivative of $prob_t^{sr}$ with respect to p_1 is linear in p_1 or zero in the case of cooperation. The derivations can be sent upon request.

From (5) we can derive the impact of a change in the Special Reserves on the optimal no loss probability. We start with the case on the very bottom, i.e. the maximum level of reserves. Reducing the level of reserves to get to the second case reduces the optimal no loss probability because in the second case b^{min} applies instead of b^{max}. Thus, the term in square brackets is bigger in the second case and because we divide by this term the optimal no loss probability is smaller in the second case. Further reducing the Special Reserves means reducing the second subtrahend by multiplying additional probabilities (that are smaller than one, of course) and by higher discounting. It also means reducing the third subtrahend by reducing its number of summands. Thus, a higher level of special reserves either increases the optimal no loss probability or does not have any impact on it.