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Developing Financial Weather Derivatives for Prairie Farmers

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UNIVERSITY OF ALBERTA
DEPARTMENT OF RESOURCE ECONOMICS
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Growing Forward

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Developing Financial Weather Derivatives for Prairie Farmers

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Introduction

Explore weather insurance for Spring Wheat.
Weather index resolves adverse selection & moral hazard.

Objective

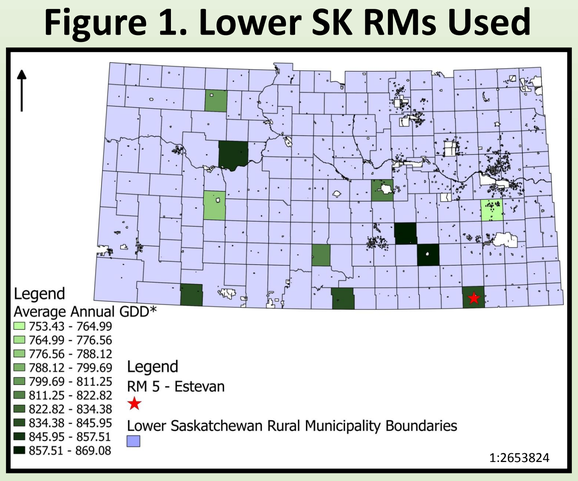
Develop weather insurance products that benefit farmers.
Model demand for insurance and optimal choice.

Findings

Modified GDD should be used.
Farmers can benefit from spending roughly $10/acre.

Study Area – Where

Figure 1. Lower SK RMs Used



Sample has good spatial extent.

Equations – What

Equation 1 defines our modified GDD measure.

$$Eq.1: GDD^*_n = \sum_{i=1}^{n} 0.5[\min(34, T_i^{\max}) + \max(8.9, T_i^{\min})] - 8.9$$

Equation 2 defines our expected utility framework.

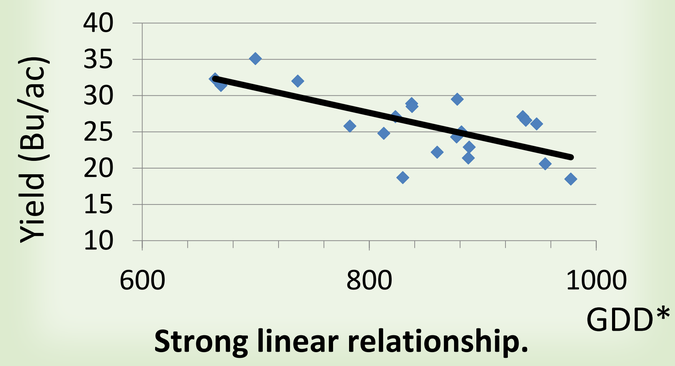
$$Eq.2: E(U(R)) = E(R) - \Theta V(R), \Theta \in (0.05, 0.20)$$

Equation 3 defines farm revenue with a call option.

$$Eq.3: R = \underbrace{\overline{P}Y(G)}_{\text{Revenue without insurance.}} + \underbrace{q[d(G-\overline{G})^{+} - C]}_{\text{Net option payoff (Strike } \bar{G}\text{, Quantity } q)}$$

Key Observation - Why

Figure 2. Relationship Between GDD* and Yield



Strong linear relationship.

Case Study: RM 5 – Estevan, Saskatchewan

Demonstration of how options affect utility.

Figure 3 shows that options can *flatten payoff*, which benefits risk averse agents.
Shows example of a call that flattens payoff (Red Line) with *high probability mass*.
To calculate Figure 3, use best fit line from Fig. 2 and net option payoff from *Eq.3*.

Figure 3. Probability of GDD* and Revenue

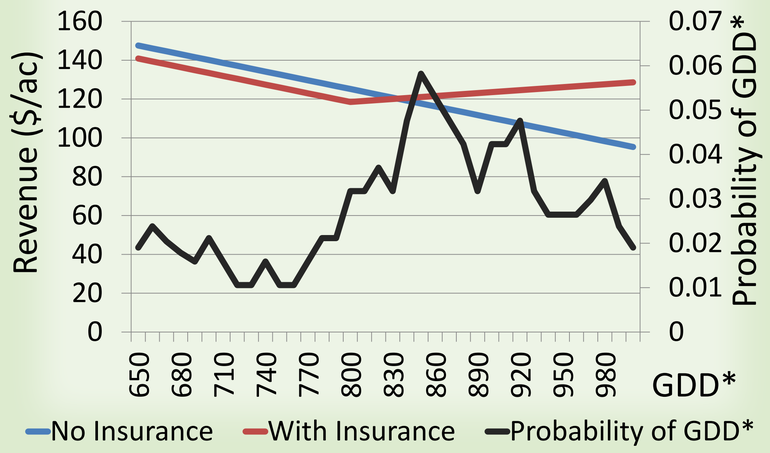
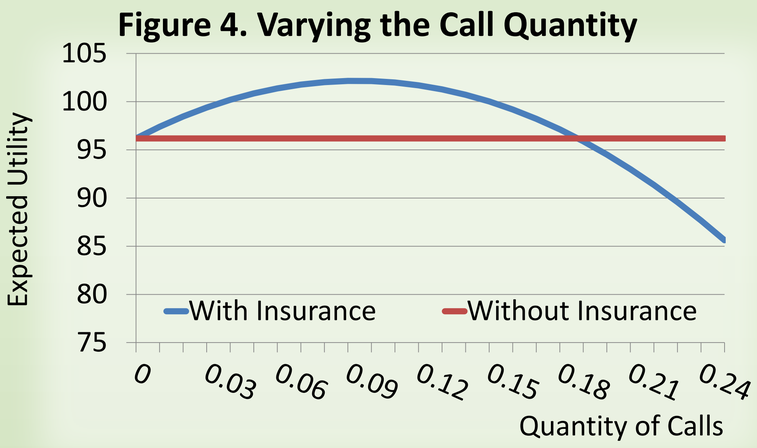
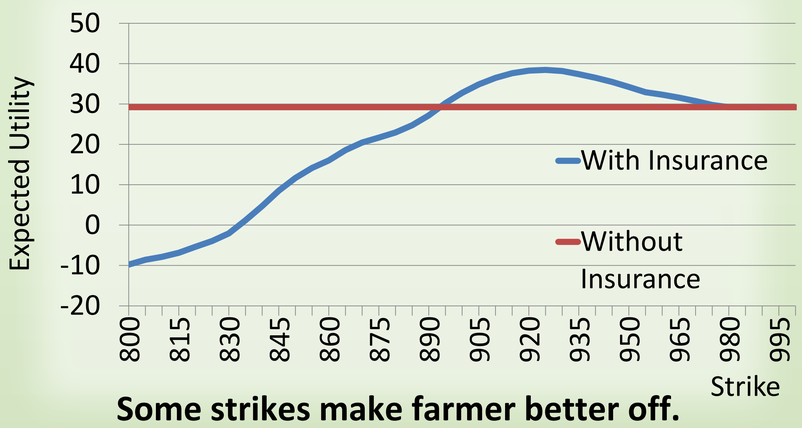


Figure 4. Varying the Call Quantity



Some quantities make farmer better off.

Figure 5. Varying the Call Strike

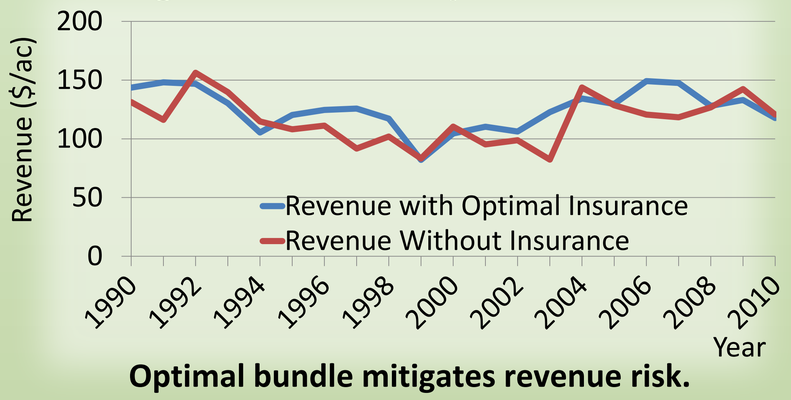


Some strikes make farmer better off.

Figures 4 and 5 show **Farmers benefit from some call options but not others.** Unique solution to utility-max over strike and quantity (*new result*).

* Exogenous Variables: Strike 800 in Fig. 4, Quantity 0.1 in Fig. 5, Risk Aversion 0.1.*

Figure 6. Case Study Conclusion



Optimal bundle mitigates revenue risk.

Figure 6 compares historical revenue with no insurance against optimal insurance.
The optimal insurance choice is: *Strike 800, Quantity 0.14* (reported in Table 1).
Insurance compensates for low yield in some years at small cost in other years, which is evidence that weather insurance can be used to benefit farmers (**Objective**).

Table 1: Province-wide Optimal Insurance Choices

Cost to farmers				Benefit to farmers	
RM	Strike	Quantity	**Cost ($) ($q * C$)**	Change Mean ($\Delta E(R)$)	Change Variance ($\Delta V(R)$)
5	800	0.14	**9.37**	8.82	-102
11	800	0.14	**9.56**	8.95	-103
18	800	0.16	**10.65**	10.01	-225
67	800	0.18	**15.44**	14.77	-298
72	890	0.38	**4.56**	3.71	-198

Shows that weather insurance can benefit farmers.

Conclusions

Affordable: The amount of money Farmers spend in optimum seems affordable without subsidies (Table 1) .
Feasible: Existing network of weather stations makes implementation feasible across province (Figure 1).
Innovative: Modified GDD has strong relation to yield (Figure 2).

Further Work: Model supply of insurance (reinsurance) - Extend to different crops and varieties - Explore different economic theory for insurance demand.

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