Do growing-region weather anomalies predict coffee futures returns?

Scott Dong · ascent-agri working paper · July 2026 *Code, data pipeline, and reproduction commands: github.com/ScottDongKhang/ascent-agri*

Abstract

Coffee is the textbook weather-driven commodity, yet most retail commentary asserts the weather–price link rather than measuring it. I test whether daily weather anomalies at two benchmark growing regions — Buon Ma Thuot, Vietnam (robusta) and Varginha, Sul de Minas, Brazil (arabica) — contain predictive information for coffee futures returns, using an event-study design with all parameters fixed a priori, a Monte-Carlo permutation test for inference, and a built-in placebo structure (each region's weather is tested against the *other* region's crop). Brazilian dry-spell events are followed by arabica returns of +5.1 percentage points over 5 trading days in excess of baseline (n=4, permutation p=0.041, uncorrected) and +12.2pp over 63 days (p=0.14, hit rate 4/4); the cross-placebo (Vietnamese dryness → arabica) is null at every horizon, as designed. Daily-frequency lead–lag correlations are indistinguishable from zero everywhere, suggesting any weather information is either priced continuously or concentrated in rare discrete events. The primary hypothesis — Vietnamese dryness → robusta — is currently *untestable at the event level*: zero qualifying dry events occur within the 17 months of hand-built robusta price history, which quantifies precisely why extending that series is the project's critical path. I also document a cautionary methodological result: the canonical July 20, 2021 Brazilian frost (+33.8% in 5 trading days) was absorbed by the cooldown window of a benign cold snap three weeks earlier, so the a-priori event rule *missed the single largest weather event in the sample* — a concrete illustration of event-definition risk. With n≤6 events per test, none of these estimates survives correction for the nine hypotheses tested; this paper is a design and a data commitment, not a discovery claim.

1. Background and mechanism

Vietnam produces roughly a third of the world's coffee and the large majority of its robusta, concentrated in the Central Highlands (Dak Lak and neighboring provinces). Brazil dominates arabica, with Sul de Minas its largest belt. Two mechanisms link local weather to world prices:

1. **Supply shocks.** Persistent dryness during critical growth phases cuts yields; in Brazil, winter frost events (June–August) can destroy both the current harvest and the following season's, because damaged trees take years to recover. The July 1975 and July 2021 frosts each produced historic price spikes.
2. **Currency pass-through.** Brazilian growers sell in dollars and spend in reais; a weakening real raises local-currency revenue per bag and adds selling pressure. The BRL/USD rate is therefore a

standing confounder for any Brazil-side analysis, and is tracked (though not yet conditioned on) throughout this project.

The question here is narrower than "does weather matter" — obviously it does, mechanically, through supply. The question is whether *publicly available daily station-level anomalies* contain information that shows up in *subsequent* futures returns, i.e., whether the market leaves anything on the table after a weather signal becomes observable.

2. Data

Series	Source	Span used
Arabica futures (KC=F, daily close)	Yahoo Finance via yfinance	2018-01-02 → 2026-06-25
Robusta continuous (hand-built, ratio roll-adjusted)	Barchart per-contract CSVs (currently 1 contract, RMU26)	2025-01-29 → 2026-06-24
Buon Ma Thuot weather (12.68 N, 108.04 E)	Open-Meteo historical archive (daily)	2017-01-01 → 2026-06-26
Varginha weather (−21.55, −45.43); rain, mean & min temperature	Open-Meteo historical archive (daily)	2017-01-01 → 2026-06-26

Two disclosures. First, arabica serves as the long-history benchmark because no compliant daily robusta series with multi-year history is freely available; the robusta series in this repository is being assembled from individual expired contracts and currently spans ~17 months. Second, each region is represented by a single grid cell; growing belts are large, and a production-weighted multi-station composite is an obvious refinement.

3. Methods

All parameters were fixed before outcomes were inspected.

Anomalies (causal). The 30-day rolling rainfall mean is z-scored against the same location's trailing 365 days, shifted one day so the baseline uses strictly past data. No future information enters any signal.

Events.

- *Dry event*: first day the 30-day rainfall anomaly closes below −1.25σ after ≥30 calendar days above it (the cooldown collapses one drought into one event).
- *Cold event* (Brazil only): first day with 2-meter minimum temperature below 6.0°C after ≥30 days without one. Reanalysis-scale 2m temperatures over this grid cell never reach 0°C, so 6°C serves as the standard ground-frost-risk proxy.

Outcome. Cumulative close-to-close returns over the next 5, 21, and 63 trading days, with each calendar-day event mapped to the first trading day at or after it.

Inference. The mean forward return across events is compared with the distribution of means across 2,000 same-size random draws of trading days (Monte-Carlo permutation test); reported p-values are two-sided and **uncorrected**. Nine event-study hypotheses are examined (3 signals × 3 horizons on the arabica target), so a Bonferroni-minded reader should require $p < 0.006$ — none of the results clears that bar. Lead–lag analysis uses the daily Spearman correlation between the anomaly and forward returns, with a 95% moving-block bootstrap CI (block = 21 days) to respect serial dependence.

Control structure. Each weather signal is also run against the *other* region's crop. Vietnamese dryness has no supply channel to arabica (and vice versa, to first order), so those cells function as placebos: if the pipeline manufactures effects, it should manufacture them there too.

4. Results

4.1 Event studies (arabica target, 2018–2026)

Signal	n	5d excess (p)	21d excess (p)	63d excess (p)	63d hit rate
Brazil dry	4	**+5.1pp (0.041)**	+5.6pp (0.25)	**+12.2pp (0.14)**	4/4
Brazil cold (tmin<6°C)	6	+1.9pp (0.36)	−0.8pp (0.84)	+2.8pp (0.67)	4/6
Vietnam dry (placebo)	3	+0.8pp (0.80)	−0.6pp (0.92)	−3.9pp (0.68)	2/3

Baseline means over the full sample: +0.3pp (5d), +1.3pp (21d), +3.9pp (63d). Event dates — Brazil dry: 2019-06-17, 2019-08-03, 2019-09-04, 2024-05-18. Brazil cold: 2019-07-07, 2020-05-27, 2020-08-26, 2021-07-01, 2022-05-20, 2024-08-11. Vietnam dry: 2018-04-19, 2022-12-27, 2023-02-07.

The pattern is coherent with the supply mechanism: Brazilian dry events precede above-baseline arabica returns at every horizon, with the 5-day window nominally significant and all four 63-day windows positive. The placebo behaves exactly as a placebo should. But n=4 is n=4: a single different event would materially move every number, and the nominal p=0.041 does not survive multiple-comparisons correction. The honest summary is *suggestive, correctly signed, underpowered*.

4.2 The frost that the rules missed

The July 20, 2021 Sul de Minas frost is the canonical modern weather shock: from the July 19 close, arabica rose **+6.7% the next day and +33.8% over five trading days**. The a-priori event list does not contain it. A benign cold snap on July 1, 2021 triggered the tmin threshold first, and the 30-day cooldown then swallowed July 20. This is reported as a result, not fixed retroactively: redefining events after seeing outcomes is precisely the practice the fixed-parameter design exists to prevent. The lesson — threshold-plus-cooldown event definitions can absorb the very extremes they target into their refractory period — generalizes to any event-study design, and severity-weighted event definitions are the natural pre-registered refinement for the next data release.

4.3 Lead–lag (daily granularity)

Anomaly ~ target	21d Spearman	95% block-bootstrap CI
Vietnam rain ~ arabica	+0.10	[−0.04, +0.23]
Brazil rain ~ arabica	+0.01	[−0.15, +0.15]
Vietnam rain ~ robusta	−0.03	[−0.42, +0.31]
Brazil rain ~ robusta	−0.17	[−0.51, +0.30]

Every interval contains zero. At daily granularity, smoothed rainfall anomalies carry no detectable monotone signal for forward returns — either the market absorbs gradual weather information continuously (the efficient-market null), or the signal lives only in rare discrete extremes, which is what the event-study panel weakly suggests.

4.4 The primary hypothesis is data-limited

Zero Vietnamese dry events fall within the robusta price window (2025-01 → 2026-06): the Central Highlands were near or above their rainfall norm for that entire span. The project's central question — does Highlands dryness predict *robusta* returns — therefore cannot yet be tested at the event level. This is the quantified case for the repository's data roadmap: backfilling robusta contract history to ~2023 would bring the 2024 drought (which coincided with robusta's record run) into sample.

5. Limitations

Small event counts; single station per region; uncorrected multiple comparisons (disclosed); no conditioning on BRL/USD or broader commodity beta; arabica benchmark standing in for the robusta deliverable; close-to-close returns ignore intraday reaction; Open-Meteo reanalysis temperatures understate ground-level frost severity.

6. Conclusion

With a-priori definitions and honest inference, publicly available daily weather data shows correctly-signed but statistically inconclusive predictive content for coffee futures at event granularity, and none at daily granularity. The infrastructure contribution — a causal, placebo-controlled, permutation-tested pipeline that anyone can rerun in one command — is the durable result; the estimates will sharpen mechanically as the robusta series and event counts grow.

Reproduction

```
git clone https://github.com/ScottDongKhang/ascent-agri && cd ascent-agri
python3 -m venv .venv && source .venv/bin/activate
pip install -r requirements.txt
python -m ascentagri.research.weather_study   # fetches weather caches on first run
# full output: outputs/research/weather_study.json
```

Data credits: Yahoo Finance (KC=F), Open-Meteo historical weather archive, Barchart (manually downloaded per-contract CSVs, personal use). This is an educational research artifact, not investment advice.