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A Real Option Approach to NGT-Free Supply Chains

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Motivation: A Structural Asymmetry

The EU NGT framework grants NGT1 varieties conventional status, no mandatory product-level labelling, no traceability at the product stage.

NGT1 crops	Conventional market	NGT-free operators
• Treated as conventional • No mandatory product labelling • May enter supply chains unlabelled	• NGT material may be present • Invisible to downstream buyers • No public traceability obligation	• Cannot rely on public labelling • Must invest in private segregation, testing, and certification • Bear the full cost of differentiation

→ **The entire burden of maintaining NGT-free differentiation falls on private actors.**

These investments are partly irreversible: dedicated storage, PCR testing, certification, long-term supplier contracts.

Real Options

Standard DCF: invest if expected NPV > 0.

- This ignores that irreversible investment destroys a valuable option, the right to invest later, under better information. Rational operators will not invest the moment NPV turns positive; they wait.

The investment threshold is not break-even, it is break-even × real-options wedge.

Market volatility (σ)

Fluctuations in NGT-free premia. Higher σ → more valuable to wait → higher threshold.

Contamination risk (γ)

Poisson arrival rate of contamination or certification-failure events. Higher γ → higher threshold.

Real-options wedge $\beta/(\beta-1)$

Always > 1 under irreversibility and uncertainty. Rises with both σ and γ .

$$\text{Investment threshold: } \pi^* = \frac{1}{Q_t} \left(\frac{\beta}{\beta-1} IR^{IP} + C_t^{IP} \right).$$

The Model: Jump-Diffusion and the Investment Threshold

Value process (jump-diffusion):

$$d\Delta v_t = \Delta v_t(\alpha dt + \sigma dz_t - \phi dq_t)$$

α : drift; σ : volatility; dz : Wiener process

dq : Poisson jump (rate γ); ϕ : proportional loss per event

Bellman ODE (continuation region):

$$\frac{1}{2}\sigma^2\Delta v_t^2 F''(\Delta v) + \alpha\Delta v_t F'(\Delta v) + \gamma F((1-\phi)\Delta v) = (r+\gamma)F(\Delta v)$$

Power-form solution $F(\Delta v) \propto \Delta v^\beta \rightarrow$ substitute into ODE:

$$\frac{1}{2}\sigma^2\beta(\beta-1) + \alpha\beta - (r+\gamma) + \gamma(1-\phi)^\beta = 0$$

$\phi = 1$ (baseline, full loss):

Jump term $(1-\phi)^\beta$ vanishes $\rightarrow$ quadratic in $\beta \rightarrow$ closed form:

$$\beta = \frac{(\frac{1}{2}\sigma^2 - \alpha) + \sqrt{\left(\alpha - \frac{1}{2}\sigma^2\right)^2 + 2\sigma^2(r+\gamma)}}{\sigma^2}$$

$\phi \in (0,1)$ (partial loss, extension):

$(1-\phi)^\beta$ is transcendental, no elementary closed form.

(i) **IFT**: differentiating $G(\beta, \phi) = 0$ implicitly gives $d\beta/d\phi = \gamma\beta(1-\phi)^{\beta-1} / \partial G/\partial\beta > 0$ — exact sign, no approximation

(ii) **Newton-Raphson**: iterate $\beta_{n+1} = \beta_n - g(\beta_n)/g'(\beta_n)$ from $\beta_0 = \text{eq. (13)}$; converges in 5 iterations

$$\text{Investment threshold } \pi^* = \frac{1}{Q_t} \left(\frac{\beta}{\beta-1} IR^{IP} + C_t^{IP} \right) \quad \beta > 1 \Rightarrow \pi^* > \text{break-even, always.}$$

The Contamination Jump: What Makes This Setting Different

Brownian motion captures continuous premium uncertainty, standard in real options models.

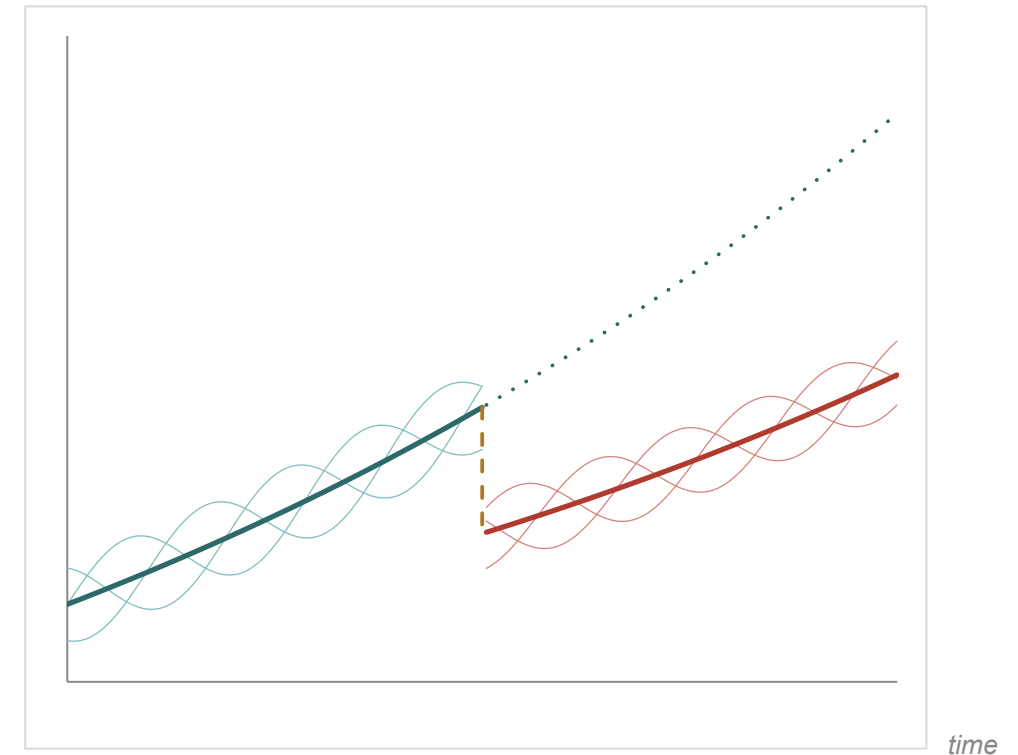
Poisson jump captures contamination or certification-failure events:

- Arrive suddenly and discretely
- Can void certified NGT-free status
- Difficult to attribute (no mandatory label on NGT1)
- Reduce Δv proportionally by ϕ per event

γ enters the investment threshold through the adjusted discount rate ($r + \gamma$),

not only through expected loss per event.

Δv



- Normal operation (drift + volatility)
- Contamination event (arrival rate γ)
- Post-event value (reduced by ϕ)

Results: Both Crops Predict WAIT

	Maize	Soybean
β (positive root)	1.681	1.546
Irreversibility premium $\beta/(\beta-1)$	2.47×	2.83×
Break-even premium (€/t)	€33	€47
Observed market premium (€/t)	€15	€55
Gap vs π^*	−€54.74/t	−€56.11/t
Decision	X WAIT	X WAIT

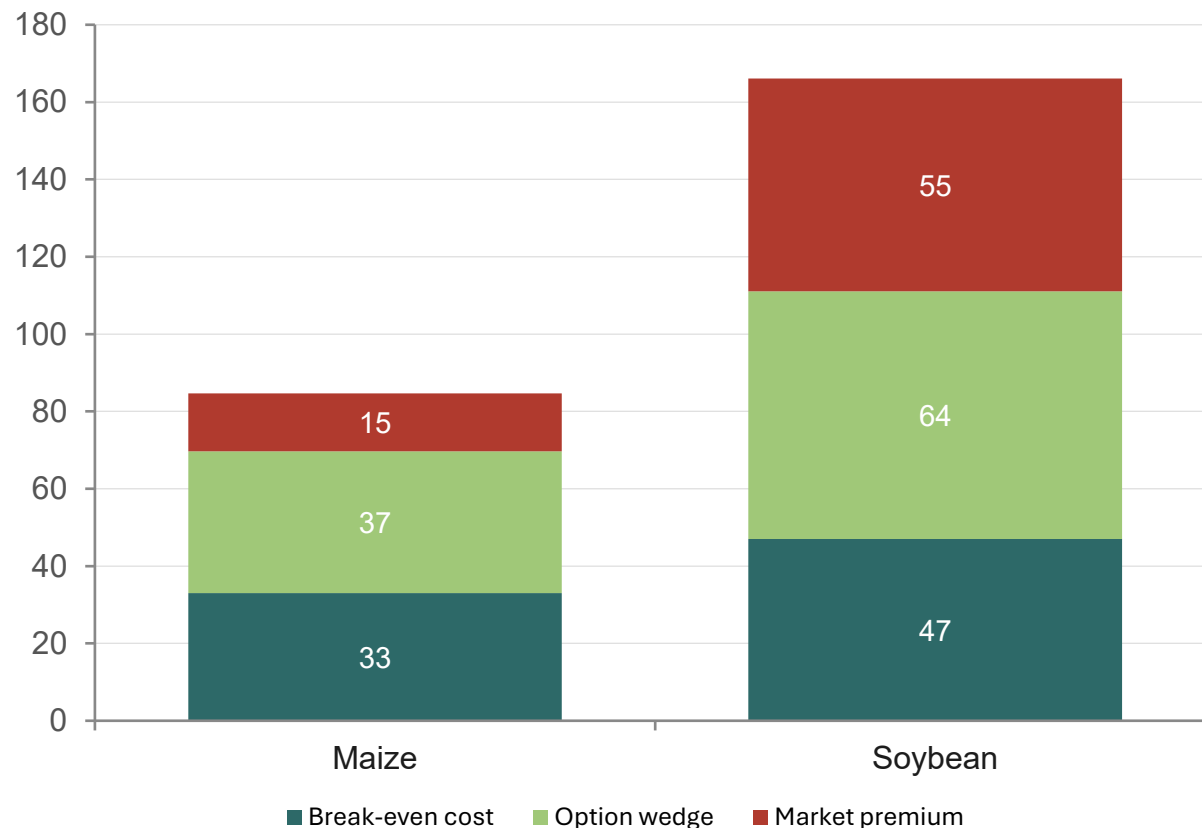
Key findings:

- For soybean, the observed premium (€55/t) exceeds break-even (€47/t), so DCF would predict investment.
- But the real-options threshold is €111.11/t. The real-options wedge of 2.83× pushes the threshold beyond what the market currently offers.
- Rational operators wait even when NPV is positive.

*This is the core real-options result:
the market is not failing to provide a premium, it is providing one. But uncertainty and irreversibility suppress investment regardless.*

Decomposing the Gap: Break-Even vs Option Wedge

Critical premium decomposition (€/tonne)



Break-even

Minimum premium to cover per-unit investment and ongoing IP costs. Maize: €33/t. Soybean: €47/t.

Option wedge

Additional premium required to compensate for foregoing the option to wait. Larger for soybean (2.83×) than maize (2.47×).

Market premium

Observed market premium. For soybean, exceeds break-even, but falls €56/t short of the real-options threshold.

Sensitivity: π^* Across (σ, γ) Parameter Space

Given the absence of reliable estimates for γ , the full (σ, γ) sensitivity table is the primary basis for interpreting results. Computed at calibrated $\phi = 0.35$ (soybean) via Newton–Raphson.

soybean) via Newton–Raphson.

	$\sigma \rightarrow$	0.15	0.20	0.25	0.30	0.35
$\gamma \downarrow$	2%	€113	€135	€161	€192	€228
	5%	€85	€99	€116	€136	€158
	8%	€74	€84	€97	€111	€128
	12%	€66	€74	€83	€94	€106
	15%	€63	€70	€77	€86	€96

Observed premium: €55/t

Soybean π^* (€/tonne)

Low-uncertainty zone (top-left)

$\sigma < 0.20, \gamma < 5\%$: $\pi^* \sim \text{€}85\text{--}135/\text{t}$
Threshold still exceeds observed premium (€55)

Baseline (outlined cell)

$\sigma = 0.30, \gamma = 8\%$: $\pi^* = \text{€}111/\text{t}$
Observed premium (€55) well below threshold.

High-uncertainty zone (bottom-right)

$\sigma \geq 0.30, \gamma \geq 8\%$: $\pi^* = \text{€}86\text{--}128/\text{t}$
Investment unlikely at any realistic premium.

Implications

1. **NPV > 0 is necessary but not sufficient.**

- The real-options wedge (2.47–2.83×) means operators rationally delay investment even when differentiation is profitable in expected-value terms. Standard project appraisal underestimates the threshold.

2. **γ is the most consequential parameter.**

- Contamination risk enters the threshold through the adjusted discount rate, not just through expected losses. Any factor that keeps γ elevated suppresses investment regardless of premium levels.

3. **Scale effects: soybean $\neq$ maize**

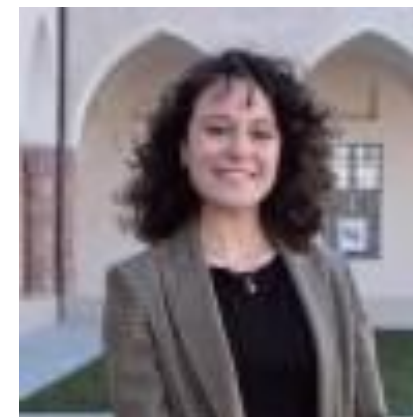
- NGT-free chains are structurally more viable in high-volume, high-premium markets. Per-unit thresholds fall as Q rises, making thin specialty markets more sensitive to coexistence conditions.

4. **Positive finding for soybean; structural problem for maize.**

- For soybean, the market premium exceeds break-even, the obstacle is uncertainty. For maize, investment is not viable even without the real-options wedge.



Thank you for your
attention !



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