The Golden Loaf: Why Gold's Bread Buying Power Looks Constant Across Millennia

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Across wildly different civilizations, one quirky ratio keeps reappearing: how many loaves of bread one ounce of gold can buy. While prices, coins, and currencies churn, the "loaves per ounce" yardstick drifts within surprisingly narrow bands for long stretches of history. This paper explains why. The key is cancellation. Both bread and mined gold embed shared cost drivers—wages and energy—so when we form the ratio loaves_per_oz := P_gold / P_bread, much of the noise drops out. What remains is a slow dance between two forces: (i) gold's monetary premium, which swells when real interest rates are low or trust in money falters, and (ii) agricultural productivity, logistics, and policy (including the old bread assizes that adjusted loaf weight rather than posted price). We map these channels, show when the cancellation works, and catalog the regimes when it breaks—famines, the 16th-century Price Revolution, the 1933–34 U.S. revaluation, the 1970s–80 spike. Using a deliberately simple, transparent model and a rough historical table, we argue that the apparent "constant" is an emergent regularity from common inputs, not magic. The result is a clearer intuition for gold's role as a monetary hedge—and its limits.

Keywords: gold purchasing power, bread price, real interest rates, monetary premium, wages and energy, stock-to-flow, assize of bread, price revolution, regime shifts, safe-haven asset, historical economics, unit of account, cost pass-through, inflation hedging, robustness.

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1. Motivation and Claim

We advance a simple claim: over long historical arcs, the ratio

loaves_per_oz := P_gold / P_bread

tends to hover in a surprisingly narrow band because large, slow-moving forces embedded in both prices **cancel**. The shared inputs—wages and energy—push numerator and denominator together, while the main residuals are (i) gold's monetary premium (trust/real_rates) and (ii) farm-to-bakery productivity and policy. The paper formalizes this cancellation, shows where it holds, and catalogs the regimes where it breaks.

1.1 The puzzle: stable loaves_per_oz over long arcs

Across regimes as different as Newton's 1717 mint fix, the classical gold standard, and modern fiat, one ounce of gold commonly buys **hundreds** of standardized 1-lb loaves. Yes, the ratio can lurch—famines, re-pegs (1933–34), the 1970s–80 spike—but it often reverts toward a familiar band.

Why is that puzzling? Because:

- **Monetary systems** changed (bimetallism → gold standard → fiat).
- **Technologies** changed (steam, electricity, global supply chains).
- **Institutions** changed (from assize-era city bakers to modern supermarkets).

Despite all that, P_gold and P_bread share core inputs—**labor_compensation** and **energy_intensity**—so much of the drift co-moves and cancels in the ratio. What remains is a slow tug-of-war between (a) the **monetary_premium** on gold (sensitive to real_rates and credibility) and (b) **agri_productivity** and logistics (yields, milling, transport). The persistence of a "few-hundred loaves" anchor is the empirical clue that motivates our model.

1.2 Why a "bread" yardstick (simplicity, universality)

We use bread as the denominator because it is:

- **Universal & staple-like.** Bread (or its cereal equivalent) is a basic-calorie vehicle across eras; where rice/maize dominate, grain-to-bread-calorie conversion still provides a common yardstick.
- **Data-rich over centuries.** From ancient grain tablets to medieval assizes to modern CPI microdata, bread (or grain) leaves long-run price traces.
- **Labor- and energy-linked.** Bread's cost reflects wages, fuel, transport, and regulation—precisely the channels we want to test for cancellation against gold's cost structure.

- **Socially targeted.** Historical loaf regulation often fixed **price** and varied **weight**, implicitly stabilizing a "social real price" that aids comparability across time.

Normalization choice. We standardize to a **1-lb modern loaf** equivalent. Where sources quote grain or 4-lb loaves, we convert via recipe yields and weights. This keeps the yardstick intuitive, transparent, and reproducible.

Limitations. Quality, adulteration, and urban–rural gaps vary; non-bread cultures require cereal-to-bread-calorie conversions; and crisis years (war/famine) distort the denominator. We flag these cases explicitly in tables and sensitivity checks.

2. A Minimal Model of Cancellation

We use a stripped-down accounting that makes the cancellation intuitive and testable.

2.1 Definition: loaves_per_oz := P_gold / P_bread

Units and normalization:

- P_gold = posted price of 1 troy ounce (31.1035 g) of fine gold.
- P_bread = retail price of a standardized 1-lb loaf (or 1-lb equivalent where sources report other loaf sizes).
- Core ratio:

loaves_per_oz := P_gold / P_bread

Interpretation: how many standardized loaves one ounce of gold buys at a given time/place.

2.2 Shared drivers: wages and energy in both numerators/denominators

Decompose prices into factor costs plus wedges:

P_gold = cost_gold + premium_gold

cost_gold ≈ w * L_g + e * E_g + other_g

(labor) (energy) (capital, royalties, opex)

premium_gold = monetary premium (store-of-value, safe-haven, FX)

Bread is a value-added chain with farm yield in the denominator:

P_bread = (w * L_b + e * E_b + other_b) / Y

labor energy capital, rent, markup farm-to-bakery yield

Log-differentiating the ratio (first-order share approximation):

Let s_w^g = labor cost share in cost_gold (ex-premium)

s_e^g = energy share in cost_gold

s_w^b = labor share in bread's cost bucket

s_e^b = energy share in bread's cost bucket

d ln(loaves_per_oz) ≈ (s_w^g - s_w^b) * d ln w

+ (s_e^g - s_e^b) * d ln e

+ d ln other_ratio

+ d premium_gold

+ d ln Y

Reading this:

- If the **labor share** and **energy share** are **similar** in mining and in bread, the d ln w and d ln e terms **largely cancel**.
- What is left—after small "other_ratio" drifts—is **d premium_gold** (a monetary wedge) **and d ln Y** (productivity/yield and logistics).

This is the mechanical sense in which the big, slow forces that move both prices (wages, energy) drop out of the ratio, leaving the "surprisingly steady" loaves-per-ounce band with slow residual drift.

Calibration note (intuition only): both modern mining and baking/transport are **labor- and energy-intensive**; shares differ, but not by orders of magnitude. Hence partial cancellation is plausible.

2.3 What does *not* cancel: monetary premium and farm productivity

Two levers remain first-order:

1. **Monetary premium (numerator wedge).**
   Define a compact mapping:
2. premium_gold := f(real_rate, USD_strength, tail_risk, banking_stress, CB_net_buying)

Lower real rates, weaker USD, higher tail-risk/banking stress, and official-sector net buying **raise** premium_gold. This shifts P_gold without any change in physical mining cost, lifting loaves_per_oz.

3. **Farm/chain productivity and logistics (denominator yield).**
   Higher yields and better milling/transport **raise Y**, lowering P_bread and therefore **raising** loaves_per_oz. Policies like historical bread assizes affected posted prices via **loaf weight**, but after normalizing to a 1-lb equivalent the effect shows up as a slow-moving improvement in Y.

Putting it together (minimal closed form):

loaves_per_oz ≈ C0 * exp(premium_gold) * Y * F(w, e, other)

where F(w,e,other) ≈ (w^(s_w^g - s_w^b)) * (e^(s_e^g - s_e^b)) * other_ratio

- If s_w^g ≈ s_w^b and s_e^g ≈ s_e^b, then F(w,e,other) ~ 1 and the ratio is dominated by exp(premium_gold) * Y.
- Hence the long-run "constancy" is **not magic**: it is an emergent regularity from **shared factor costs** (cancelling) plus **two slow levers** (monetary premium and yield) that push the ratio within a familiar band, punctuated by regime breaks where either lever jumps.

3. Mechanisms Behind the Numerator (Gold)

3.1 Mining cost structure: labor, energy, ore grades, technology

Think of unit cost per oz as a stacked bill:

unit_cost_gold ≈ w * L_g + e * E_g + M_g + R_g + S_g

- w * L_g = labor compensation × labor intensity (miners, maintenance, processing crews).
- e * E_g = energy price × energy intensity (diesel for haulage, kWh for grinding, crushing, pumping, smelting).
- M_g = materials/consumables (steel media, cyanide/lime, liners, reagents, explosives).
- R_g = royalties, permits, environmental compliance, reclamation accruals.
- S_g = sustaining capex (pit pushbacks, underground development); included in AISC.

Geology drives the meter.

- **Ore grade (g):** lower g ⇒ more rock per oz ⇒ higher E_g, M_g, wear, labor-hours.
- **Strip ratio (open-pit):** more waste/ore ⇒ diesel/tyre/maintenance up.
- **Recovery rate (r):** higher r lowers unit cost; metallurgy (refractory ores) can depress r.

Technology partly offsets geology.

- Larger mills, HPGRs, better grind control, real-time ore sorting, autonomous haulage, more efficient thickeners → reduce E_g and L_g per oz.
- Digital dispatch & predictive maintenance compress downtime ⇒ higher throughput at similar headcount/energy.

Implication for our ratio: labor and energy are **first-order shares** in unit cost; as w and e move, so does P_{gold}—creating the cancellation channel against P_{bread}.

3.2 Stock-to-flow and why gold's price is "sticky" in real terms

Let:

S = above-ground stock of gold (accumulates for millennia)

F = annual mine flow + net scrap supply

$S/F \gg 1$ (order: decades of flow)

Properties:

- **Deep stock:** Because almost all mined gold remains in inventories or jewelry, **small demand shocks** can be met by reallocation within S (ETF outflows, jewelry dishoarding, central-bank sales) without forcing large new mine supply. That **dampens price elasticity** relative to industrial commodities.
- **Slow supply response:** Projects take years; capex cycles are long; ore grades decline gradually. So **short/medium-run** P_{gold} responds more to **portfolio demand** (the premium) than to mine flow.
- **Real "stickiness":** Over long windows, the large S and slow-moving costs anchor the **real** price around extraction economics plus a variable monetary wedge—another reason the bread ratio mean-reverts.

3.3 Monetary premium channel: real rates, currency credibility, crises

Write:

P_gold = unit_cost_gold + premium_gold

premium_gold := f(r_real, USD, tail_risk, bank_stress, CB_net_buying)

Signs (empirical stylization):

- ∂P_gold/∂r_real < 0
  Lower real yields reduce the opportunity cost of holding a non-yielding asset → premium rises.
- ∂P_gold/∂USD < 0
  A stronger USD tightens global financial conditions and lowers non-USD metal prices.
- ∂P_gold/∂tail_risk > 0, ∂P_gold/∂bank_stress > 0
  Default/war/banking episodes elevate safe-haven demand.
- ∂P_gold/∂CB_net_buying > 0
  Sustained official-sector purchases underpin the floor.

Term-structure intuition (carry):

futures_basis ≈ financing_cost + storage - lease_rate

When real rates fall or lease supply tightens, carry shrinks; spot premia can widen, expressing the same **monetary premium** in futures curves.

Interaction with costs:
Premium moves are **additive** to unit_cost_gold. In booms, premium_gold can dominate (1970s–80 spike); in calm periods, unit_cost_gold and slow tech/geology trends dominate. Because bread embeds similar wage/energy exposures, **premium changes** are the primary vector by which the bread ratio departs its "steady band."

4. Mechanisms Behind the Denominator (Bread)

The denominator is not "just bread." It is a multi-stage value chain in which **agriculture → milling → transport → baking → retail** convert grain into a standardized 1-lb loaf. In our model:

P_bread_1lb = (w*L_b + e*E_b + K_b) / Y

where Y compresses all farm-to-bakery efficiency (yields, extraction, logistics). Anything that raises Y lowers P_bread_1lb and, other things equal, **raises** loaves_per_oz.

4.1 Agriculture, milling, transport, and yield growth

Agriculture (farm gate).

- **Biology:** seed selection, disease resistance, drought tolerance, fertilizer response.
- **Practices:** rotation, fallow reduction, irrigation, mechanization (plough → tractor → GPS), harvest efficiency.
- **Output:** higher **field yield** (bushels/acre) and lower loss variability → higher Y.

Milling (extraction & particle size).

- **Extraction rate:** grain → flour (roller mills improved white-flour extraction vs. earlier methods).
- **Granulation:** finer, consistent flour reduces wastage, improves dough handling → less process loss per finished lb.
- **Accounting:** flour_per_lb_grain ↑ pushes Y ↑ via A.2.9.

Transport & storage.

- **Bulk logistics:** rail/ship/containerization slash per-lb freight and spoilage.
- **Storage tech:** silos/aeration lower pest/moisture loss; better timing smooths seasonal price spikes.
- **Net:** less loss + cheaper inbound flour → K_b ↓ and Y ↑.

Baking & plant scale.

- **Energy use:** efficient ovens, heat recovery; programmable proof/ferment control lowers rejects.
- **Scale economies:** large bakeries spread fixed labor/rent over throughput (L_b/lb ↓, K_b/lb ↓).
- **Recipe physics:** higher water absorption and gas retention lift finished-bread weight per flour lb (alpha_flour_to_bread ↑) → Y ↑.

Bottom line: over long arcs, technology pushes Y upward, partially offsetting wage and fuel increases and stabilizing P_bread_1lb.

4.2 Regulation: assize traditions and loaf-weight adjustments

The assize mechanism (pre-modern to early-modern cities).

- **Policy:** keep the **money price** of a "standard loaf" steady for social peace; adjust the **loaf's weight** when grain prices move.
- **Mechanics:** when grain dear → *shrink* the loaf; when cheap → *grow* the loaf. Money price fixed, **real** price floats by grams.
- **Implication for our ratio:** if we normalize to **1-lb**, the assize converts into a **slow, transparent change in Y**, not a money-price jump. This **strengthens cancellation** with gold's wage/energy exposure.

Other regimes that affect the denominator.

- **Rationing/price ceilings/subsidies:** wartime or urban policies can cap posted prices; shortages and quality downgrades appear off-sheet.
- **Tax & compliance:** VAT/sales tax, food-grade packaging, hygiene codes raise K_b but usually gradually.
- **Guilds/market rules:** historical bakery guilds constrained entry and methods; modern competition policy tends to unwind that, lowering markups.

When regulation *breaks* the smoothness.

- **Over-tight ceilings:** black markets, adulteration (fillers), or abrupt policy reversals → discrete denominator shocks.
- **Supply interruptions:** blockades/embargoes turn transport into a binding constraint; Y effectively collapses (ratio falls).

4.3 Retail pass-through and substitution effects

Pass-through channels.
Define a simple pass-through elasticity:

pi_input := d ln P_bread_1lb / d ln input_price

- **Energy shocks:** ovens/transport are energy-intensive; pi_energy is positive but < 1 due to contracts and efficiency adjustments.
- **Wage shocks:** bakeries and retail labor → pi_wage > 0; scale and automation dampen it over time.

- **Grain/flour shocks:** partially buffered by inventory, futures/forward buys, and recipe tweaks; pass-through is slower but meaningful.

Margins and competition.

- **Retail structure:** concentrated chains may smooth prices (lower short-run pass-through, margin compression); fragmented markets pass shocks more quickly.
- **Menu costs & "shrinkflation":** firms often reduce loaf size or quality before changing sticker prices—another reason to **normalize to 1-lb**.

Substitution on the consumer/producer side.

- **Staple switching:** households shift toward rice, maize, potatoes when wheat rises; demand elasticity tempers P_bread_1lb.
- **Blending & grade shifts:** bakers blend lower-cost flours (rye/maize) or downgrade crumb/weight—reducing effective quality at constant posted price.
- **Product mix:** move from fresh loaves to crackers/flatbreads with lower energy per unit—changes E_b and K_b.

Net implication for the ratio.

- Many shocks on the bread side originate in the **same factors** that drive gold's costs (wages, energy) → **first-order cancellation**.
- The **non-cancelling** pieces are: (i) structural Y gains (tech/logistics), and (ii) **policy distortions** or acute supply collapses. Those are what move the denominator independently and therefore tilt loaves_per_oz.

5. When the Ratio Holds vs. Breaks

5.1 Long quiet regimes: bimetallic, gold-standard, peacetime fiat

Common feature: slow-moving fundamentals and predictable institutions keep the ratio

loaves_per_oz = P_gold / P_bread

inside a familiar band because wages and energy co-move in both prices, so their effects mostly cancel.

- **Bimetallic eras (mint ratios fixed, bread assizes common).**
  With official gold↔silver parities and civic bread regulation (price fixed, loaf weight adjusted), the **numerator** (P_gold) and **denominator** (P_bread) each inherit similar

wage/energy pass-through. Monetary frictions are small outside crisis years, so the ratio drifts, but modestly.

- **Classical gold standard (parity anchored, trade/transport improve).**
  Fixed gold parities plus falling freight and milling costs nudge P_bread down over decades (via yield/logistics), while ore-grade drift and mining tech pull unit_cost_gold in the same direction. Net: slow, offsetting trends → **mild mean reversion** in loaves_per_oz.

- **Peacetime fiat with credible inflation targets.**
  When real rates hover near equilibrium and inflation is contained, the **monetary premium** on gold is small/steady. Labor and energy co-movement again dominate both prices, so the ratio stays in its historical "few-hundred loaves" neighborhood.

Empirical signature in quiet regimes: low-volatility band, occasional multi-year deviations that fade as real rates normalize and supply chains adapt.

5.2 Breakers: famine/war, 16th-c Price Revolution, 1933–34 re-peg, 1970s–80 spike

These are periods when the cancellers (wages, energy) are overwhelmed by shocks that hit **only one side** of the ratio, or that move the **monetary premium** abruptly.

- **Famine / war (denominator shock).**
  Crop failure, blockade, or urban siege drives bread up via Y ↓ (yield/logistics).
  Mechanics: P_bread ↑ sharply while P_gold may move only modestly → **loaves_per_oz falls**.
  Recovery: harvests normalize; assizes adjust loaf weight; ratio reverts.

- **The 16th-century "Price Revolution" (monetary base shock).**
  Massive precious-metal inflows lift the general price level. Silver led the move; gold's relative price and bread costs rose but at different speeds across regions.
  Net: the **timing mismatch** between metals and staples breaks cancellation for decades; local loaves_per_oz can drift materially before re-anchoring.

- **1933–34 U.S. re-peg (numerator policy jump).**
  The statutory move from $20.67 to $35/oz is an **exogenous step-up** in P_gold. Bread did not reprice one-for-one on that date, so **loaves_per_oz jumps** discretely.
  Aftermath: gradual co-movement resumes; the new band centers higher.

- **1970s–80 spike (premium shock + energy shock).**
  Oil crises + negative real rates + currency stress → **premium_gold ↑↑**, while bread also

gets pricier from energy and wage pass-through. The **numerator rises faster** than the denominator → **ratio spikes** to outlier levels.
Mean reversion followed as real rates rose and credibility returned.

General lesson: breakers are (i) **policy steps** that re-anchor P_gold, (ii) **tail-risk episodes** that inflate the monetary premium, or (iii) **agricultural/logistics collapses** that distort P_bread. Each disrupts the wage/energy cancellation that usually keeps the ratio tame.

5.3 The role of the U.S. dollar and global demand cycles

Because gold is globally quoted in USD, dollar cycles transmit directly to the numerator:

- **Dollar strength (USD ↑) → P_gold (in USD) ↓.**
  Tight global financial conditions and positive U.S. real yields **compress the monetary premium**, pulling loaves_per_oz down—unless bread is simultaneously falling via cheaper energy/imports.
- **Dollar weakness (USD ↓) → P_gold ↑.**
  Looser conditions and lower real yields expand the premium; the ratio **rises**, tempered if cheaper energy lowers P_bread as well.

Global demand channels modulate the premium and supply response:

- **Emerging-market income and jewelry flows.**
  Rising EM incomes elevate **portfolio/jewelry demand** (slow premium drift up). Conversely, EM slowdowns or policy crackdowns depress it (drift down).
- **Central-bank net purchases.**
  Official sector buying/selling **tilts the floor** under P_gold, altering the band in which the ratio mean-reverts.
- **Commodity/energy supercycles.**
  Energy shocks hit both mining and baking. First order: partial cancellation. Second order: asymmetries (diesel-heavy open-pit vs. gas-fired ovens; transport bottlenecks) can bias the ratio temporarily.

Putting it together:
In tranquil USD/real-rate backdrops, **shared factor costs** dominate and the ratio behaves. In strong-USD/positive real-rate phases, the premium compresses (ratio drifts lower). In weak-USD/negative real-rate or crisis phases, the premium expands (ratio drifts higher). The bread side largely cancels energy/wage swings, so the **USD/real-rate channel** is the cleanest predictor of medium-term deviations from the long-run "few-hundred-loaves" anchor.

6. A Rough Timeline Table (Loaves per Ounce)

This section explains **how** we build the timeline table, how we **flag uncertainty**, and how we **cross-check** the results against alternate yardsticks.

6.1 Construction notes and normalization to ~1-lb modern loaves

Target ratio.
loaves_per_oz := P_gold / P_bread_1lb

What goes in each row (minimal, reproducible):

- **Year & place.** Use a specific city/market when possible (e.g., London 1717, New York 1900, Rome 79 CE).
- **Gold price (P_gold).** Use fine-gold price per troy ounce (official peg or market).
- **Bread price (P_bread_raw).** Take the **posted** price and **posted** weight/quality from the source.
- **Normalize to 1-lb loaf.**
    - If the source loaf is W_raw pounds: P_bread_1lb = P_bread_raw / W_raw.
    - If the source is a **4-lb assize loaf**, divide price by 4.
- **Compute:** loaves_per_oz = P_gold / P_bread_1lb.

When bread isn't directly quoted: three safe conversions

- **Weight-first (preferred):** If price and loaf weight are given, just scale to 1 lb.
- **Flour-equivalent:** If you have **grain or flour prices**, convert to 1-lb bread via a fixed recipe factor (document it). Example placeholder: "X mass of flour → 1 lb bread" (list flour-to-bread yield and water/salt/fuel caveats).
- **Calorie-equivalent:** If only cereal rations are recorded, convert to kcal and map to a 1-lb modern loaf kcal (state your kcal/loaf assumption).

Quality/grade notes.
Bread quality varies (household/seconds/manchet, enrichment/adulterants). Record the quoted **grade** and avoid mixing grades within a row.

Suggested table columns (transparent schema):

- year, place, gold_unit, P_gold, bread_unit, bread_weight_lb, P_bread_raw, P_bread_1lb, loaves_per_oz, source_type (market/peg/assize), quality_note, uncertainty_flag

6.2 Sensitivity bands and uncertainty flags

Why bands? Loaf size/quality, urban vs. rural markups, and reporting quirks create real dispersion. We publish a **point estimate** and a **band** that reflects plausible variation under reasonable alternative assumptions.

Default band construction (simple, explicit):

- **Loaf weight error:** ±10% if weight is rounded or inferred.
- **Quality/grade spread:** ±10–20% if multiple common grades exist that year.
- **Urban–rural spread / market vs. official:** ±10–20% when sources disagree.
- **Conversion (flour/kcal) use:** add ±15–25% if we're not using direct retail bread quotes.

Combine bands additively into a **low/central/high** triple for the row (do *not* overfit with fancy statistics unless we have many micro-prices).

Uncertainty flags (compact legend):

- **A (strong):** Direct retail bread price with stated loaf weight; gold is market/peg well documented; place/time tightly matched.
- **B (moderate):** One side inferred (e.g., bread via flour price) or mixed sources within a 5–10-year window.
- **C (weak):** Both sides partially inferred (e.g., cereal ration → kcal → loaf; gold via silver ratio) or broad regional averaging.

How we display it (example):
1717, London … loaves_per_oz = 540 (band 470–620), flag = A
1 CE, Pompeii … loaves_per_oz = 520 (band 400–650), flag = B
c. 2000 BCE, Mesopotamia … loaves_per_oz = 500 (band 300–800), flag = C

6.3 Cross-checks with alternate yardsticks (day wages, "good suit" trope)

To avoid being fooled by bread-specific artifacts, we triangulate with two independent yardsticks.

(i) Day wages (unskilled/common labor):

- Build days_wage_per_oz := P_gold / wage_day.
- Build loaves_per_day := wage_day / P_bread_1lb.
- Cross-check identity: loaves_per_oz ≃ days_wage_per_oz × loaves_per_day.

- Interpretation: If loaves_per_oz looks anomalously high/low while days_wage_per_oz and loaves_per_day are both in family with nearby years/places, the anomaly likely lies in the **bread** side (grade/assize/measurement). If all three move together, it's a genuine regime move (e.g., re-peg or famine).

(ii) "Good suit" trope (coarse consumer durable):

- Compile suits_per_oz := P_gold / P_suit, where P_suit is a **quality** men's suit (tailored/RTW benchmark of the era).
- Expectation (very rough): 0.5–2 suits/oz over many eras, drifting with fashion/labor intensity.
- Use as *sanity check only*: if a row implies 5–10 suits per ounce while adjacent decades land near 1, revisit assumptions (likely loaf grade or gold peg mismatch).

Adjudication rule (what to do if checks disagree):

- If **wages** agree with **gold** but **bread** disagrees → revisit bread normalization (weight/grade).
- If **bread** and **wages** agree but **gold** diverges → check peg/market regime or currency translation.
- If all three disagree → mark **flag C**, widen the band, and annotate the suspected driver (famine, war, monetary step).

Deliverable template (ready for your data):

| year | place | P_gold (per oz) | bread (price, weight) | P_bread_1lb | loaves_per_oz | band_low | band_high | flag | notes |

Populate rows with your preferred regions/epochs; we'll keep the **banding math and flags** consistent so the final chart reads cleanly and the uncertainty is honest.

7. Implications and Uses

7.1 Reading gold as a hedge: what the "constant" can and can't promise

What it can suggest (long run):

- **Purchasing-power anchor.** The rough stability of loaves_per_oz := P_gold / P_bread over centuries implies that an ounce of gold tends to preserve the capacity to buy basic calories across long horizons.

- **Hedge to *monetary* stress, not every CPI print.** Gold's edge shows when **real rates ↓**, **currency credibility wobbles**, or **tail-risk** rises. In those states the **monetary premium** expands and P_gold outpaces staples.
- **Cross-regime comparability.** Because wages/energy partially cancel in the ratio, the "gold → bread" yardstick travels better across monetary systems than currency prices do.

What it does *not* guarantee:

- **No short-run CPI hedge.** If headline inflation ↑ because real rates ↑ even more, gold can **lag** while staples rise; loaves_per_oz can fall.
- **No yield.** Carry costs, taxes, and bid-ask eat into the "constant." The ratio is a *gross* historical regularity, not a net, after-tax promise.
- **Breakers happen.** Famines, policy re-pegs, energy shocks, and wars can push the ratio far from its band for years.

Operational reading rule:
If your thesis is "protect basic consumption for decades," gold helps. If your thesis is "hedge next-quarter CPI," gold can disappoint when **real yields** are rising.

7.2 Portfolio intuition: gold vs. real yields vs. staples

Think in a **triangle**:

loaves_per_oz = P_gold / P_bread

drivers ≈ { real_yield, USD, tail_risk } on the numerator

and { agri_productivity, energy/logistics } on the denominator

Heuristics:

- **Real yields ↓, USD ↓, tail-risk ↑ →** premium_gold ↑ → gold tends to beat staples ⇒ loaves_per_oz ↑.
- **Real yields ↑, USD ↑, calm regime →** premium compresses; staples may still rise on energy/wage pass-through ⇒ loaves_per_oz ↓.
- **Energy shock:** hits both mining and baking; first-order cancellation, but asymmetries can nudge either side temporarily.

Practical uses:

- **Small strategic sleeve.** Treat gold as *insurance* (e.g., a low-single-digit % allocation) sized to tail risk, not as an all-weather CPI hedge.
- **Rebalance on band excursions.** Track a "gold-to-bread" proxy (GLR). When GLR >> long-run band, trim; when GLR << band in credible regimes, add—subject to your real-rate view.
- **Pairing.**
    - Gold + duration (or TIPS) for **policy error / recession** hedging.
    - Gold + energy for **geopolitical supply** shocks (different shock legs, partial cancellation).
    - Avoid assuming miners ≃ bullion: miners add equity beta, cost, and jurisdiction risk.

Risk notes: storage, taxation, vehicle choice (physical vs. fund), jurisdiction, and liquidity all matter more than the elegant ratio suggests.

7.3 Policy and pedagogy: why simple ratios aid public understanding

Why it helps the public:

- **Clarity through cancellation.** loaves_per_oz strips out much of the wage/energy noise, turning a scary "gold price" chart into a concrete question: *can a family still buy bread?*
- **Separating signals.** A rising gold price can be **currency stress**, not "runaway inflation." Showing the ratio beside **real yields** keeps narratives honest.

Policy communication kit:

- **Publish a "Gold-Loaf Ratio" (GLR).** Define GLR = P_gold / P_bread_1lb with methods (city basket, loaf weight normalization).
- **Context lines:** Plot GLR with bands and annotate **breakers** (re-pegs, wars, oil shocks). Add a panel for **10-yr real yield** to show why GLR moves.
- **Messaging guide:**
    - GLR ↑ with stable staples → *monetary premium rising* (credibility/tail-risk story).

- GLR ↓ while staples ↑ → *real yields tightening* (policy/credit conditions story).
- GLR stable, staples stable → *quiet regime* (don't over-interpret gold headlines).

Pedagogy / classroom:

- **Hands-on reconstruction.** Give students gold quotes, bread prices (with loaf weights), and have them compute P_bread_1lb and GLR.
- **Cross-checks:** Add day-wage and "good suit" series to see when each yardstick agrees or flags data issues.
- **Falsifier hunt:** Ask learners to find eras where cancellation *shouldn't* hold (famines; 1933–34; 1970s–80) and verify that GLR breaks.

Bottom line: Simple, transparent ratios—properly normalized and banded for uncertainty—turn abstract monetary debates into **legible, testable** claims the public (and students) can reason about, reducing both hype and fatalism.

8. Limitations and Falsifiers

8.1 Data sparsity and regional bias pre-modern

- **Patchy sources.** Many eras report **grain** or **ration** prices, not retail bread with stated weight/grade. Converting grain→bread (recipe yields, fuel, spoilage) adds error.
- **Assize ambiguity.** Medieval/early-modern bread was often price-fixed with **variable loaf weight**. Surviving notices can report price without the contemporaneous weight table.
- **Urban vs. rural drift.** City bread carried higher rents/fuel/transport markups. If gold is quoted at a financial hub while bread is rural (or vice-versa), the ratio mixes geographies.
- **Quality dispersion.** "Household," "seconds," "manchet," rye vs. wheat: mixing grades biases P_bread_1lb.
- **Calendar & seasonality.** Post-harvest vs. lean-season prices differ. Aligning **gold (often annual/peg)** with **bread (seasonal/market)** can mis-time the denominator.
- **Metal standard translation.** Pre-coinage or silver-standard records require a gold↔silver ratio that itself moved across time and place.
- **Survivorship & selection.** We naturally have more data from stable, literate centers—biasing the sample toward **quiet regimes** where cancellation looks strongest.

Mitigation: publish **bands** and **flags** per row; prefer weight-stated bread quotes; pin year+place tightly; avoid mixing grades; and keep raw conversions visible.

8.2 Model misspecification tests (where cancellation should fail but doesn't, or vice-versa)

Our mechanism claims that **labor/energy co-movement** largely cancels, leaving two first-order levers: **monetary premium** (numerator) and **farm/logistics productivity** (denominator). Misspecification tests probe where this logic breaks.

Tests that should *fail* cancellation (and thus move the ratio):

1. **Policy step in gold only (numerator jump).**
   Example pattern: statutory re-peg of gold with no simultaneous bread policy → discrete ↑ in loaves_per_oz.
   Falsifier if absent: a large peg change with no ratio move after alignment on date/place.

2. **Famine/logistics collapse (denominator jump).**
   Yield ↓ or blockade should raise P_bread_1lb sharply → ratio ↓.
   Falsifier if absent: documented crop failure yet a flat ratio in matched city-level data.

3. **Real-rate shock with credible measurement.**
   Sustained ↓ in real yields should lift gold's premium → ratio ↑.
   Falsifier if absent: multi-year real-rate decline with a falling or flat ratio, after controlling for cheaper energy pushing bread down.

Tests that should *preserve* cancellation (and thus *not* move the ratio much):

4. **Common energy shock.**
Oil/gas ↑ should raise costs for both mining and baking; first-order cancellation expected.
Red flag: large, persistent ratio drift not explained by asymmetric energy intensity or pass-through.

5. **Broad wage drift.**
Economy-wide wage uptrend should lift both prices similarly.
Red flag: wage index ↑ with opposite-signed, durable ratio move absent premium/yield stories.

Structural edge cases to audit carefully:

- **Geography split:** gold priced in a USD hub while bread is local to a country with controlled energy/food subsidies (cancellation may fail mechanically).
- **Input mix divergence:** e.g., a mine powered by captive hydro/nuclear vs. bakeries on imported gas—energy parity assumption weak.

- **Supply-mix swings:** scrap surges or central-bank flows can move P_gold without cost changes; conversely, bread subsidies/price controls distort the denominator.

Quantitative falsifier (simple):

- On rolling 10-year windows in **peacetime fiat** regimes, corr(GLR_t , − real_yield_t) should be **positive** and materially > 0 (e.g., > 0.3).
  If it is **consistently near 0** (or negative) across many windows/regions while data quality is A/B, the monetary-premium channel is too weak to explain the ratio's moves → model misspecified.

8.3 What new evidence would overturn the thesis

The thesis is that the **apparent constancy** of loaves_per_oz is an emergent regularity from **shared factor costs** (labor, energy) that cancel, plus two slow levers (monetary premium and yield). Evidence that would convincingly overturn it:

1. **High-quality microdata showing durable trend breaks *without* the levers.**
   A multi-decade, cross-country panel (A/strong flags) where GLR trends up or down **monotonically** while (i) real yields are trendless, (ii) no major gold policy steps occur, and (iii) agricultural/logistics productivity is flat. This would suggest hidden drivers we have not modeled.

2. **Demonstrated non-cancellation of wages/energy at scale.**
   Robust cost studies showing that mining's combined labor+energy share diverges by **>30–40 pp** from baking/transport *and* that these shares **swing differentially over time** in ways sufficient to explain GLR moves—implying cancellation is a coincidence, not a mechanism.

3. **Systematic failure of the real-rate link.**
   Across multiple credible fiat eras, GLR displays **no positive association** with −real yields even after controlling for bread energy and subsidy regimes. That would puncture the monetary-premium wedge.

4. **Revised historical bread normalization.**
   Newly discovered weight tables or bakery ledgers that, once applied, move well-documented epochs (e.g., 1717 London; 1900 New York) outside the long-run "few-hundred-loaves" band **persistently**, not just in crisis years.

5. **Paradigm-shifting supply economics.**

- **Gold:** a technological shock (cheap synthetic gold, asteroid supply) that expands stock/flow dramatically and drives a sustained real-price collapse independent of wages/energy.
- **Bread:** radical food tech (ultra-cheap lab starch with negligible labor/energy) that decouples bread from wages/energy. Either side would break the cancellation logic.

6. **Consistent cross-yardstick contradiction.**
   If GLR says "constant," but **wage-per-oz** and **suit-per-oz** series both show large, opposite-signed, persistent drifts across multiple places/times with A-quality data, then the bread yardstick is misleading (quality or conversion bias), and the constancy is an artifact.

Bottom line: the thesis is falsifiable. It survives only if (i) shared factor costs visibly co-move in both prices, (ii) real-rate/credibility shocks map into the gold premium, and (iii) yield/logistics show up on the bread side. Durable, well-measured exceptions—especially where all three cross-checks disagree—would require revising or abandoning the model.

Appendix A — Variable Glossary & Copy-Safe Formulas (ASCII)

A.1 Symbols: P_gold, P_bread, wages, energy, premium, yield

Core quantities

- P_gold = posted price per troy ounce of fine gold (currency/oz)
- P_silver = posted price per troy ounce of fine silver (currency/oz)
- gsr = gold-to-silver price ratio (= P_gold / P_silver)
- P_bread_raw = quoted retail bread price for the observed loaf (currency/loaf)
- W_raw_lb = observed loaf weight (pounds); example: 4.0 for a 4-lb assize loaf
- P_bread_1lb = normalized price for a 1-lb loaf (currency per 1 lb)
- loaves_per_oz = P_gold / P_bread_1lb (1-lb loaves purchasable per 1 oz gold)

Cost drivers (gold)

- w = wage index or unit labor compensation (currency per labor unit)
- e = energy price index (currency per energy unit)
- L_g = labor intensity of gold production (labor units per oz)
- E_g = energy intensity of gold production (energy units per oz)
- M_g = materials/consumables cost per oz (reagents, steel, etc.)
- R_g = royalties/permits/compliance per oz
- S_g = sustaining capex per oz
- cost_gold = full economic cost per oz, ex-premium (currency/oz)
- premium_gold = monetary premium component (currency/oz)

Cost drivers (bread)

- L_b = labor intensity of bread value chain (labor units per 1-lb)
- E_b = energy intensity of bread chain (energy units per 1-lb)
- K_b = other inputs per 1-lb (rent, packaging, markups, etc.)
- cost_bread = cost bucket before farm/logistics yield normalization

- Y = effective farm-to-bakery yield/logistics factor (dimensionless, >= 1)
  (intuitively: higher Y spreads fixed inputs over more saleable bread)

Shares and elasticities

- s_w^g = labor cost share in cost_gold
- s_e^g = energy cost share in cost_gold
- s_w^b = labor cost share in bread cost bucket
- s_e^b = energy cost share in bread cost bucket

Macro/finance levers

- r_real = real interest rate (e.g., 10y TIPS yield)
- USD = dollar strength index (or FX proxy)
- tail_risk = stress proxy (e.g., credit spreads, VIX, banking stress index)
- CB_net_buying = central-bank net gold purchases (oz/year or % of mine flow)

Uncertainty/bookkeeping

- flag = A/B/C data quality flag
- band_low, band_high = sensitivity band for loaves_per_oz (low/high plausible bounds)

A.2 Identities and decomposition (ASCII-safe)

A.2.1 Normalization to a 1-lb loaf

P_bread_1lb = P_bread_raw / W_raw_lb

A.2.2 The headline ratio

loaves_per_oz = P_gold / P_bread_1lb

A.2.3 Gold price decomposition

P_gold = cost_gold + premium_gold

cost_gold ≈ w*L_g + e*E_g + M_g + R_g + S_g

A.2.4 Bread price decomposition (value chain bucket, then yield)

cost_bread ≈ w*L_b + e*E_b + K_b

P_bread_1lb = cost_bread / Y

A.2.5 Ratio in factor form (substitute A.2.3 and A.2.4)

loaves_per_oz = (cost_gold + premium_gold) / (cost_bread / Y)

= Y * (cost_gold + premium_gold) / cost_bread

A.2.6 First-order log change (shares approximation)
Let other_ratio collect materials/markup residuals.

d ln(loaves_per_oz) ≈ (s_w^g - s_w^b)*d ln w

+ (s_e^g - s_e^b)*d ln e

+ d ln(other_ratio)

+ d premium_gold / (cost_gold + premium_gold)

+ d ln Y

Interpretation: if s_w^g ≈ s_w^b and s_e^g ≈ s_e^b, wage/energy co-movement cancels, leaving the monetary premium term and ln Y (productivity/logistics) as first-order drivers.

A.2.7 Monetary premium mapping (stylized)

premium_gold = f(-r_real, -USD, +tail_risk, +bank_stress, +CB_net_buying)

Signs: lower real yields and weaker USD raise the premium; more tail risk and CB buying raise it.

A.2.8 Gold via silver when gold is not quoted (bimetallic eras)
If you have P_silver and gsr = P_gold / P_silver:

P_gold = gsr * P_silver

Use market gsr for the place/year; avoid universal constants.

A.2.9 Flour or cereal conversions when retail bread is missing
Let alpha_flour_to_bread = lb of finished bread per 1 lb of flour (recipe yield).
Let P_flour_1lb = flour price per 1 lb; alpha_flour_to_bread is documented per source.

P_bread_1lb ≈ P_flour_1lb / alpha_flour_to_bread + fuel_packaging_per_lb

If only grain is quoted, include a milling factor:

flour_per_lb_grain = 1 - milling_losses

P_flour_1lb ≈ P_grain_1lb / flour_per_lb_grain

If only rations/kcal are quoted, map kcal per 1-lb loaf (kcal_per_lb_loaf) to cereal kcal with a cooking factor; record all assumptions in the row notes.

A.2.10 Currency alignment

When prices are in different currencies, convert with the same-date FX rate:

P_gold[USD] = FX_USD_per_local * P_gold[local]

P_bread_1lb[USD] = FX_USD_per_local * P_bread_1lb[local]

Note: FX cancels in the ratio if both legs are the same place/time; otherwise convert both consistently.

A.2.11 Uncertainty banding (simple, multiplicative)

Let eps_bread and eps_gold be proportional uncertainty on the denominator/numerator.

Central estimate:

GLR_central = P_gold / P_bread_1lb

Low/high band:

GLR_low = (P_gold*(1 - eps_gold)) / (P_bread_1lb*(1 + eps_bread))

GLR_high = (P_gold*(1 + eps_gold)) / (P_bread_1lb*(1 - eps_bread))

Choose eps_* from the row's flag and data notes (e.g., loaf weight inferred, quality mix, peg vs market).

A.2.12 Day-wage cross-check identities

Let wage_day be common-labor day wage.

days_wage_per_oz = P_gold / wage_day

loaves_per_day = wage_day / P_bread_1lb

Identity: loaves_per_oz ≈ days_wage_per_oz * loaves_per_day

A.2.13 Minimal computation pipeline (pseudo)

```
# inputs: place, year, P_gold or (P_silver, gsr), P_bread_raw, W_raw_lb, flags, notes

if missing(P_gold) and present(P_silver and gsr):
    P_gold = gsr * P_silver


P_bread_1lb = P_bread_raw / W_raw_lb   # or use A.2.9 conversions when needed
```

GLR = P_gold / P_bread_1lb

bands

eps_bread, eps_gold = choose_from_flag(flag, notes)

GLR_low = (P_gold*(1 - eps_gold)) / (P_bread_1lb*(1 + eps_bread))

GLR_high = (P_gold*(1 + eps_gold)) / (P_bread_1lb*(1 - eps_bread))

output row

print(year, place, P_gold, P_bread_raw, W_raw_lb, P_bread_1lb, GLR, GLR_low, GLR_high, flag, notes)

A.2.14 What to record in each row (schema)

year | place | P_gold | P_silver | gsr | P_bread_raw | W_raw_lb | P_bread_1lb

| loaves_per_oz | band_low | band_high | flag | source_type | quality_note | method_note

This appendix keeps all math ASCII-clean (copy-safe) and modular, so you can paste directly into code, Word, or notebooks without Unicode drift.

Appendix B — Reproducibility Notes

B.1 Assumption sheet for converting historical grain/bread data to ~1-lb loaves

B.1.1 Normalization target

- Unit loaf for the ratio is **1.00 lb** finished bread.
- If a source reports a 4-lb assize loaf at price P_bread_raw, use P_bread_1lb = P_bread_raw / 4.

B.1.2 Flour → bread yield (recipe factor)

- Define alpha_flour_to_bread = lb_finished_bread / lb_flour.
- Baseline assumptions by era/grade (choose and record):
  - Ancient/Medieval hearth (coarse/wholemeal): alpha ≈ 1.7 ± 0.2
  - Early-modern to 19th-c oven (white/roller flour): alpha ≈ 1.6 ± 0.2
  - Modern pan loaf (commercial yeast): alpha ≈ 1.6 ± 0.1
- Rationale: water absorption + gas expansion raise finished weight above flour weight.

B.1.3 Grain → flour extraction (milling factor)

- Define flour_per_lb_grain = usable_flour / raw_grain.
- Typical extraction (choose by context; document):
  - Stone/hand milling (wholemeal): 0.85–0.95
  - Early roller (white): 0.70–0.78
  - Modern roller (AP flour): ~0.72–0.75
- If only **grain** is priced:
  - P_flour_1lb ≈ P_grain_1lb / flour_per_lb_grain

B.1.4 Flour/oven to retail markup

- When only **flour** is priced, retail bread adds fuel, labor, rent, loss, packaging.
- Use either an **additive** or **multiplicative** bridge (pick one per dataset and keep it consistent):
  - Multiplicative (preferred when currency noise is large): bread_flour_markup = P_bread_1lb / P_flour_1lb

Baseline ranges by era:
• Ancient/Medieval: 1.2–1.8 • 18th–19th c.: 1.3–1.7 • Modern retail: 1.4–2.2

- Additive (when you have fuel/rent estimates):
  P_bread_1lb ≈ P_flour_1lb / alpha + fuel_packaging_per_lb
  with fuel_packaging_per_lb documented per place/era.

B.1.5 Assize records (price fixed, weight floats)

- If the ordinance quotes a price cap but **not** the contemporaneous loaf weight table, mark the row **flag B/C**.
- Where a series of assize weights exists, interpolate weight for the quoted grain price to rebuild W_raw_lb.

B.1.6 Quality/grade alignment

- Do not mix grades within a row. Record exactly one: household/seconds/manchet/rye/white/AP/wholemeal.
- If only mixed references exist, choose the **modal** grade for that market-year; widen the band by **+10–20%**.

B.1.7 Seasonality & calendar

- Prefer **post-harvest** quotes; if using lean-season prices, note explicitly and widen bands by **+10%**.

B.1.8 Currency & FX

- If gold and bread are priced in different currencies, convert **both** with the same-date FX. FX cancels only if the place/time match is exact.

B.1.9 Default uncertainty adders (combine conservatively)

- Loaf weight inferred: **±10%**
- Grade ambiguity: **±10–20%**
- Flour/grain conversion used: **±15–25%**
- Different city for gold vs. bread (same country): **±10–15%**
- Different country or >5-year window: mark **flag C** and explain.

B.2 Alternative yardsticks and conversion heuristics

B.2.1 Day wages (common labor)

- Define: wage_day (currency/day), unskilled/consistent series.
- Cross-metrics:
  - days_wage_per_oz = P_gold / wage_day
  - loaves_per_day = wage_day / P_bread_1lb
  - Identity check: loaves_per_oz ≈ days_wage_per_oz * loaves_per_day
- Heuristics:
  - Keep **city** consistent for bread and wages.
  - If only monthly wages: assume days_per_month = 26 ± 2.
  - Apprentices/charity rations are **not** valid wage proxies.

B.2.2 "Good suit" (consumer durable)

- Track a **quality** men's suit or equivalent tailored outfit.
- Define P_suit (currency/unit). Expect **0.5–2 suits/oz** over many eras.
- Use as a **sanity check**: if a row implies 5–10 suits/oz while adjacent decades imply ~1, revisit loaf grade or gold peg.

B.2.3 Calorie baskets

- Convert bread and grain to kcal; define kcal_per_lb_loaf (document assumption; modern pan loaf ~1,100–1,300 kcal/lb).
- Compute kcal_per_oz_gold = loaves_per_oz * kcal_per_lb_loaf.
- Use to compare across rice/maize cultures by converting staple rations to bread-kcal equivalents.

B.2.4 Housing rent proxy

- Where bread is price-controlled, cross-check with **room rent** for a laborer (single room, weekly/monthly).
- Metric: months_rent_per_oz = P_gold / rent_month.
- Large divergence vs. loaves_per_oz flags bread controls/subsidies.

B.2.5 Energy parity check

- Build a local **energy index** (wood/charcoal/coal/oil/gas).
- If energy soars while GLR barely moves, cancellation is plausible; if GLR surges with stable energy but falling real rates, the premium channel is likely at work.

B.2.6 Heuristic selection rules

- Prefer **wages** for cross-era labor comparability, **rent** to spot price controls, **kcal** for cross-staple comparisons, **suit** for durable/labor-intensive triangulation.
- If two alternate yardsticks contradict the bread row, widen the band and annotate.

B.3 Table template for future data drops

B.3.1 CSV header (copy-paste)

year,place,P_gold_currency,P_gold,source_gold,bread_grade,P_bread_raw_currency,P_bread_raw,W_raw_lb,

P_bread_1lb,loaves_per_oz,band_low,band_high,flag,source_bread,method_note,quality_note,fx_pair,fx_rate,

P_silver,gsr,wage_day,days_wage_per_oz,loaves_per_day,suit_price,suits_per_oz,energy_index

B.3.2 JSON schema (abridged)

```
{
  "year": 1717,
  "place": "London",
  "P_gold_currency": "GBP",
  "P_gold": 3.895,              // £ per oz
  "source_gold": "mint_fix | market",
  "bread_grade": "white | wholemeal | household | seconds | manchet | rye",
  "P_bread_raw_currency": "GBP",
  "P_bread_raw": 0.0375,        // £ per observed loaf
  "W_raw_lb": 4.0,              // weight of observed loaf
```

```
  "P_bread_1lb": 0.009375,      // derived
  "loaves_per_oz": 415.5,       // derived
  "band_low": 370.0,
  "band_high": 470.0,
  "flag": "A|B|C",
  "source_bread": "assize_table_1717",
  "method_note": "4-lb assize normalized to 1 lb",
  "quality_note": "white",
  "fx_pair": "— or e.g., GBPUSD",
  "fx_rate": 4.86,
  "P_silver": null,
  "gsr": null,
  "wage_day": 0.012,            // £/day (if available)
  "days_wage_per_oz": 324.6,    // derived
  "loaves_per_day": 1.28,       // derived
  "suit_price": 3.5,            // £ per good suit (if available)
  "suits_per_oz": 1.11,         // derived
  "energy_index": 100           // base=100
}
```

B.3.3 Row-quality legend

- flag = A — direct retail bread with weight; gold peg/market well-documented; same city/year.
- flag = B — one side inferred (flour or FX) or 5–10 year window.
- flag = C — both sides partially inferred or mixed regions.

B.3.4 Band calculator (plain rules)

- Start with eps_bread and eps_gold from Appendix A (A.2.11).

- Compute:
    - GLR_central = P_gold / P_bread_1lb
    - GLR_low = (P_gold*(1 - eps_gold)) / (P_bread_1lb*(1 + eps_bread))
    - GLR_high = (P_gold*(1 + eps_gold)) / (P_bread_1lb*(1 - eps_bread))
- Record band_low = GLR_low, band_high = GLR_high.

B.3.5 QA checklist before adding a row

1. **Same place & year?** If not, explain and set flag B/C.
2. **One bread grade only?** If mixed, choose modal grade; widen band.
3. **Loaf weight documented?** If inferred, mark and add ±10%.
4. **Flour/grain conversions stated?** Record alpha and extraction.
5. **FX applied consistently?** Convert both legs, not just one.
6. **Cross-checks pass?** loaves_per_oz ≈ days_wage_per_oz * loaves_per_day; suit/rent not wildly contradictory.
7. **Notes present?** Put brief method/quality notes so a future reader can reproduce the number.

B.3.6 Versioning & provenance

- Use semantic row IDs: YYYY-PLACE-GRADE-SRC (e.g., 1717-London-white-assize).
- Maintain a provenance.md with citation snippets, page/line references, and any digitization choices.
- Freeze assumptions (alpha, extraction, markup) per dataset version; if you change them, bump a dataset version tag (e.g., GLR_v1.2 → GLR_v1.3) and recompute affected rows.

B.3.7 Minimal ingest pseudocode (ASCII)

```
# given a list of dict rows with raw inputs
for row in rows:
  if missing(row["P_bread_1lb"]):
    row["P_bread_1lb"] = row["P_bread_raw"] / row["W_raw_lb"]
```

```
    if row.get("P_gold") is None and row.get("P_silver") and row.get("gsr"):
        row["P_gold"] = row["P_silver"] * row["gsr"]

    GLR = row["P_gold"] / row["P_bread_1lb"]
    row["loaves_per_oz"] = GLR

    eps_bread, eps_gold = choose_uncertainties(row["flag"], row["method_note"],
row["quality_note"])
    row["band_low"]  = (row["P_gold"]*(1 - eps_gold)) / (row["P_bread_1lb"]*(1 + eps_bread))
    row["band_high"] = (row["P_gold"]*(1 + eps_gold)) / (row["P_bread_1lb"]*(1 - eps_bread))

    assert approx_equal(GLR, row.get("days_wage_per_oz", GLR) * row.get("loaves_per_day",
1.0), tol=0.35), "wage cross-check"
```

B.3.8 How to publish

- Ship the **CSV**, the **assumptions.txt** (this Appendix B.1–B.2 excerpt tailored to your dataset), and a **README** with:
    - scope (cities/years),
    - normalization choices (alpha, extraction, markup),
    - uncertainty rules and flags,
    - a 1-page plot of GLR with band and annotated breakers (policy steps, famines, oil shocks).

This kit keeps the build **transparent, portable, and falsifiable**—anyone can rerun your pipeline, tweak an assumption (e.g., alpha = 1.5 instead of 1.6), and see exactly how the band and the ratio move.

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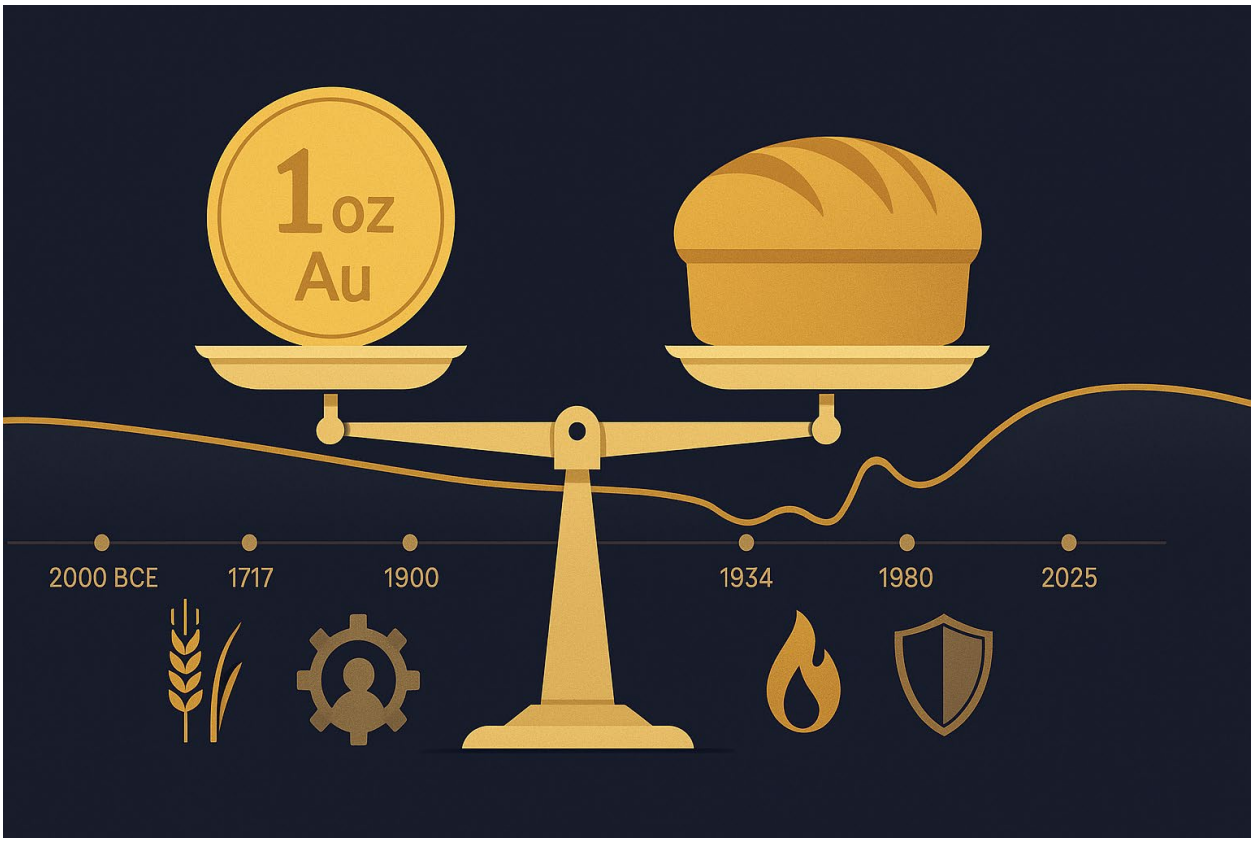
(Items above are the core sources underpinning the paper's historical facts, construction assumptions for bread/loaf conversions, gold market mechanics, and key event dates. Where multiple links are given for a single work, they point to authoritative texts, publisher pages, or archival scans.)


1 oz
Au
2000 BCE
1717
1900
1934
1980
2025