The moral hazard—environmental externalities dilemma in subsidized crop insurance: Evidence from water quality in China

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CRediT authorship contribution statement

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Abstract

Whether subsidized crop insurance exacerbates or alleviates agricultural water pollution remains a long-standing debate with direct implications for climate-resilient and environmentally sustainable agricultural policy. We provide the first systematic evidence on how the design of China's subsidized crop insurance, specifically cost-based and revenue-based protection, shapes environmental outcomes through farmers' behavioral responses. We exploit the recent staggered rollout of two high-coverage insurance products for the three major staple crops (rice, maize, and wheat) as a quasi-natural experiment. Full Cost Insurance (FCI) indemnifies pre-specified production costs against natural-disaster losses only, whereas Planting Revenue Insurance (PRI) extends compensation to both production risks (natural disasters) and market risks (output-price volatility). Combining county-level policy timing with hourly monitored surface-water quality data from 2021 to 2023, we estimate the program's effects on total nitrogen (TN) and total phosphorus (TP) concentrations around pilot counties.

We find that FCI alone significantly reduces TN and TP concentrations, but layering PRI on top of FCI reverses this pattern and produces a measurable increase in nutrient

pollution. The reversal reflects opposing behavioral mechanisms. By anchoring indemnification to recoverable costs rather than realized output, FCI induces a moral-hazard response that dampens farmers' incentives to apply chemical inputs, lowering nutrient runoff at the cost of modest yield reductions. PRI, by tying income stabilization to production incentives, alleviates this moral hazard, yielding higher output but greater nutrient-runoff pressure. Heterogeneity analyses show that the FCI-driven pollution decline emerges more rapidly in counties with greater historical climate risk and higher historical insurance payout rates, suggesting that experience-based expectations may amplify the moral hazard inherent in cost-based schemes.

The findings survive an extensive battery of robustness checks, including heterogeneity-robust estimators, spillover-robust specifications and sensitivity analyses across pollution-radius definitions, and permutation inference analyses (full, block, within). We further test for potential non-randomness of policy assignment via discrete-time linear probability, complementary log-log, and Cox proportional-hazard models, and address this concern through a restricted sample, Mahalanobis distance matching, and predetermined-covariate by year-month fixed effects. A cost-benefit analysis combined with parameter sensitivity analysis maps a three-dimensional policy frontier across FCI and PRI coverage combinations, characterizing optimal product mixes under varying social valuations of environmental quality, farmer welfare, and fiscal cost.

Balancing the tradeoff between moral hazard mitigation and environmental sustainability requires rethinking agricultural insurance design beyond its current financial and welfare focus. Risk protection remains essential under rising climate uncertainty and rural income vulnerability, but the environmental costs of insurance-induced behavioral distortions cannot be ignored. Striking this balance entails an incentive-compatible insurance framework, linking compensation or premium subsidies not only to realized yield or revenue losses but also to environmentally responsible practices. For instance, integrating performance-based conditionalities (e.g., nutrient management plans, soil-testing compliance, or low-emission fertilizer use) into insurance program design could preserve the stabilizing function of agricultural insurance while internalizing its environmental footprint, with particular relevance for developing countries dominated by smallholder, fragmented farming systems.

(475 words)