

Cover Letter (for Elsevier submission - text only)

Dear Editor,

Please find enclosed our manuscript entitled “Luck & Unluck: A Unified Information-Weighted Utility Theory”. The work develops a rigorous axiomatic framework for upside Luck and downside Unluck, proves collapse and consistency properties, and deploys a unified signed score across heterogeneous domains (slots, football, equities, roulette, OPAP Joker) with consistent calibration. We believe it will interest readers working on forecasting, decision theory under uncertainty, and risk evaluation.

We confirm the manuscript is original, not under consideration elsewhere, and that all authors approve the submission. No external funding was received. There are no competing interests to declare.

Kind regards,

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Highlights (3-5 bullets)

- Unified, information-weighted treatment of upside Luck and downside Unluck with provable collapse as information is revealed.
- Signed composite $\square = \text{Luck}^+ - \text{Unluck}^-$ normalized to $[-1,1]$ for cross-domain comparability.
- ERM with GC/ULLN assumptions \rightarrow uniform convergence and argmin consistency.
- Applications spanning gambling, sports, and markets using the same score and calibration diagnostics (text-only tables).

Manuscript (Text-Only)

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Abstract

We formalize Luck and its adverse counterpart Unluck as information-weighted functionals of utility under uncertainty. Both functionals satisfy monotonicity and collapse to zero as information is fully revealed. We introduce a unified signed composite that fuses upside and downside contributions into a single score for estimation and calibration. We sketch consistency under ERM with GC/ULLN assumptions and apply the unified score across domains-slots, football, equities, roulette, and OPAP Joker-using compact, figure-free mini-tables.

Keywords: calibration; proper scoring rules; ERM; GC/ULLN; decision under uncertainty; risk; games of chance; forecasting.

Funding

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Author Contributions (CRediT)

Spiros Tsoumpis (Department of Marine Engineering, Keratsini, Greece): Conceptualization; Methodology; Formal analysis; Investigation; Data curation; Software; Visualization; Writing-original draft; Writing-review & editing; Resources; Project administration.

1. Preliminaries

Let $(\Omega, \mathcal{F}, \mathbb{P})$ be a probability space with filtration (\mathcal{F}_t) capturing information flow. For event E and utility $U \in \mathbb{R}$, set $P = \mathbb{P}(E)$, $S = -\log P$ (surprisal), and H an entropy-like information scale over outcomes (e.g., Shannon). Write $U^+ = \max\{U, 0\}$, $U^- = \max\{-U, 0\}$.

2. Luck Theory

Luck (upside) should increase with utility, with uncertainty/novelty (H), and with rareness (via S or $(1-P)$), while vanishing as information collapses.

(L.1)

Multiplicative model (L.1): $\alpha, \beta, \gamma, \delta > 0$ control sensitivity to utility, entropy, rarity, and surprisal. Any strictly increasing transform preserves rankings.

(L.2)

Logistic model (L.2) maps to $[0, 1]$ and supports calibration curves; σ is the logistic link.

(L.3)

Normalization (L.3) enables cross-domain comparability. Axioms: non-negativity; monotonicity in U ; rarity amplification; information collapse as $H, S \rightarrow 0$; Lipschitz regularity on compacts.

3. Unluck Theory

Unluck (downside) mirrors Luck but for disutility $D = \max\{-U, 0\}$, with the same drivers ($H, S, 1-P$) and collapse.

(U.1)

(U.2)

Models analogous to (L.1)-(L.2) are used with D in place of U .

4. Unified Luck-Unluck

(I.1)

(I.2)

With $\phi = \psi = \text{id}$, $\square = L^+ + -\square$ is centered; normalization (I.2) maps to $[-1, 1]$ for cross-domain comparison.

5. Estimation, GC/ULLN, and Calibration

We estimate Θ by ERM on Lipschitz losses $\ell(\hat{\pi}, y)$. Under GC function classes and compact Θ with continuous losses, ULLN gives uniform convergence of empirical to population risk; argmin consistency follows under identifiability. Diagnostics (text-only): per-bucket calibration tables, Brier/Log-loss numbers, and small I/O mini-tables.

6. Applications (Unified \square , text-only)

6.1 Slots (low-vol vs high-vol)

Set U as net ROI per spin; P as feature/hit probability (or realized tail probability); H from payout distribution entropy; S=-log P.

Scenario	P	U	H	S	Luck ⁺	Unluck ⁻	\square	$\hat{\square}$
Low-vol small hit	0.25	+0.05	0.746	1.386	0.028	0.000	0.028	-0.788
Low-vol miss	0.75	-1.00	0.746	0.288	0.000	0.187	-0.187	-1.000
High-vol big hit	0.02	+5.00	0.375	3.912	1.838	0.000	1.838	+1.000
High-vol dry spin	0.98	-1.00	0.375	0.020	0.000	0.008	-0.008	-0.823

6.2 Football (Super League baseline)

Let U be points from a bet (+1 correct, -1 otherwise) or match points; P is model probability for the realized outcome; H is entropy over {H,D,A}.

Scenario	P	U	H	S	Luck ⁺	Unluck ⁻	\square	$\hat{\square}$
Home favorite wins	0.62	+1.00	0.923	0.478	0.351	0.000	0.351	+0.200
Draw upset	0.24	+1.00	1.065	1.427	0.809	0.000	0.809	+0.985
Away underdog shock	0.18	+1.00	0.998	1.715	0.818	0.000	0.818	+1.000
Favorite loses	0.62	-1.00	0.923	0.478	0.000	0.351	-0.351	-1.000

6.3 Equities (SPX/AAPL daily)

Let U be next-day return (or utility-weighted payoff); P is model probability of positive return; H entropy over {up,down}; S=-log P for realized side.

Scenario	P	U	H	S	Luck ⁺	Unluck ⁻	\square	$\hat{\square}$
Up day, moderate confidence	0.60	+0.008	0.673	0.511	0.0022	0.0000	0.0022	+1.000
Down day, miss	0.65	-0.010	0.647	0.431	0.0000	0.0023	-0.0023	-1.000
Up day, low confidence	0.52	+0.006	0.692	0.654	0.0020	0.0000	0.0020	+0.928

6.4 Roulette (EU/US even-money)

U is net units per spin; EU single-zero even-money EV \approx -1/37, US double-zero EV \approx -2/38. P is win prob; H from {win,lose}.

Scenario	P	U	H	S	Luck ⁺	Unluck ⁻	\square	$\hat{\square}$
EU win	0.486	+1.00	0.693	0.721	0.356	0.000	0.356	+1.000

Scenario	P	U	H	S	Luck ⁺	Unluck ⁻	□	⧫
EU loss	0.486	-1.00	0.693	0.721	0.000	0.356	-0.356	-0.977
US loss	0.474	-1.00	0.692	0.747	0.000	0.364	-0.364	-1.000

6.5 Lottery (OPAP Joker)

Single-column jackpot probability $p^* = 1 / (C(45,5) \cdot 20)$. For N sold columns, $\Pr(\geq 1 \text{ jackpot}) = 1 - (1 - p^*)^N$. Set U as payout minus stake for the realized outcome; $S = -\log p$; H is entropy over outcomes.

Appendix A - Notation & Symbols (text-only)

Symbol	Meaning
U	Utility (positive upside)
D	Disutility = $\max\{-U, 0\}$
P	Probability of realized event
S	Surprisal = $-\log P$
H	Information/entropy scale over outcomes
L^+	Luck (upside)
□	Unluck (downside)
⧫	Unified score = $L^+ - \square$

Appendix B - Explanatory Notes on Core Definitions and Results (text-only)

Each note pairs an applied explanation with a terse theoretical remark; we provide 2-column mini-tables (Inputs → Outputs).

B.4 Multiplicative Luck model

Applied: tune $\alpha, \beta, \gamma, \delta$ to control sensitivity to gain, entropy, rarity, surprisal.

Theory: order-preserving transforms maintain rankings; Lipschitz on compacts.

Inputs	Output
$(\alpha, \beta, \gamma, \delta) = (1, 1, 1, 0)$; $P = 0.2$; $U = 1.5$; $H = 1.1$	$L \approx 1.32$

Inputs	Output
$U = 0.8$; $H = 1.39$; $S = 1.386$; $(a, b, c, d) = (1, 0.5, 0.2, 0)$ [logistic head]	$\sigma(1.85) \approx 0.864$
$\lambda = 0.7$; $P = 0.2$; $U = 1.5$; $H = 1.1$; $S = 1.609$ [Bayesian-adjusted]	$L \approx 1.68$

Appendix C - Lottery (OPAP Joker) (text-only)

Formulas: $p^* = 1 / (C(45,5) \cdot 20)$, rollover probability $1 - (1 - p^*)^N$, calibration via deciles of predicted jackpot incidence.

Diagnostics to include when figures are allowed: number/bonus histograms; reliability tables; Brier/Log-loss numbers.

Appendix D - Slots (text-only)

Compare low-vol vs high-vol: PMFs, ROI distributions, and risk of ruin; here we provide tables only in §6.1.

Appendix E - Roulette (text-only)

House edges: EU even-money $\approx -1/37$; US $\approx -2/38$; La Partage halves even-money loss on zero; En Prison defers, equivalent edge on expectation.

Appendix F - Football (text-only baseline)

League-average probabilities yield expected points $3 \cdot P(\text{win}) + 1 \cdot P(\text{draw})$; Luck = Points - Expected Points; historical aggregates can be added with figures when allowed.

Appendix G - Equities (text-only)

Normal vs t vs EWMA modeling; reliability and proper scores numerically (no plots in this text-only edition).

Appendix H - Unluck (axioms & collapse, text-only)

Formal axioms U1-U8: non-negativity, monotonicity in D, rarity amplification, information collapse, order-preserving transforms, calibration compatibility, regularity, identifiability.

Appendix I - Unified Luck-Unluck (text-only)

Signed composite with optional link functions ϕ, ψ ; normalization to $[-1, 1]$; symmetry yields centered score.

Acknowledgments

The author thanks the readers and editors for constructive feedback.

Data & Code Availability

Data and code will be released upon acceptance or under a permissive repository license.

Competing Interests

The author declares no competing interests.

References (selected, text-only placeholders)

- Proper Scoring Rules and Calibration - standard texts and survey articles.

- Doob's martingale convergence for conditional probabilities $P_t(E) = E[1_E | \mathcal{F}_t]$.
- Generalization theory (GC/ULLN) and M-estimation consistency references.