# A Theory of Subsidy Harvesting in Livestock Price Insurance

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**Abstract**

USDA designed the Livestock Risk Protection (LRP) program to help producers insure against declining prices for fed cattle, feeder cattle, and swine. Prices in derivatives markets determine program indemnities, making LRP policies similar to put options. Beginning in 2019, USDA made several changes to the program to encourage producer take-up, including increased premium subsidies. We introduce a theoretical model to show that subsidizing LRP premiums can invite producers to “subsidy harvest,” i.e. extract the government’s premium subsidy by offsetting the policy in a derivatives market—potentially removing the downside protection the program was intended to provide. The subsidy harvest is a rent transfer and costlier than a direct payment because it requires administrative oversight and federally subsidized delivery through approved insurance providers. According to the model, the government’s premium subsidy leads producers to favor LRP-oriented strategies over market options alone, while their choice to offset actual risk protection using options depends on individual risk tolerance, transaction costs, and margin costs. As a result, subsidizing livestock insurance may crowd out producers’ trading of market options, unless it also invites subsidy harvesting.

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# 1 Introduction

Since 1938, the U.S. government has offered crop insurance through the Federal Crop Insurance Program (FCIP), which is responsible for facilitating the private delivery of insurance to the producers of most field crops, many specialty crops, a limited set of livestock and animal products, and managers of grazing lands—worth a combined $150 billion in liability (Rosch, 2022). FCIP policies can be customized to a farm's specific risk management objectives and are sold and serviced by approved insurance providers (AIPs). The Risk Management Agency (RMA) regulates the terms of the available policies and their pricing. To induce farmers to purchase coverage, which protects them from adverse events that could affect their operations from weather shocks to pest infestations and unexpected declines in commodity prices, FCIP premiums are heavily subsidized (Rosch, 2021, 2022). In addition, the United States Department of Agriculture (USDA) provides subsidies to AIPs to compensate them for the costs of administering the program and shares in their underwriting risk through a favorable reinsurance agreement.

For nearly a century, livestock insurance in the United States was largely confined to dairy producers who participated in price and income support programs created during the New Deal era (Glauber, 2022). But in 2000, USDA initiated pilot programs to cover livestock products in the form of both price and margin (i.e., the difference between revenue and input costs) coverage tied to futures prices. (In contrast, most *crop* insurance available through the FCIP is designed to insure against production or revenue risk.) Three programs make up the bulk of the livestock insurance offered through the FCIP: Livestock Risk Protection (LRP), Livestock Gross Margin (LGM), and Dairy Revenue Protection (DRP) (Glauber, 2022). Each program ties indemnity payments to declines in futures prices over a period of coverage; participation is encouraged through premium subsidies.

Prior to 2019, participation in livestock insurance programs was limited due to (1) a statutory cap on related annual government spending, (2) relatively low subsidies on livestock insurance products, and (3) a prohibition against simultaneously covering dairy producers under both the Dairy Margin Coverage program (an income support program administered by the USDA Farm Service Agency) and dairy insurance offered through the FCIP. The 2018 Farm Bill eliminated both (1) and (3), while substantially raising subsidy rates (Glauber, 2022). Following these changes, participation in livestock insurance programs increased dramatically. According to RMA data (2026b), between 2018 and 2025, the number of livestock head covered under these programs increased from 129,000 to over 39 million. At the same time, liabilities increased from $126 million to over $22 billion, while producer subsidies increased from

$0.6 million to $415 million.

Rapid increases in LRP take-up, and participation in livestock insurance more broadly, have drawn scrutiny from market observers and policymakers. While higher subsidy rates and other recent changes successfully drew livestock producers into the programs, mirroring increased liability on the crop side of the Federal Crop Insurance Corporation's book of business (Goodwin and Smith, 2013), some have wondered whether increased LRP participation affects futures market trading and prices (Carrico, 2024). Little work has been done on the market effects of livestock insurance, although research on the impacts of subsidized crop insurance is more substantial (Horowitz and Lichtenberg, 1993; Young et al., 2001; Goodwin et al., 2004; Yu et al., 2018; Yu and Sumner, 2018).

The design of LRP, and other similarly subsidized livestock insurance policies, is based on protecting against downside swings in the prices of existing commodity futures contracts. LRP, for example, operates like a put option on a futures contract—guaranteeing a floor price to the option purchaser (LGM and DRP can also be shown to operate like synthetic options contracts).[1] Since an LRP policy is a subsidized substitute for an existing derivative, it may be that the program crowds out participation in the target derivatives market, lowering trading volume (Glauber, 2022; Belasco, 2025). Reduced commercial interest in a commodity futures market can have significant negative consequences, including harming its price discovery function (Working, 1953; Peck, 1985).

Conversely, LRP might attract participants *into* the market, increasing trading volume. This effect could work through two channels: first, if LRP subsidies attract producers into insurance policies, the AIPs who write them (and the reinsurers they purchase policies from) may use commodity derivatives to hedge at least some of the risk they take on—by purchasing options.[2] Second, RMA provisions set the LRP policy premium near prevailing option premia (i.e., the price of an option), so it may be possible to earn an arbitrage profit equivalent to the subsidy, termed a *subsidy harvest*, by simultaneously purchasing an LRP contract and selling an option on the related futures contract (Baker, 2023, 2024; Carrico, 2024).

Since LRP works like a long put option, a producer can pair an LRP policy with a short put at the same strike, canceling the policy's downside protection while retaining the subsidy, less transaction costs and the opportunity cost of necessary margin account funds in the interim. Alternatively, and

[1]Futures markets are zero-sum; for any contract to exist one party (*the long*) must promise to buy the underlying commodity at an *ex ante* known contract expiration, while another (*the short*) must agree to sell it for an agreed-upon price. All other elements of a futures contract are standardized. Trading futures, or writing options, requires collateral posted through a *margin account*; *margin calls* can occur that require the account to be topped up when prices move adversely. A call option gives the holder the right, but not the obligation, to take a long position in a futures contract for the underlying commodity at a given *strike price*. Alternatively, a put option gives the holder the right, but again not the obligation, to take a short position in a futures contract for the underlying commodity at a given strike. Option buyers pay the premium up front; option sellers, also called writers, receive the premium but face margin obligations.

[2]Use of derivatives among livestock producers is not widespread (Hill, 2015; McKendree et al., 2021; Barua, 2024).

unremarked upon up to now,[3] the producer can combine an LRP policy with a short call option to lock in the futures-implied price plus the subsidy, after transaction and margin costs. We term the first type of subsidy-arbitrage trade, which leaves the producer exposed to price risk, a *dirty subsidy harvest*; we term the second, which fixes the producer's indexed return less costs, a *clean subsidy harvest*.[4]

Subsidy harvesting via the sale of look-alike options tied to USDA insurance products can present several problems for the viability of the FCIP's livestock insurance portfolio. First, producers may take on additional risk, contravening the statutory purpose of livestock insurance as a risk management tool: a dirty subsidy harvest totally eliminates the downside protection afforded by LRP. Moreover, writing options requires margin maintenance, so producers need access to cash or credit to preserve the margin as positions are marked to market each day until options contract expiry. Second, the clean subsidy harvest caps the upside. It offers producers only the ability to earn at most the futures-implied price plus the policy subsidy, reducing potential producer returns. Third, whichever arbitrage trade producers pursue, subsidy harvesting is an inefficient way to deliver a transfer from the perspective of taxpayers, due to the associated administrative costs USDA must pay to insurance firms and its own staff who monitor the program. If the policy objective is purely distributional, a direct payment would likely achieve the same transfer with lower administrative complexity.

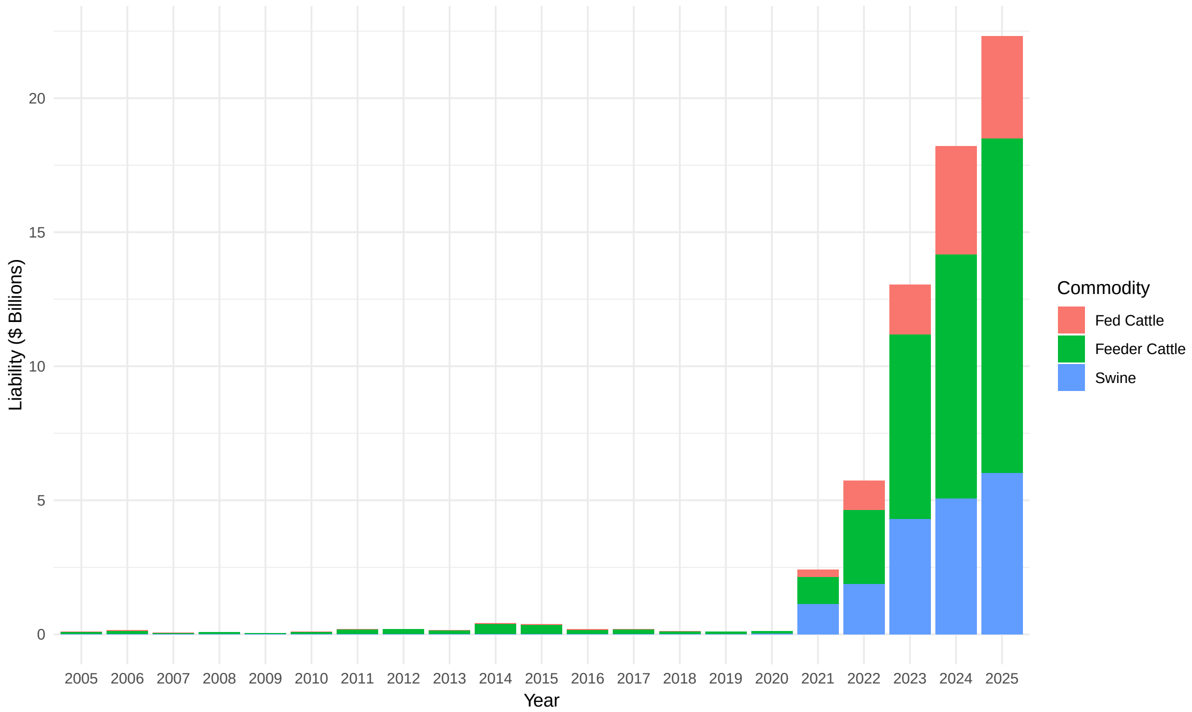
While these later policy changes are an explicit recognition of the potential for subsidy harvesting, the theoretical and empirical literature on the potential arbitrage relationship between LRP and derivatives markets remains thin (Boyer and Griffith, 2023; Feuz, 2025).

We develop a theoretical framework for livestock risk management under uncertainty in the presence of subsidized price insurance. The model predicts that strategies involving subsidized insurance dominate unhedged behavior and market put options alone. Based on their risk tolerance and the costs of trading, producers then choose among LRP alone and two types of subsidy harvests: one that insulates producers from index-price risk and another that removes the protection offered by the insurance policy. We compare these strategies under increasingly realistic assumptions; our results suggest important considerations for the design of subsidized insurance programs whose prices are tied to derivatives markets.

[3]To our knowledge.

[4]Beginning with the 2026 crop year, RMA provisions prohibit policyholders and persons with a substantial beneficial interest from offsetting LRP coverage for the purpose of subsidy capture and identify several presumptive trading patterns (U.S. Department of Agriculture, Risk Management Agency, 2025, 2026a). The model below should therefore be read as characterizing the economic incentive that exists before those constraints are imposed, or equivalently the payoff logic before expected enforcement costs are introduced.

Figure 1: LRP Liability by Commodity, 2005-2024

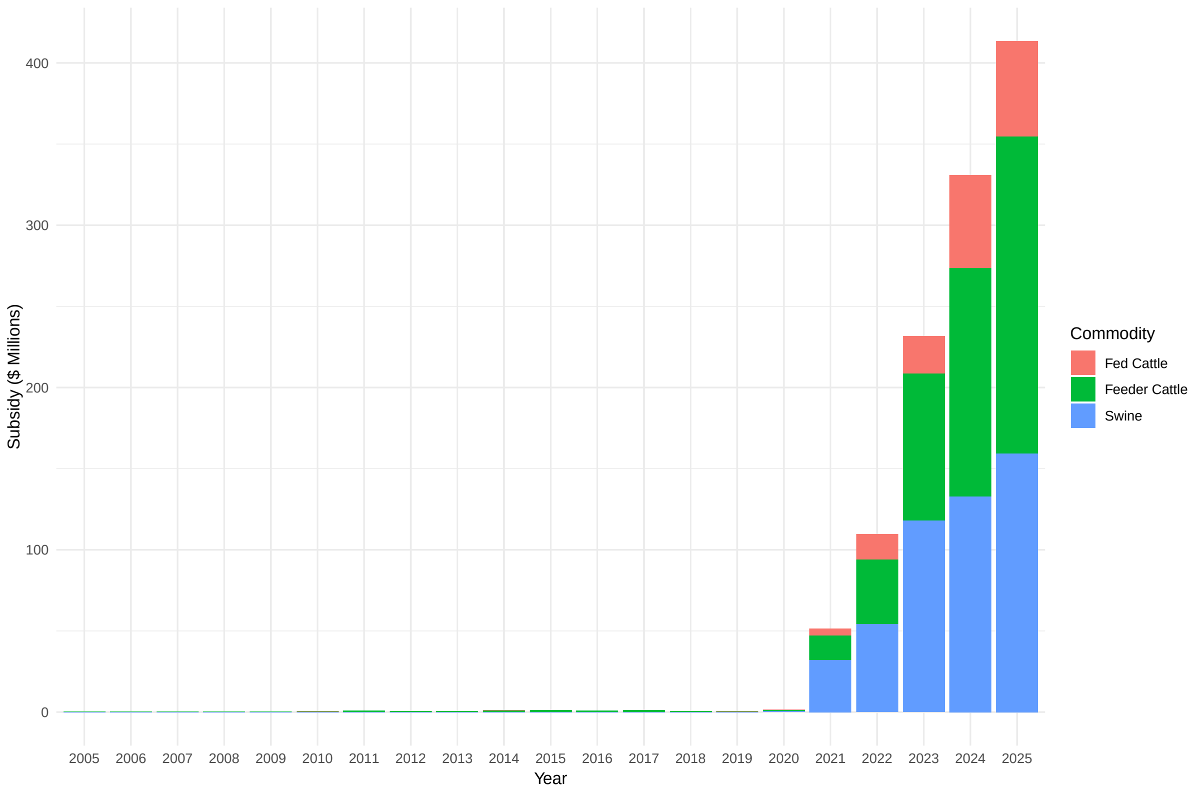



## 2 Livestock Risk Protection Insurance

Liability in livestock insurance programs grew significantly starting in 2019 with changes to dairy insurance. Total liability in livestock programs also increased dramatically, starting in 2021, with increased uptake of Livestock Risk Protection (LRP). By 2024, LRP, which covers feeder cattle, swine, and fed cattle, accounted for the majority of liability in livestock insurance programs. Values in figure 1 identify total LRP liability by commodity year for each type of livestock. Roughly 68% of policies sold and 50% of total liability in 2024 were in feeder cattle. Premium subsidies by commodity are shown in figure 2. Premium subsidies in 2024 were around $320 million with the majority of the subsidy again accruing to producers of feeder cattle (U.S. Department of Agriculture, Risk Management Agency, 2026b). LRP policy provisions specify an expected ending value for insured livestock, based on CME futures prices, and pay an indemnity if the actual ending value falls below a percentage of expected ending value.

The insured must identify the type of feeder cattle, swine, or fed cattle to be marketed and a target weight. For example, feeder cattle covers steer feeder cattle, heifer feeder cattle, Brahman feeder cattle, dairy feeder cattle, and several types of unborn feeder cattle. Steer feeder cattle with a target weight of 1.0–5.99 cwt comprise one type of steer feeder cattle, while those between 6.0–10.0 cwt comprise a second type. The set of insurable types changes over time; the figures below use the historical RMA

Figure 2: LRP Premium Subsidies by Commodity, 2005-2024




commodity groupings, while recent policy revisions added additional feeder- and fed-cattle types (U.S. Department of Agriculture, Risk Management Agency, 2025).

Different types of livestock have different price adjustment factors, the reasoning for which is most obvious for feeder cattle. Coverage prices and actual ending prices for feeder cattle are based on the Chicago Mercantile Exchange (CME) Feeder Cattle Contract which is cash settled to the CME Feeder Cattle Index. The contract and index are based on prices for steers of a certain weight (700 to 899 pounds) and do not include Brahman or dairy breeds. Price adjustment factors are intended to account for differences between steer prices in the CME contract and prices of other types and weights of cattle. The price adjustment factors are used in calculating expected ending values and actual ending values. For instance, type 2 steers (6.0 - 10.0 cwt) are the closest to the type of cattle included in the CME contract or index and therefore have a price adjustment factor of 100%, i.e. the price used in calculating the expected and actual ending values is simply the price for the CME contract or index.

LRP policies are sold on a continuous, daily basis. Based on the type of livestock, the producer identifies a target date when the livestock will be ready for market or reach a desired weight. The insurance period for the policy should end within 60 days of the target date. Available insurance periods are shown in table 1. The insured also selects from one of 12 coverage levels available: 75%, 80%, 85%, 87.5%, 90%, 92.5%, 95%, 96%, 97%, 98%, 99%, and 100%. The coverage level is the percentage of the expected ending value of the livestock covered by the policy. Premium subsidies are based on the coverage level chosen by the producer. The subsidy rates are: 35% for coverage levels 95%, 96%, 97%, 98%, 99%, and 100%, 40% for coverage levels 90% and 92.5%, 45% for coverage levels 85% and 87.5%, 50% for coverage level 80%, and 55% for coverage at the 75% level.

Table 1: Available Insurance Periods by Commodity

| Weeks | Feeder Cattle | Fed Cattle | Swine | Unborn Swine |
|---|---|---|---|---|
| 13 | X | X | X | |
| 17 | X | X | X | |
| 21 | X | X | X | |
| 26 | X | X | X | |
| 30 | X | X | X | X |
| 34 | X | X | | X |
| 39 | X | X | | X |
| 43 | X | X | | X |
| 47 | X | X | | X |
| 52 | X | X | | X |

The loss (indemnity) under an LRP policy can be calculated as

$$\text{Loss} = \max(0, (H \times TW) \times (P_C - P_A)) \tag{2.1}$$

where $H$ is the number of head insured, $TW$ is the target weight, $P_C$ is the coverage price, and $P_A$ is the actual ending value (or actual price). The coverage price $P_C$ is quoted in dollars per live cwt and is the expected ending value multiplied by the coverage level. Equation 2.1 shows indemnities under the policy are determined by the difference between the actual ending value and the coverage price. If the actual ending value is less than the coverage price, a loss is realized. Otherwise, there is no indemnity. Figure 3 shows loss ratios (total losses over total premiums) for LRP between 2005 and 2024. The total loss ratio is based on the premium remitted to the insurer, whereas the producer loss ratio is based on the producer-paid premiums. If the premiums on the policies are actuarially fair, then the loss ratio should average 100% over a long period of time. The loss ratio indicates good performance, which might be expected, given that there is limited potential for moral hazard or adverse selection under LRP (Boyer et al., 2024; Merritt et al., 2017; Haviland and Feuz, 2025).

Two crucial inputs to equation 2.1, which link LRP to the derivatives markets, are the expected ending value and the actual ending value. The expected ending value is published each day by RMA,[5]

[5] See `https://public.rma.usda.gov/livestockreports/LRPReport.aspx`

Figure 3: LRP Loss Ratios, 2005-2024


Note: Loss ratios are only for LRP on fed cattle, feeder cattle, and swine. They do not include LRP for lamb which was discontinued in 2021.

whereas the precise formula RMA uses to derive it is not publicly disclosed, though it is widely understood to draw on corresponding futures markets, with feeder cattle based on the CME feeder cattle futures, fed cattle based on CME live cattle futures, and swine based on CME lean hog futures (Boyer et al., 2024).

Actual ending values are based on the price of various indices at the end of the insurance period. In the case of LRP for feeder cattle, the actual ending value is the weighted average price of feeder cattle reported by the CME Feeder Cattle Reported Index at `https://www.cmegroup.com/market-data/browse-data/commodity-index-prices.html?redirect=/market-data/reports/cash-settled-commodity-index-prices.html`. For fed cattle, the price is calculated by the Agricultural Marketing Service (AMS) in the "5 Area Weekly Weighted Average Direct Slaughter Cattle" report at `https://mymarketnews.ams.usda.gov/viewReport/2477`. The calculated ending value for swine is slightly more complicated but is based on AMS price series used to settle the lean hog futures contract at CME. The report can be found online at `https://mymarketnews.ams.usda.gov/viewReport/2511`. Because the premiums and expected ending values for all LRP policies are ultimately based on futures markets, the potential for subsidy harvesting exists whether one is purchasing LRP for fed cattle, feeder cattle, or swine.

## 2.1 Related Literature

Our work connects to several strands of the literature, including the effects of subsidized crop insurance on producer behavior and market outcomes. Horowitz and Lichtenberg (1993) showed that subsidized insurance could induce moral hazard by encouraging production on marginal land. Young et al. (2001) and Goodwin et al. (2004) studied the effects of insurance subsidies on acreage decisions and found that subsidies modestly increased planted area. More recently, Yu et al. (2018) and Yu and Sumner (2018) examined how the design of insurance products interacts with producer risk preferences and commodity market conditions. Goodwin and Smith (2013) documented that rising subsidies on the crop side of the FCIP's book of business were associated with increased liability—much like the pattern we now observe in livestock insurance.

In contrast to crops, the behavioral effects of subsidizing livestock price insurance have received comparatively little attention. Yet, the concern that government-subsidized insurance could crowd out private risk management is long-standing. Glauber (2022) raised this possibility for livestock insurance specifically, noting that LRP's design as a subsidized put-option substitute creates a direct channel for substitution. Belasco (2025) examined the potential for livestock insurance to reduce commercial participation in commodity futures markets, with implications for price discovery and market liquidity.

Rapid growth of livestock insurance is recent, so the related literature is thin. What little LRP research has been conducted mainly focuses on the impact of changes to the subsidy structure on premiums (Boyer and Griffith, 2022) or factors affecting take-up (Boyer and Griffith, 2023; Boyer et al., 2024). A study by Merritt et al. (2017) examined the likelihood that producers would receive indemnities for feeder cattle under different insurance periods, while Haviland and Feuz (2025) conducted a similar assessment for all types of livestock. Baker (2023) and Baker (2024) discuss the arbitrage potential for subsidy harvesting in trade publications. On the question of subsidy harvesting specifically, Feuz (2025) and Zhang et al. (2026) offer empirical treatments of the extent of subsidy capture using LRP policies.

Our contribution, in the form of a theoretical framework, demonstrates that subsidized instruments can create arbitrage opportunities when they share features with market assets. In the LRP setting the insurance product mimics closely a traded derivative, the subsidy is large and well-defined, and the offsetting trade is straightforward for any producer with access to a commodity brokerage account. The institutional details described above—in particular, the tight link between LRP policy parameters and futures-market prices, the availability of matching options contracts, and the structure of premium subsidies—are what make subsidy harvesting feasible. The model we develop in the next section formalizes this relationship and derives the conditions under which rational producers would choose to harvest the subsidy rather than use LRP purely for risk management.

# 3 A Model of Livestock Producer Decisions with Subsidized Insurance

We develop a theoretical framework to analyze a livestock producer's strategic choices under price uncertainty, integrating futures markets, options, and subsidized insurance. The producer holds a fixed quantity of livestock and faces a decision among five distinct strategies: selling unhedged, purchasing subsidized price insurance (i.e., LRP), buying a market put option, conducting a clean subsidy harvest, or conducting a dirty subsidy harvest. Using a mean-variance certainty-equivalent criterion, we compare strategies on the basis of wealth, expected wealth, variance, and certainty equivalent.

## 3.1 Market Setup and Basic Assumptions

A livestock producer raises $Q$ cwt of livestock to sell at time $T$ and ranks risky strategies by a mean-variance certainty equivalent, with risk-preference parameter $\lambda$ (specified below); $W$ denotes wealth. The producer can transact in a futures market, where the time $t$ contract price for delivery at $T$ is denoted $F(t,T)$. Let $K$ denote the LRP coverage price and the strike price of the matching market option. In the illustrative benchmark, the terminal index price equals the cash price, $P(T)$, and follows a normal distribution with mean $F(t,T)$ and variance $\sigma_T^2$, i.e., $P(T) \sim N(F(t,T), \sigma_T^2)$. We focus first on the at-the-money case, $K = F(t,T)$. European put and call options are available on this futures contract and expire at $T$. The put premium is $\phi = \pi_{\text{fair}}$, and the call premium is $c$, again equal to $\pi_{\text{fair}}$ for at-the-money options under symmetry and a zero-rate simplification.[6] The protected sale price generated by holding the physical commodity and a long put has variance $\kappa\sigma_T^2$, where $\kappa < 1$.[7]

Subsidized insurance replicates a put option with strike $K$, costing the producer $\theta$. More generally, the harvestable amount is the difference between the private put premium and the producer-paid LRP

[6] Using European options, exercisable only at maturity, simplifies our expressions. The relevant Chicago Mercantile Exchange livestock options are generally American-style, meaning that buyers can exercise before expiration and writers can be assigned. Appendix C explains why we treat this as an implementation friction rather than part of the benchmark payoff identity.

[7] For example, the effective sale price for a producer who holds the physical commodity and a long put with strike $K = F(t,T)$ is $\max(P(T),K)$, since the option payoff $\max(K - P(T), 0)$ raises the realized sale price whenever market prices fall. Such a strategy sets the floor price at the strike so that the put option holder is exposed only to upside fluctuations. At the money, the put option's expected payoff is $\mathbb{E}[\max(K - P(T), 0)] = \delta\sigma_T$, where $\delta$ arises from the standard normal density's integral over positive values; it is calculated as $\delta = 1/\sqrt{2\pi} \approx 0.3989$. The protected sale price's variance is $\kappa\sigma_T^2$, where $\kappa = (\pi - 1)/(2\pi) \approx 0.341$. Censoring downside price fluctuations therefore reduces the variance of the protected sale price to about one-third of $\sigma_T^2$, the variability of the livestock price itself.

premium, $\phi - \theta$. In the benchmark case we set $\theta = \pi_{\text{fair}} - s$, where $\pi_{\text{fair}} = \mathbb{E}[\max(K - P(T), 0)] = \delta\sigma_T$, so that $s > 0$ is both the per-unit dollar value of the statutory premium subsidy and this premium difference. Below we refer to $s$ simply as the subsidy.

Our assumption that $P(T)$ follows a normal distribution amounts to a Bachelier model for futures prices, which we adopt for tractability.[8] We price options as expected payoffs, which assumes zero risk premia so that the physical and pricing measures coincide and the risk-free rate is negligible for option valuation purposes. When we later introduce a positive risk-free rate $r$ in the relaxed case, it enters only through the opportunity cost of margin, not through option pricing—consistent with our simplification. Finally, we set the strike equal to the current futures price for expositional clarity; we show in the clean subsidy harvest derivation below that the payoff identity itself does not depend on this and extends to LRP coverage levels under 100%.

To build intuition, we first impose simplifying assumptions: first, no transaction costs for options market transactions. Second, no basis risk—the spot price the producer faces in the local market equals the indexed market price used as the basis for futures, $P(T) = I(T)$, and so $F(t,T) = \mathbb{E}[I(T)] = K$. Third, we impose no margin requirements so options market participants face no margin costs. We relax these assumptions later to incorporate real-world frictions.

## 3.2 Decision Framework and Certainty Equivalents

At $t = 0$, the producer ranks strategies by a mean-variance certainty equivalent (CE)

$$\text{CE} = \mathbb{E}[W] - \frac{\lambda}{2}\text{Var}[W] \tag{3.1}$$

This trades expected wealth against wealth variance, scaled by the risk-preference parameter $\lambda$. Here, $\lambda > 0$ denotes risk aversion, $\lambda = 0$ risk neutrality, and $\lambda < 0$ a reduced-form speculative preference. We adopt this objective directly rather than deriving it from a particular expected-utility function. For $\lambda > 0$ it coincides with the second-order (mean-variance) approximation of expected utility under constant absolute risk aversion, and it is exact whenever wealth is normally distributed—as it is for the unhedged, clean subsidy harvest, and dirty subsidy harvest strategies below. For the subsidized-insurance and market-put strategies, whose payoffs are censored by the price floor $\max(P(T), K)$ and hence non-

[8] The normal model allows closed-form expressions for $\delta$ and $\kappa$ that clarify the economic intuition. Our qualitative results—the dominance rankings among strategies and the role of the subsidy in driving them—extend to standard option-pricing setups that impose, e.g., lognormality.

normal, the CE is a mean-variance approximation that neglects higher-order moments such as skewness.[9] We compare CEs under each of the five strategies: unhedged sale ($u$), subsidized insurance ($i$), market put option ($p$), clean subsidy harvest ($h_c$), and dirty subsidy harvest ($h_d$).

### 3.3 Illustrative Case

We begin with restrictive assumptions to isolate the core trade-offs among strategies. With no basis risk ($P(T) = I(T)$), no transaction costs, and no margin requirements, the producer faces price uncertainty only from $P(T) \sim N(F(t,T), \sigma_T^2)$, with strike $K = F(t,T)$. We derive each strategy's wealth, expected wealth, variance, and certainty equivalent in order to reveal its risk-return profile, and then compare strategies to understand the factors that would lead producers to select one or another.

#### 3.3.1 Unhedged Sale (u)

The producer waits until $T$ and sells $Q$ livestock at the cash market price $P(T)$

$$W_u = Q \cdot P(T) \tag{3.2}$$

Under our simplifying assumptions the producer's expected wealth is a function of the expected livestock price

$$\mathbb{E}[W_u] = Q \cdot F(t,T) \tag{3.3}$$

The producer's wealth variance reflects full exposure to price risk

$$\mathrm{Var}[W_u] = Q^2 \cdot \sigma_T^2 \tag{3.4}$$

The certainty equivalent is

$$\mathrm{CE}_u = Q \cdot F(t,T) - \frac{\lambda}{2} Q^2 \cdot \sigma_T^2 \tag{3.5}$$

This strategy incurs no costs but exposes the producer to the full range of price volatility, offering high returns if prices rise but significant losses if they fall. As a result it is unappealing to risk-averse producers.

[9] Adopting the CE as the primitive objective is also what lets us represent a speculative producer through $\lambda < 0$: in a literal constant-absolute-risk-aversion specification $u(W) = -\exp(-\gamma W)$, a negative $\gamma$ would give marginal utility $u'(W) = \gamma e^{-\gamma W} < 0$—a preference for less wealth, which is not what we mean by risk seeking—whereas the mean-variance CE stays increasing in certain wealth for any $\lambda$ and simply rewards variance when $\lambda < 0$.

### 3.3.2 Subsidized Insurance (i)

The producer purchases a subsidized insurance policy guaranteeing a minimum coverage price $K$ in exchange for a premium that is partially subsidized $\theta = \pi_{\text{fair}} - s$. This strategy mimics a put option, ensuring a price floor of at least $K$ per unit

$$W_i = Q \cdot (\max(P(T), K) - \theta) \tag{3.6}$$

Taking expectations gives[10]

$$\mathbb{E}[W_i] = Q \cdot (F(t,T) + s) \tag{3.7}$$

With the reduction offered by the price floor, the variance is now

$$\text{Var}[W_i] = Q^2 \cdot \kappa\sigma_T^2 \tag{3.8}$$

The certainty equivalent is

$$\text{CE}_i = Q \cdot (F(t,T) + s) - \frac{\lambda}{2} Q^2 \cdot \kappa\sigma_T^2 \tag{3.9}$$

With insurance the producer receives a floor price of $K$; the subsidy boosts the producer's expected wealth. This strategy's wealth variance is lower than being unhedged, making it attractive for risk-averse producers.

### 3.3.3 Market Put Option (p)

The producer could instead simply buy a market put option at the fair premium $\phi = \pi_{\text{fair}}$, securing a minimum price $K$ as in the case of (fairly-priced) insurance

$$W_p = Q \cdot (\max(P(T), K) - \pi_{\text{fair}}) \tag{3.10}$$

Taking expectations gives[11]

$$\mathbb{E}[W_p] = Q \cdot F(t,T) \tag{3.11}$$

[10] With $K = F(t,T)$, $\mathbb{E}[\max(P(T),K)] = F(t,T) + \delta\sigma_T$. Since $\theta = \pi_{\text{fair}} - s = \delta\sigma_T - s$, taking expectations generates $\mathbb{E}[W_i] = Q \cdot (F(t,T) + \delta\sigma_T - (\delta\sigma_T - s)) = Q \cdot (F(t,T) + s)$.

[11] Since $\mathbb{E}[\max(P(T),K)] = F(t,T) + \delta\sigma_T$, and $\pi_{\text{fair}} = \delta\sigma_T$, then $\mathbb{E}[W_p] = Q \cdot (F(t,T) + \delta\sigma_T - \delta\sigma_T) = Q \cdot F(t,T)$.

Wealth variance under the put matches that of the subsidized insurance strategy

$$\mathrm{Var}[W_p] = Q^2 \cdot \kappa\sigma_T^2 \tag{3.12}$$

Its certainty equivalent is the same, less the subsidy

$$\mathrm{CE}_p = Q \cdot F(t,T) - \frac{\lambda}{2} Q^2 \cdot \kappa\sigma_T^2 \tag{3.13}$$

Purchasing a put provides the same downside protection as subsidized insurance. Without benefit of the subsidy, however, it offers a lower expected wealth, making it less appealing.

### 3.3.4 Clean Subsidy Harvest $(h_c)$

To accomplish a clean subsidy harvest the producer first takes out a subsidized insurance policy at a given coverage price $K$, and then writes a call option with an equivalent strike price. Combined with the producer's endowed long cash market position, the two financial positions lock in a deterministic terminal payoff in the frictionless benchmark

$$W_{h_c} = Q \cdot (P(T) + \max(K - P(T), 0) - \theta + c - \max(P(T) - K, 0)) \tag{3.14}$$

This simplifies to[12]

$$W_{h_c} = Q \cdot (K - \theta + c) \tag{3.15}$$

Using $\theta = \pi_{\text{fair}} - s$ and $c = \pi_{\text{fair}}$ gives

$$W_{h_c} = Q \cdot (K + s) \tag{3.16}$$

Since $K = F(t,T)$, expected wealth is

$$\mathbb{E}[W_{h_c}] = Q \cdot (F(t,T) + s) \tag{3.17}$$

By locking in the strike plus the subsidy, the producer's wealth variance is zero in the frictionless benchmark; the terminal payoff is deterministic

$$\mathrm{Var}[W_{h_c}] = 0 \tag{3.18}$$

[12] See Appendix A for a proof that $P(T) + \max(K - P(T), 0) - \max(P(T) - K, 0) = K$.

The certainty equivalent is

$$\mathrm{CE}_{h_c} = Q \cdot (F(t,T) + s) \tag{3.19}$$

This strategy eliminates price risk in the frictionless benchmark by synthetically selling the livestock forward at $F(t,T)$, capturing the subsidy without exposure to price changes, ideal for highly risk-averse producers.

**Robustness to the coverage level.** The lock-in does not rely on the at-the-money assumption. For any strike $K$—an LRP coverage level below 100% corresponds to $K < F(t,T)$—put–call parity gives

$$\max(K - P(T), 0) - \max(P(T) - K, 0) = K - P(T),$$

so pairing the physical position with a long put and a short call at strike $K$ locks the price component at $K$. Under the same zero-rate option-pricing simplification used here, the short-call premium exceeds the long-put premium by $F(t,T) - K$, so the producer locks in $F(t,T) + s(K)$ net of costs, where $s(K)$ denotes the subsidy associated with the chosen coverage level. The dirty subsidy harvest's long and short puts at strike $K$ cancel for any $K$, so the producer retains exposure to $P(T)$ while capturing $s(K)$. The constants $\delta$ and $\kappa$ that govern the insurance and market-put variances vary with moneyness, but the subsidy-arbitrage logic is unchanged.

### 3.3.5 Dirty Subsidy Harvest ($h_d$)

The dirty subsidy harvest pairs the long cash market position with subsidized insurance and a short put option, canceling downside protection but capturing the subsidy

$$W_{h_d} = Q \cdot (P(T) + \max(K - P(T), 0) - \theta + \phi - \max(K - P(T), 0)) \tag{3.20}$$

Using $\phi = \pi_{\text{fair}}$ and $\theta = \pi_{\text{fair}} - s$, this simplifies to

$$W_{h_d} = Q \cdot (P(T) + s) \tag{3.21}$$

Expected wealth is

$$\mathbb{E}[W_{h_d}] = Q \cdot (F(t,T) + s) \tag{3.22}$$

The variance reflects full price risk

$$\mathrm{Var}[W_{h_d}] = Q^2 \cdot \sigma_T^2 \tag{3.23}$$

The certainty equivalent is

$$\mathrm{CE}_{h_d} = Q \cdot (F(t,T) + s) - \frac{\lambda}{2} Q^2 \cdot \sigma_T^2 \tag{3.24}$$

This strategy also harvests the subsidy but retains full price exposure, akin to an unhedged position but with a wealth boost from $s$, appealing to those producers willing to retain upside price exposure.

### 3.4 Comparing Strategies under Restrictive Assumptions

By comparing certainty equivalents, we determine which of the five strategies best suits a given producer. Without basis risk or frictions, all three subsidy-bearing strategies—subsidized insurance, the clean subsidy harvest, and the dirty subsidy harvest—deliver the same expected wealth, $F(t,T) + s$, so they are ranked purely by variance. For any risk-averse producer ($\lambda > 0$) this gives a strict ordering, $\mathrm{CE}_{h_c} > \mathrm{CE}_i > \mathrm{CE}_{h_d}$: the clean subsidy harvest, with zero variance, dominates; subsidized insurance, with the censored variance $\kappa\sigma_T^2$, is second; and the dirty subsidy harvest, with full variance $\sigma_T^2$, is last. Risk-neutral producers ($\lambda = 0$) are indifferent among the three, and the unhedged and market-put strategies are dominated throughout. Table 2 summarizes the strategies.

In this frictionless benchmark, then, the model does not by itself generate sorting *across* the three subsidy-bearing strategies for risk-averse producers: the clean subsidy harvest is uniformly preferred. Producers separate across strategies only after we move away from the benchmark in one of two ways. First, the frictions introduced in the general case below—transaction and margin costs borne by the subsidy-harvest strategies—lower expected wealth under the clean subsidy harvest and the dirty subsidy harvest relative to subsidized insurance. As a result, LRP alone can be the best choice for producers who are risk averse, but not risk averse enough to pay the added trading and margin costs required to harvest the subsidy. Second, a producer with a speculative preference ($\lambda < 0$) values the retained price exposure of the dirty subsidy harvest and may select it despite its higher variance. A producer with sufficiently bullish subjective beliefs about $P(T)$ could reach the same choice for a different reason, but that belief is not part of the maintained objective. We make the first channel explicit below and return to the second in the numerical illustration.

Table 2: Strategy summary under restrictive assumptions.

| **Strategy** | **Exposure to $P(T)$ at $T$** | **Wealth at $T$ ($W_T$)** | **Var$(W_T)$** | **Key Features** |
|---|---|---|---|---|
| Unhedged ($u$) | Full | $QP(T)$ | $Q^2\sigma_T^2$ | Nothing locked in; pure speculation. |
| Subsidized Insurance ($i$) | Upside only | $Q[\max(P(T),K)-\theta]$ | $Q^2\kappa\sigma_T^2$ | Subsidized floor at $K$; retains upside. |
| Market Put ($p$) | Upside only | $Q[\max(P(T),K)-\pi_{\text{fair}}]$ | $Q^2\kappa\sigma_T^2$ | Unsubsidized floor; more costly than insurance. |
| Clean Subsidy Harvest ($h_c$) | None | $Q(K+s)$ | 0 | Locks in $F(t,T)+s$; no possible upside. |
| Dirty Subsidy Harvest ($h_d$) | Full | $Q[P(T)+s]$ | $Q^2\sigma_T^2$ | Unhedged but harvests the subsidy. |

*Source:* Authors' calculations. *Notes:* The table summarizes the benchmark model with no basis risk, transaction costs, or margin costs. $W_T$ is terminal wealth; exposure describes residual terminal price risk after the strategy is implemented. $Q$ is insured quantity in cwt; $P(T)$ is the terminal livestock price, equal to the index price in the benchmark; $K$ is the LRP coverage price and option strike, set equal to $F(t,T)$, the time-$t$ futures price for maturity $T$, in the benchmark; $\theta$ is the producer-paid LRP premium; $\pi_{\text{fair}}$ is the fair market put premium; $s$ is the per-cwt subsidy; $\sigma_T^2 = \text{Var}[P(T)]$; and $\kappa$ is the variance share of the protected sale price relative to $\sigma_T^2$. The clean subsidy harvest combines LRP with a written call. The dirty subsidy harvest combines LRP with a written put.

### 3.4.1 Dirty Subsidy Harvest ($h_d$) versus Unhedged (u)

The dirty subsidy harvest adds the subsidy to the spot price

$$\mathbb{E}[W_{h_d}] - \mathbb{E}[W_u] = Q \cdot s \tag{3.25}$$

Since $\mathrm{Var}[W_{h_d}] = \mathrm{Var}[W_u] = Q^2 \cdot \sigma_T^2$, the certainty equivalent difference is

$$\mathrm{CE}_{h_d} - \mathrm{CE}_u = Q \cdot s \tag{3.26}$$

Since $s > 0$, $\mathrm{CE}_{h_d} > \mathrm{CE}_u$. The dirty subsidy harvest dominates the unhedged strategy because it increases expected wealth by the subsidy $s$ without altering variance. This dominance holds for all rational producers, including risk-neutral ($\lambda = 0$) and risk-averse ($\lambda > 0$), because the subsidy provides a cost-free (to the producer) wealth boost while retaining the same price exposure.

### 3.4.2 Subsidized Insurance (i) versus Market Put (p)

Subsidized insurance offers the same risk profile as the market put but includes the subsidy

$$\mathbb{E}[W_i] - \mathbb{E}[W_p] = Q \cdot s \tag{3.27}$$

Since variances are equal ($\mathrm{Var}[W_i] = \mathrm{Var}[W_p] = Q^2 \cdot \kappa\sigma_T^2$), the certainty equivalent difference is

$$\mathrm{CE}_i - \mathrm{CE}_p = Q \cdot s \tag{3.28}$$

Since $s > 0$, $\mathrm{CE}_i > \mathrm{CE}_p$. Subsidized insurance dominates the put option since the subsidy $s$ increases producer wealth without affecting risk. Rational producers always prefer the subsidized insurance.

### 3.4.3 Subsidized Insurance (i) versus Clean Subsidy Harvest ($h_c$)

The clean subsidy harvest locks in a deterministic payoff in the frictionless benchmark

$$\mathbb{E}[W_{h_c}] - \mathbb{E}[W_i] = 0 \tag{3.29}$$

Its variance is lower

$$\mathrm{Var}[W_{h_c}] = 0 < Q^2 \cdot \kappa\sigma_T^2 = \mathrm{Var}[W_i] \tag{3.30}$$

The certainty equivalent difference is

$$\text{CE}_{h_c} - \text{CE}_i = \frac{\lambda}{2} Q^2 \cdot \kappa \sigma_T^2 \tag{3.31}$$

Since the variance term is positive ($\lambda > 0$), $\text{CE}_{h_c} > \text{CE}_i$. For risk-averse producers, the clean subsidy harvest's deterministic payoff makes it superior, locking in a return equal to the futures-implied price plus the subsidy, $F(t,T) + s$, without exposure to price fluctuations. Risk-neutral producers ($\lambda = 0$) are indifferent due to equivalent expected wealth.

### 3.4.4 Subsidized Insurance (i) versus Dirty Subsidy Harvest ($h_d$)

The dirty subsidy harvest retains full price exposure

$$\mathbb{E}[W_{h_d}] - \mathbb{E}[W_i] = 0 \tag{3.32}$$

Its variance is higher

$$\text{Var}[W_{h_d}] = Q^2 \cdot \sigma_T^2 > Q^2 \cdot \kappa \sigma_T^2 = \text{Var}[W_i] \tag{3.33}$$

The certainty equivalent difference is

$$\text{CE}_{h_d} - \text{CE}_i = -\frac{\lambda}{2} Q^2 \cdot (1 - \kappa) \sigma_T^2 \tag{3.34}$$

Since the variance term is negative ($\lambda > 0$), $\text{CE}_i > \text{CE}_{h_d}$. Subsidized insurance dominates for risk-averse producers, as its price floor reduces risk while matching the dirty subsidy harvest's expected wealth. Risk-neutral producers ($\lambda = 0$) are once again indifferent due to shared expected wealth across strategies.

### 3.4.5 Clean Subsidy Harvest ($h_c$) versus Dirty Subsidy Harvest ($h_d$)

The clean subsidy harvest eliminates risk, while the dirty subsidy harvest retains it (along with upside potential)

$$\mathbb{E}[W_{h_c}] - \mathbb{E}[W_{h_d}] = 0 \tag{3.35}$$

The variance comparison is

$$\text{Var}[W_{h_c}] = 0 < Q^2 \cdot \sigma_T^2 = \text{Var}[W_{h_d}] \tag{3.36}$$

The certainty equivalent difference is

$$\mathrm{CE}_{h_c} - \mathrm{CE}_{h_d} = \frac{\lambda}{2} Q^2 \cdot \sigma_T^2 \tag{3.37}$$

Since the variance term is positive, $\mathrm{CE}_{h_c} > \mathrm{CE}_{h_d}$ and the clean subsidy harvest dominates overall for risk-averse producers. It fixes the terminal price component in the benchmark, while the dirty subsidy harvest is fully exposed to risk. Of course, risk-neutral producers ($\lambda = 0$) remain indifferent.

## 3.5 General Case: Relaxed Assumptions

We now relax the simplifying assumptions to incorporate real-world complexities: basis risk, transaction costs, and margin requirements. The cash market price is modeled as $P(T) = I(T) + b(T)$, where $I(T) \sim N(F(t,T), V_I)$ is the index or delivery market price tied to the relevant futures contract,[13] with variance $V_I = \sigma_T^2$, and $b(T) \sim N(\mu_b, V_b)$ is the local basis. The basis mean $\mu_b$ represents systematic differences (e.g., transportation costs or local supply and demand factors) between the producer's local price and the index price; thus, the expected cash market price is $\mathbb{E}[P(T)] = F(t,T) + \mu_b$, and the basis cannot be hedged away. Futures and options are written on the index, with $F(t,T) = \mathbb{E}[I(T)]$. We allow for a non-zero correlation $\rho$ between $I(T)$ and $b(T)$, so the variance of $P(T)$ is $\mathrm{Var}[P(T)] = V_I + V_b + 2\rho\sqrt{V_I V_b}$. Each option trade incurs a transaction cost $\tau > 0$, and writing options requires posting initial margin $m$ ($m_{\text{call}}$ for calls, $m_{\text{put}}$ for puts), with an opportunity cost of $m \cdot (e^{r\Delta t} - 1)$, where $r > 0$ is the risk-free rate and $\Delta t = T - t$. These frictions introduce unhedgeable basis risk, reduce expected wealth through transaction and margin costs, and alter the relative attractiveness of strategies, particularly those involving option writing (the clean subsidy harvest and the dirty subsidy harvest). Below, we describe each strategy and highlight how basis risk and costs modify outcomes compared to the illustrative case. Table 3 summarizes the strategies under these relaxed assumptions.

### 3.5.1 Unhedged Sale (u)

The producer sells $Q$ cwt at the spot price $P(T) = I(T) + b(T)$

$$W_u = Q \cdot (I(T) + b(T)) \tag{3.38}$$

[13] At the Chicago Mercantile Exchange, futures prices for Feeder Cattle and Lean Hogs settle to a cash-price index, while Live Cattle may be physically delivered. For simplicity we refer to $I(T)$ as the index cash price.

Expected wealth includes the expected basis

$$\mathbb{E}[W_u] = Q \cdot (F(t,T) + \mu_b) \tag{3.39}$$

Variance includes both index and basis risk, accounting for correlation

$$\text{Var}[W_u] = Q^2 \cdot (V_I + V_b + 2\rho\sqrt{V_I V_b}) \tag{3.40}$$

The certainty equivalent is

$$\text{CE}_u = Q \cdot (F(t,T) + \mu_b) - \frac{\lambda}{2} Q^2 \cdot (V_I + V_b + 2\rho\sqrt{V_I V_b}) \tag{3.41}$$

Unlike the illustrative case, where variance arises solely from $P(T)$, basis risk adds unhedgeable local price volatility. If non-zero, $\mu_b$ shifts expected wealth (higher if positive, lower if negative). A negative correlation ($\rho < 0$) may reduce variance below $V_I + V_b$, making this strategy less risky than under independence, but it remains exposed to both index and basis fluctuations, and perhaps less appealing than in the simplified scenario.

### 3.5.2 Subsidized Insurance (i)

The producer purchases subsidized insurance written on the index, guaranteeing a minimum price, but paying premium $\theta = \pi_{\text{fair}} - s$ and transaction cost $\tau$

$$W_i = Q \cdot (\max(I(T), K) + b(T) - \theta - \tau) \tag{3.42}$$

Expected wealth accounts for transaction costs and the expected basis[14]

$$\mathbb{E}[W_i] = Q \cdot (F(t,T) + s - \tau + \mu_b) \tag{3.43}$$

Variance includes basis risk, accounting for correlation[15]

[14] As in the illustrative case, $\mathbb{E}[\max(I(T),K)] = F(t,T) + \delta\sqrt{V_I}$, and $\theta = \delta\sqrt{V_I} - s$, but $\tau$ reduces wealth and $\mu_b$ adds to the expected basis.

[15] Because $I(T)$ and $b(T)$ are jointly normal, this covariance term is exact rather than approximate. Writing $X = I(T) - F(t,T)$ and $B = b(T) - \mu_b$, Stein's lemma gives $\text{Cov}(\max(X,0),B) = \mathbb{E}[\mathbf{1}\{X>0\}]\,\text{Cov}(X,B) = \frac{1}{2}\rho\sqrt{V_I V_b}$, since $\Pr(X>0) = \frac{1}{2}$ at the money. The protected-price variance is therefore $\kappa V_I + V_b + \rho\sqrt{V_I V_b}$ exactly; the same expression applies to the market put.

$$\mathrm{Var}[W_i] = Q^2 \cdot (\kappa V_I + V_b + \rho \sqrt{V_I V_b}) \tag{3.44}$$

The certainty equivalent is

$$\mathrm{CE}_i = Q \cdot (F(t,T) + s - \tau + \mu_b) - \frac{\lambda}{2} Q^2 \cdot (\kappa V_I + V_b + \rho \sqrt{V_I V_b}) \tag{3.45}$$

Compared to the illustrative case, transaction costs reduce expected wealth and basis risk increases wealth variance, but the subsidized floor on $I(T)$ lowers index-related risk. If non-zero, $\mu_b$ adjusts expected wealth (higher if positive, lower if negative), and a negative $\rho$ may reduce variance, making this strategy attractive if the subsidy outweighs costs and basis variance is low.

### 3.5.3 Market Put Option (p)

The producer buys a market put option on the index at the fair premium $\phi = \pi_{\text{fair}}$, incurring transaction cost $\tau$

$$W_p = Q \cdot (\max(I(T), K) + b(T) - \pi_{\text{fair}} - \tau) \tag{3.46}$$

Expected wealth is

$$\mathbb{E}[W_p] = Q \cdot (F(t,T) - \tau + \mu_b) \tag{3.47}$$

Variance matches the insurance strategy

$$\mathrm{Var}[W_p] = Q^2 \cdot (\kappa V_I + V_b + \rho \sqrt{V_I V_b}) \tag{3.48}$$

The certainty equivalent is

$$\mathrm{CE}_p = Q \cdot (F(t,T) - \tau + \mu_b) - \frac{\lambda}{2} Q^2 \cdot (\kappa V_I + V_b + \rho \sqrt{V_I V_b}) \tag{3.49}$$

Relative to the illustrative case, transaction costs lower wealth, and basis risk increases variance. The market put provides the same index floor as insurance but without the subsidy, making it less attractive unless insurance is unavailable. The basis $\mu_b$ adjusts expected wealth, and a negative $\rho$ may reduce its variance.

### 3.5.4 Clean Subsidy Harvest ($h_c$)

The clean subsidy harvest combines the long spot position, subsidized insurance, and a short call option to lock in the index price

$$W_{h_c} = Q \cdot \big(F(t,T) + b(T) + s - 2\tau - m_{\text{call}} \cdot (e^{r\Delta t} - 1)\big) \tag{3.50}$$

Expected wealth reflects frictions and the expected basis

$$\mathbb{E}[W_{h_c}] = Q \cdot \big(F(t,T) + s - 2\tau - m_{\text{call}} \cdot (e^{r\Delta t} - 1) + \mu_b\big) \tag{3.51}$$

Variance arises only from basis risk

$$\text{Var}[W_{h_c}] = Q^2 V_b \tag{3.52}$$

The certainty equivalent is

$$\text{CE}_{h_c} = Q \cdot \big(F(t,T) + s - 2\tau - m_{\text{call}} \cdot (e^{r\Delta t} - 1) + \mu_b\big) - \frac{\lambda}{2} Q^2 V_b \tag{3.53}$$

Unlike the illustrative case's zero variance, basis risk introduces unhedgeable volatility, and transaction and margin costs erode wealth. The basis $\mu_b$ adjusts expected wealth, but basis variance remains the only risk, making this strategy appealing for risk-averse producers if costs are low.

### 3.5.5 Dirty Subsidy Harvest ($h_d$)

The dirty subsidy harvest pairs the long spot position with subsidized insurance and a short put option, canceling downside protection

$$W_{h_d} = Q \cdot \big(I(T) + b(T) + s - 2\tau - m_{\text{put}} \cdot (e^{r\Delta t} - 1)\big) \tag{3.54}$$

Expected wealth is

$$\mathbb{E}[W_{h_d}] = Q \cdot \big(F(t,T) + s - 2\tau - m_{\text{put}} \cdot (e^{r\Delta t} - 1) + \mu_b\big) \tag{3.55}$$

Variance includes both index and basis risk

$$\text{Var}[W_{h_d}] = Q^2 \cdot (V_I + V_b + 2\rho\sqrt{V_I V_b}) \tag{3.56}$$

The certainty equivalent is

$$\mathrm{CE}_{h_d} = Q \cdot \big(F(t,T) + s - 2\tau - m_{\mathrm{put}} \cdot (e^{r\Delta t} - 1) + \mu_b\big) - \frac{\lambda}{2} Q^2 \cdot (V_I + V_b + 2\rho\sqrt{V_I V_b}) \tag{3.57}$$

Compared to the illustrative case, frictions reduce wealth, and basis risk amplifies variance, aligning this strategy's risk profile with unhedged. The basis $\mu_b$ adjusts expected wealth, but full exposure to $V_I + V_b + 2\rho\sqrt{V_I V_b}$ makes it less attractive for risk-averse producers when costs are significant (unless $\rho < 0$).

## 3.6 Comparing Strategies under Relaxed Assumptions

Real-world frictions—basis risk, transaction costs, and margin requirements—alter the trade-offs among strategies compared to the illustrative case. Basis risk introduces unhedgeable local price volatility, transaction costs erode expected wealth, and margin costs penalize strategies involving option writing. "Locking in" a price means fixing wealth with respect to the index price $I(T)$, leaving only basis risk, while exposure to $I(T)$ offers potential upside but also downside risk. We compare certainty equivalents to determine the optimal strategy for a risk-averse producer, maintaining the comparison order from the illustrative case but explaining why dominance relationships differ due to frictions. As in the illustrative case, the market put is dominated by subsidized insurance, which shares its variance but adds the subsidy. The unhedged strategy is dominated as well, but the cleanest argument runs through subsidized insurance rather than the dirty subsidy harvest: insurance raises expected wealth over unhedged by $Q(s-\tau)$—positive whenever the subsidy exceeds the single transaction cost, $s > \tau$—while lowering variance by $Q^2[(1-\kappa)V_I + \rho\sqrt{V_I V_b}]$, which is positive in the empirically relevant case in which index-price risk is large relative to basis risk ($\rho \geq -(1-\kappa)\sqrt{V_I/V_b}$). We therefore exclude the unhedged and market-put strategies from subsequent comparisons and, as in the restrictive case, focus on how a producer sorts among subsidized insurance and the two subsidy harvests according to risk preference.

Table 3: Summary of strategies under relaxed assumptions.

| **Strategy** | **Exposure to $P(T)$ at $T$** | **Wealth at $T$ ($W_T$)** | **Var($W_T$)** | **Key Features** |
|---|---|---|---|---|
| Unhedged ($u$) | Full: $P(T) = I(T) + b(T)$ | $Q[I(T) + b(T)]$ | $Q^2(V_I + V_b + 2\rho\sqrt{V_I V_b})$ | No costs; maximum price risk. |
| Subsidized Insurance ($i$) | $I(T)$ upside $+ b(T)$ | $Q[\max(I(T), K) + b(T) - \theta - \tau]$ | $Q^2(\kappa V_I + V_b + \rho\sqrt{V_I V_b})$ | Subsidized index floor; basis remains. |
| Market Put ($p$) | $I(T)$ upside $+ b(T)$ | $Q[\max(I(T), K) + b(T) - \pi_{\text{fair}} - \tau]$ | $Q^2(\kappa V_I + V_b + \rho\sqrt{V_I V_b})$ | Unsubsidized index floor. |
| Clean Subsidy Harvest ($h_c$) | Basis only: $b(T)$ | $Q[F(t,T) + b(T) + s - 2\tau - m_{\text{call}}(e^{r\Delta t} - 1)]$ | $Q^2 V_b$ | Locks in $F(t,T) + s$; basis & frictions remain. |
| Dirty Subsidy Harvest ($h_d$) | Full: $P(T) = I(T) + b(T)$ | $Q[I(T) + b(T) + s - 2\tau - m_{\text{put}}(e^{r\Delta t} - 1)]$ | $Q^2(V_I + V_b + 2\rho\sqrt{V_I V_b})$ | Harvests subsidy; keeps full price risk. |

*Source:* Authors' calculations. *Notes:* The table adds basis risk, transaction costs, and margin costs to the benchmark model. $W_T$ is terminal wealth; exposure describes residual terminal price risk after the strategy is implemented. $Q$ is insured quantity in cwt; $P(T) = I(T) + b(T)$ is the producer's terminal cash price; $I(T)$ is the terminal index or delivery-market price; $b(T)$ is local basis; $\mu_b = \mathbb{E}[b(T)]$; $K$ is the LRP coverage price and option strike; $F(t,T)$ is the time-$t$ futures price for maturity $T$; $\theta$ is the producer-paid LRP premium; $\pi_{\text{fair}}$ is the fair market put premium; $s$ is the per-cwt subsidy; $\tau$ is the per-cwt transaction cost; $m_{\text{call}}$ and $m_{\text{put}}$ are margin requirements for written calls and puts; $r$ is the risk-free rate; and $\Delta t$ is time to expiration. The variance terms are $V_I = \text{Var}[I(T)]$ for index-price risk and $V_b = \text{Var}[b(T)]$ for basis risk; $\rho = \text{Corr}(I(T), b(T))$, so $\text{Cov}(I(T), b(T)) = \rho\sqrt{V_I V_b}$. $\kappa$ is the variance share of the protected sale price relative to index-price variance. "Locks in" refers to the index-price component; basis risk remains. The clean subsidy harvest combines LRP with a written call. The dirty subsidy harvest combines LRP with a written put.

### 3.6.1 Dirty Subsidy Harvest ($h_d$) versus Unhedged (u)

The wealth difference includes frictions

$$\mathbb{E}[W_{h_d}] - \mathbb{E}[W_u] = Q \cdot (s - 2\tau - m_{\text{put}}(e^{r\Delta t} - 1)) \tag{3.58}$$

This is positive as long as the subsidy exceeds costs ($s > 2\tau + m_{\text{put}}(e^{r\Delta t} - 1)$). Since variances are equal ($\text{Var}[W_{h_d}] = \text{Var}[W_u] = Q^2(V_I + V_b + 2\rho\sqrt{V_I V_b})$), the certainty equivalent difference matches the wealth difference

$$\text{CE}_{h_d} - \text{CE}_u = Q \cdot (s - 2\tau - m_{\text{put}}(e^{r\Delta t} - 1)) \tag{3.59}$$

Unlike the illustrative case, where the dirty subsidy harvest always dominated unhedged due to the cost-free subsidy ($\text{CE}_{h_d} > \text{CE}_u$ by $Q \cdot s$), transaction and margin costs could conceivably offset it, making dominance conditional on the net subsidy being positive. The basis $\mu_b$ affects both strategies equally, since both sell at $P(T)$, so it does not affect the dominance relationship. When dominance holds, rational producers would always choose the dirty subsidy harvest for its net wealth gain.

### 3.6.2 Subsidized Insurance (i) versus Market Put (p)

The wealth difference reflects the subsidy

$$\mathbb{E}[W_i] - \mathbb{E}[W_p] = Q \cdot s \tag{3.60}$$

Since variances are equal ($\text{Var}[W_i] = \text{Var}[W_p] = Q^2(\kappa V_I + V_b + \rho\sqrt{V_I V_b})$), the certainty equivalent difference is

$$\text{CE}_i - \text{CE}_p = Q \cdot s \tag{3.61}$$

Since $s > 0$, subsidized insurance dominates, consistent with the illustrative case. The dominance holds because both strategies incur the same transaction cost $\tau$, and the subsidy provides a net wealth advantage without altering risk. Basis $\mu_b$ and its correlation to index price risk $\rho$ affect both strategies equally. As a result the market put is dominated and excluded from further comparisons.

### 3.6.3 Subsidized Insurance (i) versus Clean Subsidy Harvest ($h_c$)

The clean subsidy harvest incurs additional costs

$$\mathbb{E}[W_{h_c}] - \mathbb{E}[W_i] = Q \cdot (-\tau - m_{\text{call}}(e^{r\Delta t} - 1)) \tag{3.62}$$

Its variance is lower

$$\text{Var}[W_{h_c}] = Q^2 V_b < Q^2(\kappa V_I + V_b + \rho\sqrt{V_I V_b}) = \text{Var}[W_i] \tag{3.63}$$

The certainty equivalent difference is

$$\text{CE}_{h_c} - \text{CE}_i = Q(-\tau - m_{\text{call}}(e^{r\Delta t} - 1)) + \frac{\lambda}{2} Q^2(\kappa V_I + \rho\sqrt{V_I V_b}) \tag{3.64}$$

Unlike the illustrative case, where the clean subsidy harvest always dominated due to its deterministic nature, basis risk ($V_b$) and costs ($\tau$, $m_{\text{call}}$) make this a closer comparison. Basis $\mu_b$ shifts expected wealth for both equally, but its correlation to the index $\rho$ does not affect the clean subsidy harvest's variance, which depends only on $V_b$. The cost difference favors insurance, but the variance is lower for the clean subsidy harvest. Therefore, greater risk aversion (large $\lambda$) or higher index volatility ($V_I$) makes the clean subsidy harvest more attractive; it locks in $F(t,T) + s$ net of frictions. Instead, if transaction and margin costs are high and/or risk aversion is low, subsidized insurance may be preferred, especially if $\rho < 0$.

### 3.6.4 Subsidized Insurance (i) versus Dirty Subsidy Harvest ($h_d$)

The dirty subsidy harvest again faces additional costs

$$\mathbb{E}[W_{h_d}] - \mathbb{E}[W_i] = Q \cdot (-\tau - m_{\text{put}}(e^{r\Delta t} - 1)) \tag{3.65}$$

It likely also has more wealth variance

$$\text{Var}[W_{h_d}] = Q^2(V_I + V_b + 2\rho\sqrt{V_I V_b}) > Q^2(\kappa V_I + V_b + \rho\sqrt{V_I V_b}) = \text{Var}[W_i] \tag{3.66}$$

The certainty equivalent difference is

$$\text{CE}_{h_d} - \text{CE}_i = Q(-\tau - m_{\text{put}}(e^{r\Delta t} - 1)) - \frac{\lambda}{2} Q^2[(1-\kappa)V_I + \rho\sqrt{V_I V_b}] \tag{3.67}$$

Both terms are negative provided $\rho \geq -(1-\kappa)\sqrt{V_I/V_b}$ (so that the variance term favors insurance), which holds comfortably whenever index-price risk is large relative to basis risk; subsidized insurance then dominates for risk-averse producers. Unlike the illustrative case, where insurance dominated due to lower variance alone, frictions here further penalize the dirty subsidy harvest's higher variance and added costs. The basis $\mu_b$ wealth difference affects both equally, and a negative $\rho$ reduces variance for both, but insurance benefits more from the censored index variance ($\kappa V_I$).

### 3.6.5 Clean Subsidy Harvest ($h_c$) versus Dirty Subsidy Harvest ($h_d$)

The wealth difference depends on margin costs, but the difference is likely to be quite small if requirements are similar

$$\mathbb{E}[W_{h_c}] - \mathbb{E}[W_{h_d}] = Q \cdot (m_{\text{put}}(e^{r\Delta t}-1) - m_{\text{call}}(e^{r\Delta t}-1)) \tag{3.68}$$

The clean subsidy harvest variance is lower

$$\text{Var}[W_{h_c}] = Q^2 V_b < Q^2(V_I + V_b + 2\rho\sqrt{V_I V_b}) = \text{Var}[W_{h_d}] \tag{3.69}$$

The certainty equivalent difference is

$$\text{CE}_{h_c} - \text{CE}_{h_d} = Q(m_{\text{put}}(e^{r\Delta t}-1) - m_{\text{call}}(e^{r\Delta t}-1)) + \frac{\lambda}{2}Q^2(V_I + 2\rho\sqrt{V_I V_b}) \tag{3.70}$$

The variance term is positive provided $\rho > -\frac{1}{2}\sqrt{V_I/V_b}$ (always satisfied here, since index risk dominates basis risk), favoring the clean subsidy harvest for risk-averse producers. Unlike the illustrative case's clear dominance, basis risk and costs act to narrow the gap. Still, the clean subsidy harvest's elimination of index (underlying asset) risk makes it preferable when basis variance is low.

**Sorting across strategies.** Collecting the relaxed-case comparisons—and assuming $s > 0$ for the market-put comparison and $s > \tau$, with index-price risk large relative to basis risk, for the unhedged comparison—the producer's choice among the three subsidy-bearing strategies is governed by the risk-preference parameter $\lambda$. Write $\Delta V_{i,h_c} = \kappa V_I + \rho\sqrt{V_I V_b}$ for the per-unit variance reduction in moving from LRP alone to the clean subsidy harvest, and $\Delta V_{h_d,i} = (1-\kappa)V_I + \rho\sqrt{V_I V_b}$ for the per-unit variance increase in moving from LRP alone to the dirty subsidy harvest. Assuming these variance differences are positive, the clean subsidy harvest is preferred to LRP alone when

$$\lambda > \frac{2\left[\tau + m_{\text{call}}(e^{r\Delta t} - 1)\right]}{Q\Delta V_{i,h_c}}, \tag{3.71}$$

and the dirty subsidy harvest is preferred to LRP alone when

$$\lambda < -\frac{2\left[\tau + m_{\text{put}}(e^{r\Delta t} - 1)\right]}{Q\Delta V_{h_d,i}}. \tag{3.72}$$

When written-call and written-put margin costs are similar, and when index-price risk dominates basis risk, these thresholds divide producers into three economically relevant groups. A sufficiently risk-averse producer (large positive $\lambda$) conducts the clean subsidy harvest. A producer with intermediate risk preferences—including risk neutrality—purchases LRP alone, because the variance reduction from subsidy harvesting does not justify its added trading and margin costs. A sufficiently speculative producer (negative $\lambda$) conducts the dirty subsidy harvest, accepting full price exposure in exchange for the subsidy and retained upside. Frictions are essential to this result: in their absence the clean subsidy harvest weakly dominates LRP alone for all $\lambda \geq 0$, and the middle group collapses.

# 4 Numerical Illustration

To make the model's predictions more concrete, we calibrate an example using parameters representative of a typical feeder cattle producer. Suppose the producer insures $H = 62$ head of feeder cattle with a target weight of $TW = 8$ cwt per head, implying a total quantity $Q = H \times TW \approx 500$ cwt—the equivalent of one CME feeder cattle futures contract. Recent futures prices and price volatility for the related futures contract were around $F(t,T) =$ \$260/cwt and $\sigma_T =$ \$20/cwt over a 26-week insurance period ($\Delta t = 0.5$ years), respectively. Assume that the producer selects the 100% coverage level, which carries a 35% premium subsidy. Under these assumptions, the actuarially fair premium is $\pi_{\text{fair}} = \delta\sigma_T \approx$ \$7.98/cwt, the per-unit subsidy is $s \approx$ \$2.79/cwt, and the producer-paid insurance premium is then $\theta \approx$ \$5.19/cwt.

For the relaxed case, we set basis at $\mu_b = -$\$3/cwt (reflecting transportation discounts faced by producers), and its standard deviation $\sqrt{V_b} =$ \$3/cwt, the cash-futures price correlation $\rho = 0.8$, transaction cost $\tau =$ \$0.40/cwt per trade, margin requirement $m =$ \$12/cwt, and a risk-free rate of $r = 0.045$. The opportunity cost tied to margining is therefore $m(e^{r\Delta t} - 1) \approx$ \$0.27/cwt. The producer's total livestock value is approximately \$130,000, implying that the net subsidy after transaction and margin costs for a clean subsidy harvest is approximately \$860. That is small relative to the total value of the livestock, but it is sufficient to shift certainty equivalent rankings depending on risk preferences because it is accompanied by a large reduction in variance.

We generate certainty equivalents using relative risk aversion $R$, which is more interpretable across wealth levels than the absolute coefficient $\lambda$. The two are related by $\lambda = R/W$, where $W$ is a reference wealth level (here, the expected wealth of the unhedged position). We use three values of the risk-preference parameter to represent different producer types: one who is risk-averse ($R = 3$),[16] one who is risk-neutral ($R = 0$), and a third who is (symmetrically) risk-seeking ($R = -3$, i.e. $\lambda < 0$). Consistent with the reduced-form treatment of the certainty equivalent above, the risk-seeking type represents a producer who values return variance positively—for example, a subsidy harvester willing to trade price protection for upside, or one who perceives an informational advantage and behaves on the margin as if risk-seeking.

Table 4: Numerical illustration: strategy comparison for a feeder cattle producer (single contract).

| | | | **Certainty Equivalent ($)** | | |
|---|---|---|---|---|---|
| **Strategy** | **E[$W$] ($)** | **SD($W$) ($)** | $R = 3$ | $R = 0$ | $R = -3$ |
| *Panel A: Illustrative case (no frictions)* | | | | | |
| Unhedged ($u$) | 130,000 | 10,000 | 128,846 | 130,000 | 131,154 |
| Subsidized Insurance ($i$) | 131,396 | 5,840 | 131,003 | **131,396** | 131,790 |
| Market Put ($p$) | 130,000 | 5,840 | 129,607 | 130,000 | 130,393 |
| Clean Subsidy Harvest ($h_c$) | 131,396 | 0 | **131,396** | **131,396** | 131,396 |
| Dirty Subsidy Harvest ($h_d$) | 131,396 | 10,000 | 130,243 | **131,396** | **132,550** |
| *Panel B: Relaxed case (with frictions)* | | | | | |
| Unhedged ($u$) | 128,500 | 11,236 | 127,026 | 128,500 | 129,974 |
| Subsidized Insurance ($i$) | 129,697 | 6,952 | 129,133 | **129,697** | 130,261 |
| Market Put ($p$) | 128,300 | 6,952 | 127,736 | 128,300 | 128,864 |
| Clean Subsidy Harvest ($h_c$) | 129,360 | 1,500 | **129,334** | 129,360 | 129,386 |
| Dirty Subsidy Harvest ($h_d$) | 129,360 | 11,236 | 127,886 | 129,360 | **130,834** |

Notes: We use the following parameters to generate the expected wealth, its standard deviation, and the certainty equivalents of the producer strategies: $Q = 500$ cwt (one CME feeder cattle contract, ≈62 head), $F(t,T) = \$260$/cwt, $\sigma_T = \$20$/cwt, $\delta \approx 0.399$, $\kappa \approx 0.341$, $s = \$2.79$/cwt. Relaxed case adds: $\mu_b = -\$3$/cwt, $\sqrt{V_b} = \$3$/cwt, $\rho = 0.8$, $\tau = \$0.40$/cwt, $m = \$12$/cwt, $r = 0.045$, $\Delta t = 0.5$ years. Transaction costs are expressed per cwt per transaction; $\tau$ applies to purchasing LRP, buying a market put, or writing an option. Subsidized insurance and the market put each involve one trade; the clean subsidy harvest and the dirty subsidy harvest each involve two (purchasing LRP plus writing an option). Margin costs apply only to written options (the clean subsidy harvest and the dirty subsidy harvest). Bold entries indicate the dominant strategy within each panel and risk-preference column. Certainty equivalents computed as $\text{CE} = \mathbb{E}[W] - \frac{R}{2W}\text{Var}[W]$, where $R$ is relative risk aversion and $W$ is reference wealth of the unhedged strategy. All values in the table are rounded to the nearest dollar.

Table 4 reports the expected wealth, wealth standard deviation, and certainty equivalents associ-

[16] This level of risk-aversion is consistent with those commonly estimated in the literature (Hardaker et al., 2004; Moschini and Hennessy, 2001).

ated with each strategy across three different producers, classified by their risk-preference: risk-averse ($R = 3$), risk-neutral ($R = 0$), and risk-seeking ($R = -3$). Several features are worth noting. In the frictionless case (Panel A), the clean subsidy harvest delivers the highest certainty equivalent for risk-averse producers, confirming the model's prediction. By conducting the clean subsidy harvest the risk-averse producer effectively secures an arbitrage trade—capturing the full subsidy while eliminating all price risk in the frictionless benchmark—generating a certainty equivalent equal to expected wealth. By contrast, the dirty subsidy harvest dominates for risk-seeking producers: it delivers the same expected wealth as the clean subsidy harvest but retains the full variance of the unhedged position—offering the chance to earn additional returns. For the risk-neutral producer, with $R = 0$, all three subsidy-capturing strategies (subsidized insurance, the clean subsidy harvest, and the dirty subsidy harvest) are tied; each produces the same expected wealth and CE, given that risk-neutral producers are indifferent to variance.

Panel B introduces frictions for each strategy, and although they attenuate the magnitude of CE differences, the strategy ordering is generally maintained across risk preferences after accounting for added costs. In the relaxed case, the clean subsidy harvest remains the dominant strategy for the risk-averse producer, though its CE premium over subsidized insurance shrinks from \$393 to \$201 as transaction and margin costs erode part of the subsidy. The dirty subsidy harvest still dominates for risk-seeking producers in Panel B, but its certainty equivalent now exceeds subsidized insurance by just \$573. This is because it now incurs the additional transaction and margin costs of writing the offsetting put—reducing its expected wealth below the subsidized insurance choice by \$337. For risk-neutral producers, adding frictions leads subsidized insurance to strictly dominate: insurance avoids the cost of the exchange trades, which are required by both types of subsidy harvests.

Another key result is that the unhedged and market-put strategies are never optimal in either panel: each is dominated, for every risk preference, by a strategy involving subsidized insurance. The market put is dominated by subsidized insurance alone—identical risk, but the subsidy creates an advantage no risk preference can close. The unhedged position is dominated by the dirty subsidy harvest, which keeps full price exposure but adds the subsidy (net of costs in the relaxed case); risk-averse and risk-neutral producers can also beat it with subsidized insurance alone. Some form of subsidized insurance—LRP alone, the clean subsidy harvest, or the dirty subsidy harvest—is therefore optimal for every risk-preference type. As a result, subsidizing livestock insurance may crowd out producers' trading of market options, unless it also invites subsidy harvesting.

# 5 Conclusions

Rapid take-up of LRP following policy changes and subsidy increases in 2019 and 2020 raises concerns about spiking taxpayer costs (Glauber, 2022; Belasco, 2025). In addition, the design of the price-based insurance policy—when similar market-based instruments are available—presents the possibility of unintended market consequences, including the potential for subsidy harvesting by using offsetting options trades to effect subsidy arbitrage. We provide a theoretical framework to demonstrate how subsidized LRP, which mimics a market put option, leaves open the door to different types of subsidy harvests: one that locks in the futures-implied price plus the subsidy via short calls, eliminating index-price risk in a world without frictions but capping upside, and another that uses short puts to capture the subsidy while retaining full price exposure, undermining risk management objectives.

From a policy perspective, these findings highlight an inefficiency inherent in subsidized livestock price insurance. By establishing a policy program so similar to existing market derivatives, USDA left the door open to unintended subsidy capture behavior, possibly counter to the program's objectives of reducing producer revenue risk. Such activity, conducted via taking offsetting positions in the options markets, represents a rent transfer from taxpayers—and a costly one—given the administrative overhead of running the insurance and reinsurance system required to deliver those payments. Recent program amendments now prohibit offsetting positions intended to generate subsidy harvests and identify specific presumptive trading patterns (U.S. Department of Agriculture, Risk Management Agency, 2025, 2026a). These presumptions explicitly cover short put positions and certain call-plus-futures structures that replicate a short put. A standalone short call—the basis of the clean subsidy harvest in our model—is not one of the enumerated presumptions, but the prohibition is purpose-based: RMA may still determine subsidy capture if a compliance review finds that the primary purpose was arbitraging the subsidy rather than managing risk. Moreover, enforcing a ban on offsetting positions requires RMA or AIPs to monitor producers' derivatives market activity, a task that is difficult when brokerage accounts are held at separate institutions from the insurance provider.

Our model predicts that subsidizing LRP could have indeterminate effects on derivatives markets, possibly crowding out or crowding in options trading—depending on the risk tolerance and trading costs of livestock producers—with implications for derivatives market liquidity and price discovery. Observable patterns consistent with subsidy harvesting would include increased open interest in livestock options coinciding with LRP enrollment periods, particularly in contracts whose maturities align with common insurance periods. Empirical investigation of these patterns and the magnitude of subsidy harvesting in practice is left for future research.

The broader lesson that emerges from recent LRP experience, however, is that when a government program subsidizes an instrument that closely replicates a privately-traded derivative, the subsidy itself becomes the object of optimization rather than the risk management it was intended to support. This observation applies beyond livestock insurance to any setting in which subsidized insurance or guarantee programs overlap with liquid derivatives markets. Program designers should consider whether any arbitrage opportunities may be produced and whether they undermine the program's goals. If so, simpler transfer mechanisms—such as direct payments—could be employed to achieve the same distributional objectives at lower taxpayer cost.

## References


Baker, D. (2023, December). White paper on subsidy harvesting. CIH. Accessed May 30, 2026.

Baker, D. (2024, February). Livestock price insurance – the do's and the don'ts. CIH. Accessed May 30, 2026.

Barua, S. (2024). Risk Preferences Impact on Cattle Producers' Use of Price Risk Management. Master's thesis, University of Tennessee.

Belasco, E. J. (2025). The public cost, private gains, and budgetary implications of federal livestock and forage insurance expansion. Report, American Enterprise Institute.

Boyer, C. N., K. L. DeLong, A. P. Griffith, and C. C. Martinez (2024). Factors influencing united states cattle producers use of livestock risk protection. *Agricultural Economics 55*(4), 677–689.

Boyer, C. N. and A. P. Griffith (2022). Livestock risk protection subsidies changes on producer premiums. *Agricultural Finance Review 83*(2), 201–210.

Boyer, C. N. and A. P. Griffith (2023). Subsidy rate changes on livestock risk protection for feeder cattle. *Journal of Agricultural and Resource Economics 48*(1), 31–45.

Carrico, J. (2024). Risk management tool may cause cattle market price fluctuations. `https://www.dtnpf.com/agriculture/web/ag/news/article/2024/02/01/lrp-affecting-cattle-market`. Progressive Farmer, accessed July 11, 2025.

Feuz, R. (2025). Evaluation of pricing within livestock risk protection insurance and the associated vulnerability towards subsidy harvesting. Poster, AAEA. Poster presented at the 2025 AAEA and WAEA Joint Annual Meeting, July 27–29, Denver, Colorado.

Glauber, J. W. (2022). The US Animal Insurance Program: Rapid Expansion at a Growing Cost to Taxpayers. Report, American Enterprise Institute.

Goodwin, B. K. and V. H. Smith (2013). What harm is done by subsidizing crop insurance? *American Journal of Agricultural Economics 95*(2), 489–497.

Goodwin, B. K., M. L. Vandeveer, and J. L. Deal (2004). An empirical analysis of acreage effects of participation in the federal crop insurance program. *American Journal of Agricultural Economics 86*(4), 1058–1077.

Hardaker, J. B., R. B. M. Huirne, G. Lien, and J. R. Anderson (2004). *Coping with Risk in Agriculture* (2nd ed.). Wallingford, UK: CABI Publishing.

Haviland, L. B. and R. Feuz (2025). Enhancing decision making in livestock risk protection insurance: Insights into optimal lrp contract selection. *Journal of Agricultural and Resource Economics 50*(2), 221–239.

Hill, S. (2015). Exploring producer perceptions for cattle price and animal performance in the stocker industry. Master's thesis, Kansas State University.

Horowitz, J. K. and E. Lichtenberg (1993). Insurance, moral hazard, and chemical use in agriculture. *American Journal of Agricultural Economics 75*(4), 926–935.

McKendree, M. G. S., G. T. Tonsor, and L. L. Schulz (2021). Management of multiple sources of risk in livestock production. *Journal of Agricultural and Applied Economics 53*(1), 75–93.

Merritt, M. G., A. P. Griffith, C. N. Boyer, and K. E. Lewis (2017). Probability of receiving an indemnity payment from feeder cattle livestock risk protection insurance. *Journal of Agricultural and Applied Economics 49*(3), 363–381.

Moschini, G. and D. A. Hennessy (2001). Uncertainty, risk aversion, and risk management for agricultural producers. In B. L. Gardner and G. C. Rausser (Eds.), *Handbook of Agricultural Economics*, Volume 1, Chapter 2, pp. 88–153. Elsevier.

Peck, A. E. (1985). Economic role of traditional commodity futures markets. In A. E. Peck (Ed.), *Futures Markets: Their Economic Role*, pp. 1–81. Washington, D.C.: American Enterprise Institute for Public Policy Research.

Rosch, S. (2021). Federal Crop Insurance: A Primer. Report R46686, Congressional Research Service.

Rosch, S. (2022). Farm Bill Primer: Federal Crop Insurance Program. In Focus IF12201, Congressional Research Service.

U.S. Department of Agriculture, Risk Management Agency (2025, April). PM-25-028: Livestock risk protection, livestock gross margin, and dairy revenue protection – modifications effective for 2026 and succeeding crop years. Product Management Bulletin PM-25-028, April 30, 2025; accessed May 30, 2026.

U.S. Department of Agriculture, Risk Management Agency (2026a). Livestock risk protection frequently asked questions. Accessed May 30, 2026.

U.S. Department of Agriculture, Risk Management Agency (2026b). Summary of business: Livestock and dairy participation. Current and historical livestock and dairy participation data; accessed May 26, 2026.

Working, H. (1953). Futures trading and hedging. *American Economic Review 43*(3), 314–343.

Young, C. E., M. L. Vandeveer, and R. D. Schnepf (2001). Production and price impacts of US crop insurance programs. *American Journal of Agricultural Economics 83*(5), 1196–1203.

Yu, J., A. Smith, and D. A. Sumner (2018). Effects of crop insurance premium subsidies on crop acreage. *American Journal of Agricultural Economics 100*(1), 91–114.

Yu, J. and D. A. Sumner (2018). Effects of subsidized crop insurance on crop choices. *Agricultural Economics 49*(4), 533–545.

Zhang, Y., A. Keller, S. Arita, and S. Steinbach (2026). Timing, trading frictions, and the limits of subsidy capture in livestock risk protection. In B. Goodwin and T. Deryugina (Eds.), *Risk and Risk Management in the Agricultural Economy*, Chapter 2. University of Chicago Press.

# Appendix

## A The Clean Subsidy Harvest Locks in a Fixed Indexed Price

As we show in the text, the clean subsidy harvest strategy combines a subsidized, synthetic long put option with a short call option to provide the producer with a deterministic indexed price, given the benchmark assumptions. The simplification used in the text is

$$P(T) + \max(K - P(T), 0) - \max(P(T) - K, 0) = K \tag{A.1}$$

To verify this, consider two cases based on the terminal price $P(T)$.

**Case 1:** $P(T) < K$**.** The insurance policy pays off at $\max(K - P(T), 0) = K - P(T)$, while the call expires worthless, $\max(P(T) - K, 0) = 0$. As a result

$$P(T) + (K - P(T)) - 0 = K \tag{A.2}$$

**Case 2:** $P(T) \geq K$**.** The insurance policy does not pay because the livestock price is too high, $\max(K - P(T), 0) = 0$; on the other hand the producer must settle the call option and pay the holder $\max(P(T) - K, 0) = P(T) - K$. In this case

$$P(T) + 0 - (P(T) - K) = K \tag{A.3}$$

No matter which outcome is realized as $t$ approaches $T$, the indexed price component is deterministic. This clean subsidy harvest locks in a fixed indexed price of $K$; with $K = F(t, T)$, this is the futures-implied price used in the benchmark.

## B Wealth Variance is Lower Under a Long Put than When Unprotected

Assume that $P(T) \sim N(F(t, T), \sigma_T^2)$ and $K = F(t, T)$, with an at-the-money strike. The protected price is $\max(P(T), K) = K + \max(P(T) - K, 0)$. Begin by normalizing so that $Z = \frac{P(T) - K}{\sigma_T} \sim N(0, 1)$. Then, restating

$$\max(P(T), K) = K + \sigma_T \max(Z, 0).$$

The variance is

$$\mathrm{Var}[\max(P(T),K)] = \sigma_T^2 \mathrm{Var}[\max(Z,0)],$$

where

$$\mathrm{Var}[\max(Z,0)] = \mathbb{E}[\max(Z,0)^2] - (\mathbb{E}[\max(Z,0)])^2.$$

The first term is

$$\mathbb{E}[\max(Z,0)] = \int_0^\infty z \cdot \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz = \frac{1}{\sqrt{2\pi}} = \delta \approx 0.3989.$$

The second term is

$$\mathbb{E}[\max(Z,0)^2] = \int_0^\infty z^2 \cdot \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz = \frac{1}{2},$$

since the full $\mathbb{E}[Z^2] = 1$, and symmetry gives half for $z > 0$. Thus

$$\mathrm{Var}[\max(Z,0)] = \frac{1}{2} - \delta^2 = \frac{1}{2} - \frac{1}{2\pi} = \frac{\pi - 1}{2\pi} = \kappa \approx 0.34085.$$

Since $\kappa = \frac{\pi-1}{2\pi} < 1$ (as $\pi \approx 3.1416$, $\pi - 1 < 2\pi$), we have

$$\mathrm{Var}[\max(P(T),K)] = \kappa \sigma_T^2 < \sigma_T^2 = \mathrm{Var}[P(T)].$$

The inequality holds because the price floor censors downside fluctuations, reducing variability while retaining only upside deviations.

# C American Options and Early Exercise

Our benchmark assumes European options, exercisable only at maturity $T$, so that each strategy's terminal payoff takes the closed form used in the text. The relevant CME livestock options are generally American-style, so the buyer may exercise before expiration and the writer may be assigned before $T$. We treat the European case as the transparent payoff benchmark deliberately: it is what establishes that LRP replicates a put-like payoff and that an offsetting option position can convert the subsidy into rent. American options are weakly more valuable than otherwise identical European options, since the early-exercise right can only add value. Our benchmark abstracts from any resulting early-exercise premium and uses the European case to isolate the terminal-payoff logic.

American exercise can, however, create assignment before $T$ for a written option. Once assigned, the writer receives a futures position, and the resulting terminal payoff depends on whether that position is subsequently closed, rolled, or held to maturity—so it need not reproduce the European payoff mechanically. We therefore do not claim terminal equivalence under American exercise; establishing it would require modeling the producer's response to assignment, which is beyond our scope.

Instead, we interpret American exercise as an added implementation friction. Early assignment, together with the daily margining of written options, introduces timing, liquidity, and margin risk that falls on the strategies that write options—the clean subsidy harvest and the dirty subsidy harvest. For financially constrained or highly risk-averse producers, these frictions reduce the attractiveness of subsidy harvesting relative to holding subsidized insurance alone, reinforcing rather than reversing the rankings derived in the text.