

The Bias in a Minute-Rounded Record Belongs to Whether the Recorder Reacted [F041]

When the direction comes from outside the minute, the bias is 0.0038 pips against the minute's first tick and 0.0088 against the minute's mean — both under 0.01 pips — but when the recorder reacted to what happened inside the minute it is 0.7944 pips, falling to 0.2139 if the reference is switched to the mean — and 0.6544 of that 0.7944 appears on a synthetic random walk

山岸 勇輝 (Yuuki YAMAGISHI) / Independent Researcher

ORCID 0009-0006-8587-3450

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Abstract

What this paper asks is which choice of reference changes the answer when a record kept only to the minute is matched against a market that moves in milliseconds — and the answer is that it is not the reference but whether the recorder reacted inside the minute. No new mathematical theorem and no new law is claimed.

First, ★ prediction ① failed. When the direction comes from outside the minute, referencing the minute's first tick creates no bias. Across 24 combinations of four instruments and six years the median is -0.0038 pips, positive in 8 of them (Sections 3 and 6).

Second, ★ prediction ② failed too. Switching to the minute's mean gives -0.0088 pips. Since ① was already zero there is nothing to compare; both are under 0.01 pips (Sections 3 and 7).

Third, and this is the core of the paper: ★ what creates the bias is whether the recorder reacted to what happened inside the minute. When they did, the bias against the minute's first tick is 0.7944 pips (Section 4).

Fourth, ★ switching the reference to the minute's mean then cuts it to 0.2139 pips — a fall of 0.5805 pips, a factor of 3.7141. The choice of reference matters only when there was a reaction

(Section 4).

Fifth, ★ **the within-minute rank separates the two under either reference: 49.5483** when the direction came from outside and **61.1288** when it reacted. **The rank is affected neither by the rounding nor by the choice of reference** (Sections 3 and 4).

Sixth, ★ **most of the reaction effect is not the market's**. The synthetic random walk gives **0.6544** pips against the first tick. **Of the measured 0.7944, a share of 0.8238 is explained by the random walk, leaving 0.1400 pips for the market** (Section 5).

Scope of this paper: no new mathematical theorem and no new law is claimed — timestamp rounding, systematic error and rank statistics are all known. **No real course, author, or vendor is the subject here, and none is named. No real trading record is examined** — the records are synthesized from ticks, and no one's results are being audited (Section 7). **No trading is discussed** — neither cost nor slippage is included, and everything is on mid prices (Section 7). **Predictions ① and ② failed** — with the direction from outside the minute, the reference created no bias (Sections 3 and 7). **One form of reaction is fixed** — only the sign of the within-minute move; partial reactions are not measured (Section 7). **The scope is intraday and few instruments** — four instruments over six years, 20,000 minutes sampled per instrument-year. Results documented at longer holding periods, such as monthly time-series momentum, are not contradicted. **No prediction is claimed.**

1. Notation and the question

A trading record is often kept only to the minute. The market moves in milliseconds.

What gets said	What does not get said
The record was matched against the market price	Against which point inside that minute
The recorded price was worse than the market	Whether the recorder saw something inside that minute and acted
Rounding has little effect	That a statistic robust to rounding exists

Observation 1.1: ★ The true fill behind a minute-rounded record is somewhere inside that minute. Where, nobody knows.

Observation 1.2: So a reference point has to be chosen. ★ The minute's first tick, or the minute's mean. The choice looks like a detail of preprocessing. That a choice of convention can manufacture an answer was measured in [F040].

Observation 1.3: The separator is the reference point. The records, the minutes, the instruments and the period are all held fixed, and **only what they are compared against is changed.**

Question: which choice of reference changes the answer when a minute-rounded record is matched against a millisecond market?

2. State the quantities and the design first

Declared before the run and unchanged during it.

Source	Ticks (mid price), grouped by minute
Sample	20,000 minutes at random per instrument-year (at least 10 ticks, the previous minute contiguous, fixed seed)
Record	The mid at a uniformly random instant inside the minute. The timestamp is rounded to the minute
References	A the minute's first tick / B the minute's mean / C the within-minute rank (0–100)
Directions	P1 the sign of the previous minute / P2 the sign of the within-minute move / P3 random
Quantities	(record – reference) × direction (pips), within-minute rank, the minute's move
Baseline	The ticks inside the minute replaced by a synthetic random walk of the same count and the same per-step scatter
Separator	The reference point (the first tick, the mean, or the rank)
Instruments and period	USDJPY, EURUSD, GBPUSD, XAUUSD / 2019–2024

Observation 2.1: ★ The record is drawn at a uniformly random instant inside the minute. If real fill times are uniform inside the minute, this is the right model.

Observation 2.2: ★ Having three ways to set the direction is the point. P1 uses only information from outside the minute, P2 is someone who looked inside it and reacted, and P3 is the control.

Observation 2.3: P2 is positive by definition. ★ It is placed there as an upper bound, not as a finding.

Observation 2.4: The sample is 120,000 minutes per instrument and 480,000 in total.

Predictions (written before measuring)

- ① Referencing **the minute's first tick** makes a record entered on the previous minute's direction **look systematically biased** (not zero).
- ② Referencing **the minute's mean** brings that bias to about **0**.
- ③ With a random direction the bias is **0** under every reference.
- ④ **The within-minute rank** stays **near 50** when the direction came from the previous minute.
- ⑤ **On a synthetic random walk the bias in ① disappears** (there is no one-minute momentum).

3. How much the answer changes with the reference

The same records, the same minutes. Only what they are compared against differs.

Calculation 3.1 Median over four instruments and six years

Direction	Reference A, first tick	Reference B, minute mean	Reference C, rank
P1 previous minute's sign	− 0.0038	− 0.0088	49.5483
P2 within-minute sign	0.7944	0.2139	61.1288
P3 random	− 0.0008	− 0.0012	50.0255

Observation 3.2: ★ Prediction ① failed. P1 against reference A is **−0.0038** pips. **The minute's move** (the mean distance from the record to the first tick) is **0.7944** pips, so this is only **−0.0048** of it.

Observation 3.3: ★ Prediction ② failed too. Reference B gives **−0.0088** pips, farther from **0** than A. Since ① was already zero, there is nothing to compare.

Observation 3.4: The same holds instrument by instrument. P1 against reference A is **0.0115** for USDJPY, **−0.0042** for EURUSD, **−0.0090** for GBPUSD and **−0.0112** for XAUUSD. ★ **The signs do not agree and none exceeds 0.02 pips.**

Observation 3.5: ★ The within-minute rank is 49.5483, right beside 50. Prediction ④ held.

Observation 3.6: The minute's move differs by instrument (0.7701, 0.5524, 0.7627 and 1.9812 pips). ★ **The P1 bias stays at zero regardless.**

4. What creates the bias is the reaction, not the reference

Calculation 4.1 What changes with how the direction is set

Direction	Reference A	Reference B	Reference C
Previous minute's sign (no look-ahead)	− 0.0038	− 0.0088	49.5483
Within-minute sign (reacted)	0.7944	0.2139	61.1288
Random (control)	− 0.0008	− 0.0012	50.0255

Observation 4.2: ★ This is the core of the paper: what creates the bias is not the reference but whether there was a reaction. With one it is **0.7944** pips against reference A; without one, **−0.0038**.

Observation 4.3: P2 against reference A is about the same as the minute's move, 0.7944 pips. ★ By definition the record sits where the price moved to from the first tick, so it must be. A check, not a finding.

Observation 4.4: Prediction ③ held. P3 gives **−0.0008** pips against reference A and **50.0255** against reference C.

Calculation 4.5 By how much does changing the reference reduce the reaction effect? (★ added afterwards)

This part is after the fact. **Once predictions ① and ② had failed, the question was re-posed and measured.**

	Reference A, first tick	Reference B, minute mean	A ÷ B
Direction from outside the minute	− 0.0038	− 0.0088	0.4324
Direction from inside the minute	0.7944	0.2139	3.7141

Observation 4.6: ★ With a reaction, switching the reference from the first tick to the mean takes 0.7944 to 0.2139 pips, a fall of 0.5805. A factor of 3.7141.

Observation 4.7: ★ With the direction from outside the minute it is 0.0038 or 0.0088 pips either way, both under 0.01. The choice of reference matters only when there was a reaction.

Observation 4.8: ★ The within-minute rank separates the two independently of either reference: 61.1288 with a reaction and 49.5483 without. The rank is affected neither by the rounding nor by the choice of reference.

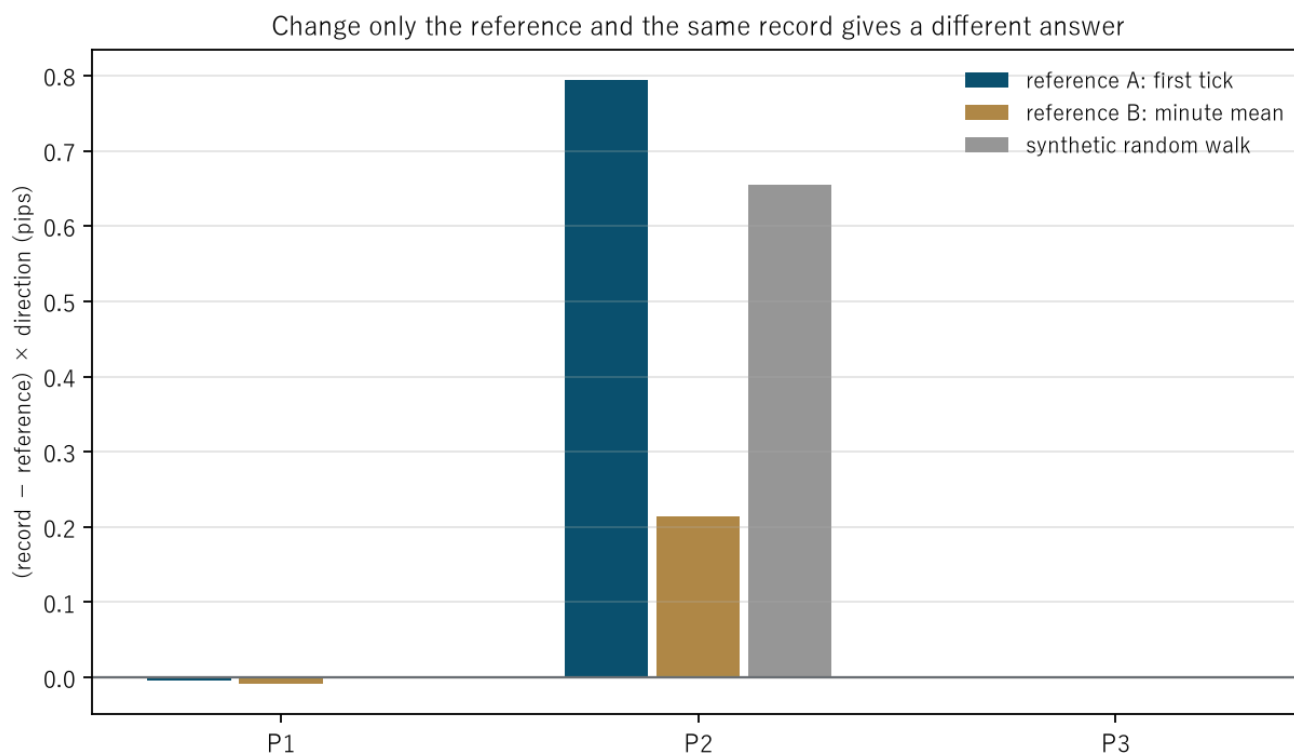


Figure 1: $(\text{record} - \text{reference}) \times \text{direction}$ (pips) for the three ways of setting the direction. **From the left: reference A (first tick), reference B (minute mean), and reference A on the synthetic random walk.**

5. The baseline — replacing the inside of the minute with a random walk

The same tick count and the same per-step scatter. The only difference is that there is no one-minute momentum.

Calculation 5.1 Measurement against synthetic random walk

Direction	A, meas.	A, RW	B, meas.	B, RW	C, meas.	C, RW
P1	-0.0038	0.0007	-0.0088	-0.0002	49.5483	49.9556
P2	0.7944	0.6544	0.2139	0.2094	61.1288	62.8083
P3	-0.0008	0.0018	-0.0012	0.0010	50.0255	50.0561

Observation 5.2: Prediction ⑤ held. The measurement is **−0.0038** against the random walk's **0.0007** pips. ★ **Though since the measurement was already zero, there was nothing to make disappear.** What this baseline is zero about was measured in [F033].

Calculation 5.3 How much of the reaction effect is the market's? (★ added afterwards)

	Measurement	Random walk	Difference	Share from the random walk
Reference A	0.7944	0.6544	0.1400	0.8238
Reference B	0.2139	0.2094	0.0045	0.9789
Reference C	61.1288	62.8083	− 1.6795	1.1509

Observation 5.4: ★ Most of the reaction effect is not the market's. The random walk explains **0.8238** of it under reference A and **0.9789** under reference B.

Observation 5.5: ★ For the rank the random walk is even larger (62.8083 against 61.1288). The share is **1.1509**, above 1.

Observation 5.6: ★ So "the record of someone who reacted looks worse than the minute's first tick" is not a property of the market. It comes from the arithmetic of recording where the price moved to inside the minute.

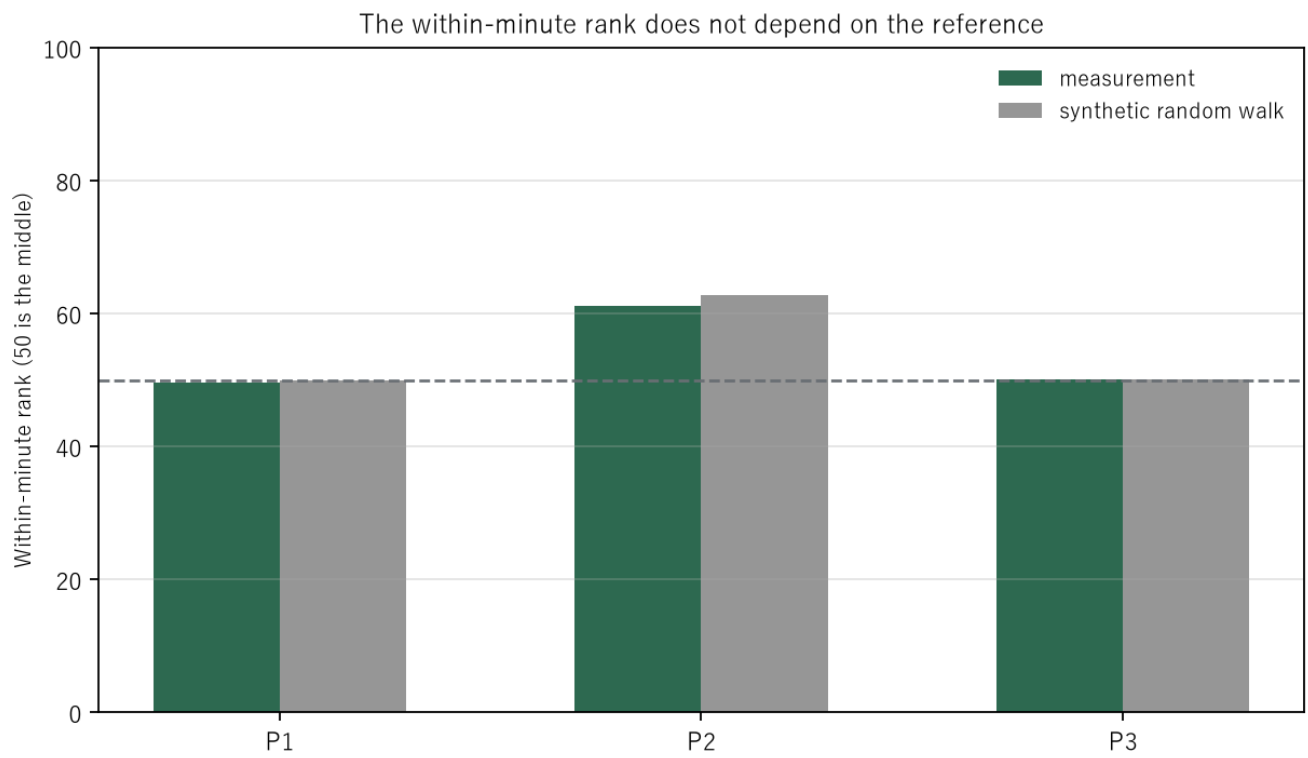


Figure 2: the within-minute rank (0–100) for the three ways of setting the direction. **The darker bars are the measurement, the lighter ones the synthetic random walk, and the dashed line is 50.**

6. Year by year

Calculation 6.1 P1 against reference A (pips)

Year	USDJPY	EURUSD	GBPUSD	XAUUSD	Median
2019	−0.0100	−0.0058	−0.0038	−0.0100	−0.0079
2020	0.0116	−0.0163	−0.0411	−0.0574	−0.0287
2021	0.0099	−0.0027	0.0032	−0.0124	0.0003
2022	0.0254	−0.0155	−0.0252	−0.0563	−0.0203
2023	0.0460	−0.0010	0.0019	−0.0021	0.0004
2024	0.0115	0.0049	−0.0141	−0.0038	0.0006

Observation 6.2: ★ Across 24 combinations the median is −0.0038 pips, the range −0.0574 to 0.0460, and 8 are positive. The signs do not agree.

Observation 6.3: Reference B is the same: median −0.0088, range −0.0571 to 0.0004, with 1 positive. ★ It leans slightly negative, but the size is in the hundredths of a pip.

Observation 6.4: Reference C ranges from 48.9215 to 49.9028. ★ All 24 sit just below 50.

Observation 6.5: USDJPY in 2023 alone is a little larger at 0.0460. ★ The mechanism is not measured.

7. Limitations

1.  **Predictions ① and ② failed.** With the direction from outside the minute, the reference created no bias. **This paper writes those failures and re-poses the question as "the reference, or the reaction".**

2. **No real trading record is examined.** The records are synthesized from ticks, and no one's results are audited.
 3. **Fill times are assumed uniform inside the minute.** If they are skewed in practice, the results change.
 4. **One form of reaction is fixed:** only the sign of the within-minute move; partial reactions are not measured.
 5. **No trading is discussed.** Neither cost nor slippage is included, and everything is on mid prices.
 6. **The sample is capped at 20,000 minutes per instrument-year.** Using every minute would shift the values slightly.
 7. **The mechanism behind USDJPY's larger 2023 value is not measured.**
 8. **Four instruments, six years.** Nothing is claimed about other markets or other periods.
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Conclusion

A trading record is often kept only to the minute; the market moves in milliseconds. **To match them, a reference point has to be chosen.**

★ **Two predictions failed. When the direction comes from outside the minute, no reference creates a bias.** It is -0.0038 pips against the minute's first tick and -0.0088 against the mean. **Across 24 combinations the range is -0.0574 to 0.0460 , with 8 positive: the signs do not even agree.**

★ **What creates the bias is not the reference. It is whether the recorder reacted to what happened inside the minute.** With a reaction, the bias against the first tick is 0.7944 pips. **That is about the minute's move of 0.7944 pips — a value that follows from the definition.**

★ **Only then does the reference matter.** Switching to the mean cuts it to 0.2139 pips: a fall of 0.5805 , a factor of 3.7141 .

★ **And most of the reaction effect is not the market's.** The synthetic random walk gives 0.6544 pips against the first tick. **Of the measured 0.7944 , a share of 0.8238 is explained by the random walk,**

leaving **0.1400 pips** for the market. Under reference B, **0.9789** is the random walk and only **0.0045** pips remain.

★ **Only the within-minute rank is affected neither by the rounding nor by the reference.** It is **49.5483** when the direction came from outside and **61.1288** with a reaction — and **62.8083** on the random walk, larger than the measurement.

So what matters when matching a minute-rounded record is not where the reference was taken. ★
It is whether the recorder saw something inside that minute and acted. And of "it looks like a worse fill", a share of 0.8238 comes from arithmetic, not the market.

Data and reproduction

Data	Foreign exchange from Dukascopy-derived ticks (from 2019 onward, matching to the millisecond, bid and ask, has been verified). Gold from Dukascopy
Period	2019–2024 (six years)
Instruments	USDJPY, EURUSD, GBPUSD, XAUUSD
Source	Tick mid prices, grouped by minute
Sample	20,000 minutes at random per instrument-year (at least 10 ticks, the previous minute contiguous). 480,000 minutes in total
Record	The mid at a uniformly random instant inside the minute; the timestamp rounded to the minute
References	A the minute's first tick / B the minute's mean / C the within-minute rank (0–100)
Directions	P1 the previous minute's sign / P2 the within-minute sign / P3 random
Quantities	(record – reference) × direction (pips), within-minute rank, the minute's move
Baseline	The ticks inside the minute replaced by a synthetic random walk of the same count and per-step scatter
Verification	<code>検算/F041.py</code> (<code>--zu</code> also writes the figures). Every number in the text comes from <code>検算/F041_output.txt</code>
Figures	<code>図/F041_zu1</code> , <code>図/F041_zu2</code> (png, svg, English versions)
Random seeds	Fixed. Re-running gives the same values
Substrate check	<code>_ツール/auditBars.py</code> (bar look-ahead, daylight saving, day boundary). The record is <code>_土台の検査.txt</code>

References

- Yamagishi, Y. (2026). A Synthetic Random Walk Has No Volatility Clustering [F033]. Zenodo. 10.5281/zenodo.22893674
- Yamagishi, Y. (2026). A Renko Turning Point Is Not a Turning Point Until the Brick Completes [F040]. Zenodo. 10.5281/zenodo.22894529