NQ Return Analysis

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1. Introduction

The present study is part of a broader research series attempting to characterize the microstructure behavior of the E-mini Nasdaq-100 continuous futures contract (NQ). The long-term objective of this program is to build a defensible modeling engine capable of mapping and accurately forecasting regime shifts, volatility structure, and directional behavior in high-frequency index futures.

This installment focuses specifically on the return behavior of NQ daily returns. This paper uses both standard and forward weighted return constructions, comparing them directly against Gaussian benchmarks to evaluate asymmetry, excess kurtosis, and the frequency of extreme moves. Because microstructure returns and action can, and often are, distorted by fluctuations in the U.S. dollar, the study also examines NQ performance in gold-denominated terms, providing a non-fiat comparison that helps to isolate the asset's intrinsic behavior from currency-driven effects. This non-fiat consideration is particularly relevant in the context of the current weakening of the U.S. dollar, which has seen a sharp split in dollar-denominated returns and non-fiat-returns.

2. Data & Methodology

Data

This analysis uses daily returns for the E-mini Nasdaq-100 continuous futures contract (NQ) and COMEX gold futures (GC) over the period September 27, 2009 to February 23, 2026. This timeframe is in line with other studies in this series. Data was pulled from Barchart.com, containing the standard fields: Time, Open, High, Low, Latest, Change, %Change, Volume, and

Open Interest. The Latest field, corresponding to close, was used as the closing value for all return calculations. Returns were calculated as follows:

$$r_t = (P_t - P_{t-1}) / P_{t-1}$$

Where r_t is the daily log return, and P_t is the settlement price and P_{t-1} is the prior trading days settlement price. This process is part of the dedicated cleaning script. After cleaning, the NQ and GC datasets are merged on the date index to ensure perfect temporal alignment. Only days where both assets report valid settlement prices are retained.

Methodology

Two return series are analyzed for NQ. Standard returns, which weight all observations equally and forward-weighted returns, where weight increases linearly with time to emphasize recent behavior. Forward weighted returns were calculated as follows:

$$w_t = t / T$$

Where T is the total number of observations and t is the weight for observation. This weighting scheme preserves the full sample while allowing the tail analysis to reflect evolving market structure.

To isolate NQ's intrinsic behavior from fluctuations in the U.S. dollar, the analysis also examines returns in gold-denominated terms. The gold-adjusted price series is defined as the ratio of NQ_t/GC_t. Gold-adjusted prices were calculated as follows:

$$r_t^{(gold)} = ((NQ_t / GC_t) / (NQ_{t-1} / GC_{t-1})) - 1$$

This transformation removes fiat-currency effects and provides a stable benchmark for assessing tail asymmetry and extreme-move frequency.

A Gaussian reference sample is also generated for each return series using the empirical mean and standard deviation. This provides a baseline for evaluating skewness, kurtosis, and tail exceedance relative to a symmetric, thin-tailed distribution.

For both fiat and gold-denominated analysis', the scripts produce the same three core outputs. A Kernel Density Estimation (KDE), a smooth density estimate produced to highlight return shape, tail thickness, and to display deviations from the Gaussian model. A Tail-Exceedance curve is also generated, meant to highlight tail asymmetry and heavy-tailed behavior. A text file reporting a set of descriptive statistics. The file contains mean, standard deviation, skewness, and kurtosis for both standard and forward-weighted returns.

All scripts are fully reproducible with Barchart CSV's and operate only on the cleaned datasets stored in data/processed/.

3. Key Findings

- NQ's daily returns in USD exhibit a mild negative skew (≈ -0.19) and moderate excess kurtosis (≈ 7.52), indicating a distribution with heavier-than-Gaussian tails and disproportionately large downside moves. When forward-weighted, the skew becomes less negative (≈ -0.09) while excess kurtosis increases (≈ 7.94), suggesting that more recent periods contain relatively larger extreme observations even as directional asymmetry diminishes.

- Gold-denominated NQ returns display a noticeably milder distributional profile. Standard gold-adjusted returns show only marginal negative skew (≈ -0.03) and substantially lower excess kurtosis (≈ 4.18), indicating thinner tails and reduced downside asymmetry
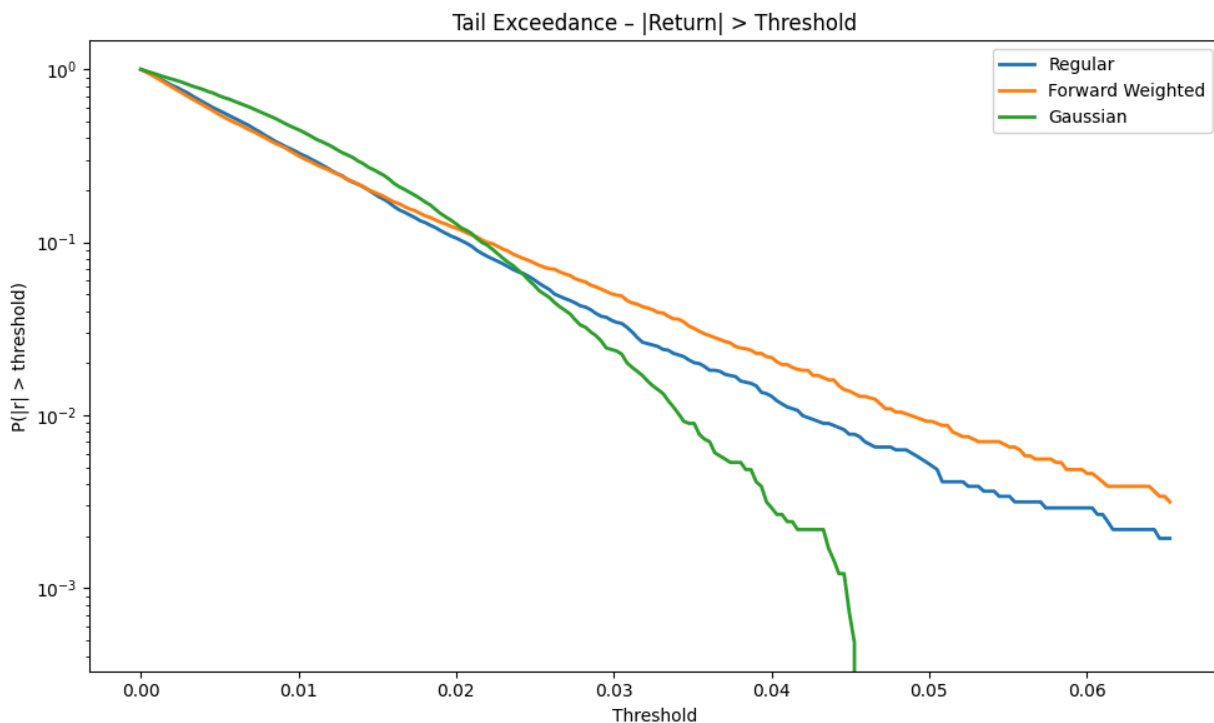
once USD fluctuations are removed. Forward-weighted gold-denominated returns exhibit a slight positive skew ($\approx +0.02$) and a further reduction in excess kurtosis (≈ 4.02). The inversion of skew direction between standard and forward-weighted gold returns suggests a structural shift in the underlying return dynamics over the sample period, with more recent gold-adjusted behavior becoming modestly right-skewed.

- Tail exceedances occur far more often than normal predicts, this phenomenon is true in all four test cases.
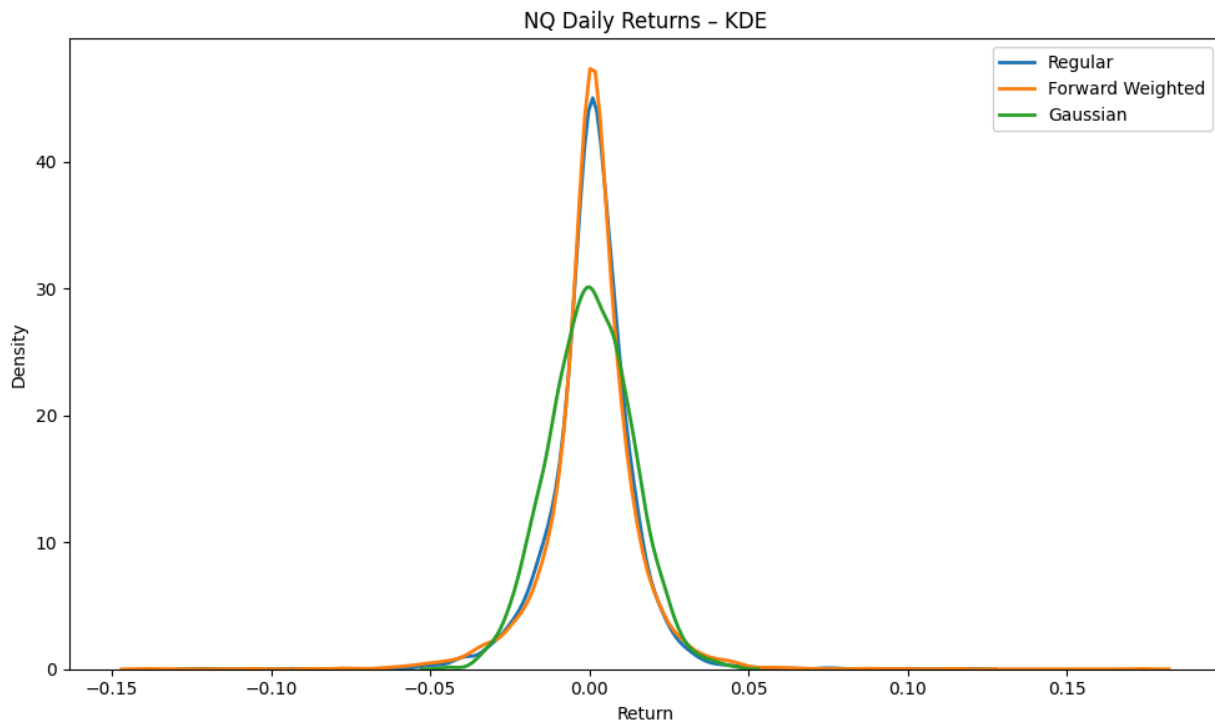
4. Return Analysis

This section examines the return distributions and tail behavior across all four NQ test cases to evaluate how their statistical properties evolve under different weighting schemes and numeraires.

As shown in the key findings section, both of the USD denominated NQ return distributions exhibit mild negative skew and moderate excess kurtosis, indicating heavier left tails than a Gaussian benchmark. This tail heaviness is especially in tail exceedance curves. As seen in figure A, while the Gaussian model decays rapidly toward zero, both empirical observations show persistent exceedance probabilities across a wide range of thresholds. The forward-weighted series lies consistently above the standard series, reflecting a higher frequency of extreme observations in more recent periods. This visual separation demonstrates the kurtosis imbalance between the two series and suggests that the market has trended towards a higher frequency of high impact events.
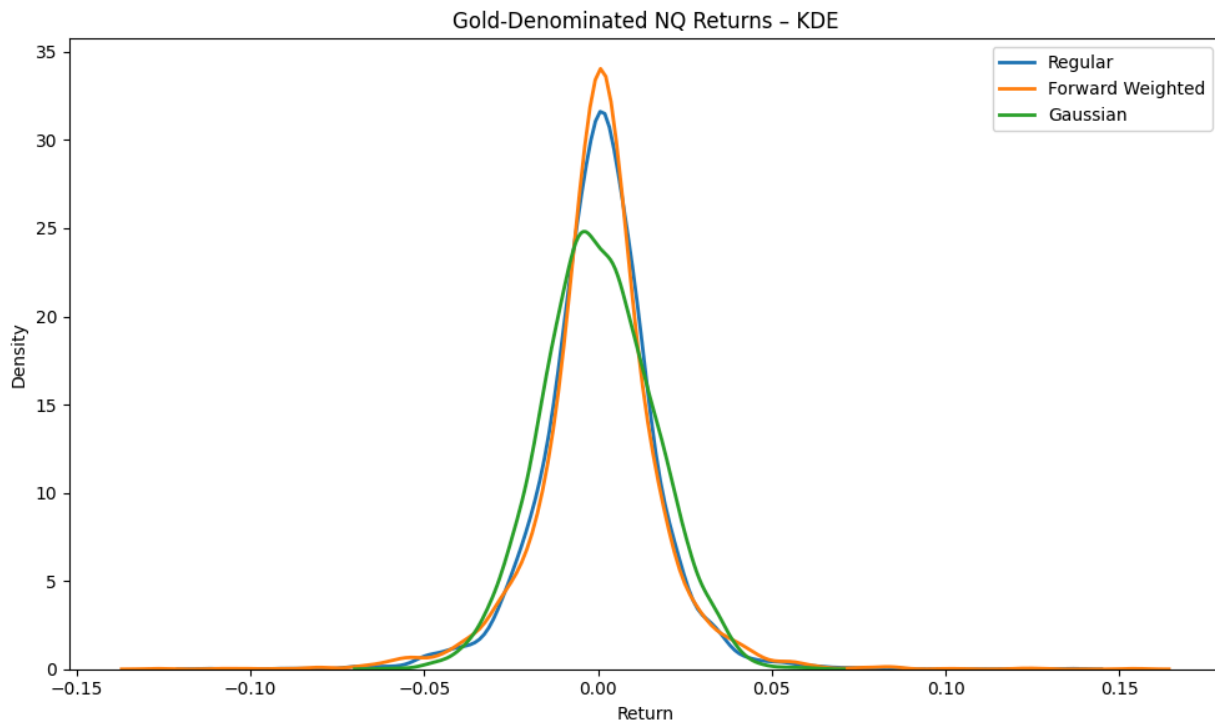
Figure A. *Empirical tail-exceedance curves for NQ daily returns, showing the probability that absolute returns exceed a given threshold under the standard return series, the forward-weighted series, and a Gaussian benchmark with matched mean and variance. The forward-weighted curve lies above the standard curve across most thresholds, indicating a higher frequency of extreme moves in more recent periods, while both empirical curves sit well above the Gaussian reference, reflecting the heavy-tailed nature of NQ returns.*

The kernel density curve, shown in figure B, emphasizes the split. The forward-weighted distribution exhibits a noticeably taller peak in figure B, consistent with a higher excess kurtosis, this comes despite a comparatively more symmetric skew. This combination suggests that markets have produced more clustered small returns alongside proportionally larger tail events, a demonstration of a regime with elevated tail risk but reduced directional asymmetry.

Figure B. *Kernel density estimates of NQ daily returns comparing the standard return distribution, the forward-weighted distribution, and a Gaussian reference with matched mean and variance. The forward-weighted series exhibits a noticeably taller central peak and heavier tails, consistent with its higher excess kurtosis and the greater influence of recent extreme observations.*

When contextualized with gold denominated returns, the daily return patterns become less aggressive and much more Gaussian. This is most noticeable in kurtosis. While USD denominated kurtosis values range from 7.52 to 7.94 for standard and forward-weighted, gold denominated kurtosis values fall far at 4.18 and 4.02 for standard and forward-weighted. This compression is clearly visible in the KDE, figure C, where the empirical curves sit closer to the Gaussian reference and exhibit a flatter peak. The reduction in kurtosis suggests that a substantial portion of the extreme moves observed in USD terms is attributable to fluctuations in the U.S. dollar rather than intrinsic volatility in NQ itself.

Figure C. *Kernel density estimates of gold-denominated NQ daily returns comparing the standard series, the*

forward-weighted series, and a Gaussian benchmark with matched mean and variance. Both empirical distributions

show a noticeably flatter central peak and thinner tails than their USD-denominated counterparts, reflecting the

reduction in extreme-move frequency once USD volatility is removed. The forward-weighted curve is slightly taller

and more right-skewed, consistent with the milder excess kurtosis and subtle shift toward positive asymmetry in

more recent gold-adjusted behavior.

Finally, the inversion of skew between standard and forward-weighted gold denominated

returns indicates a shift in the symmetry of extreme events over time. This pattern aligns with the

post-COVID market environment, which has seen >20% returns in the Nasdaq-100 five out of

the last six years. Moreover, its presence in gold denominated returns reflects a genuine

structural change in NQ's underlying return dynamics rather than a currency-driven artifact.

5. Implications, Limitations & Discussion

Implications

The contrast between USD and gold denominated returns shows that a meaningful proportion of NQ's observed tail risk is currency-amplified and not directly tied to the underlying index itself. The higher kurtosis and persistent tail exceedances in the USD terms imply that macro-monetary shocks and dollar volatility materially shape perceived risk and equity value. Forward-weighted results further demonstrate the market's progression towards more frequent high-impact events, even as directional asymmetry has flattened. The inversion of skew in gold-denominated returns reflects a change in the underlying return dynamics, with recent periods exhibiting a greater tendency toward upside shocks than historical averages.

Limitations

The analysis relies on daily data, which may obscure intraday microstructure effects and understate the true frequency of extreme moves. Forward-weighting emphasizes recent behavior but does not explicitly model regime transitions, leaving the timing and drivers of structural shifts unidentified. Gold-denominated returns remove USD effects but introduce exposure to gold's own volatility regime, which may not perfectly isolate "intrinsic" NQ behavior. Finally, KDE and tail-exceedance methods are descriptive rather than causal, limiting the ability to attribute tail behavior to specific economic mechanisms.

Discussion

The results of this study reveal a market environment where tail risk is elevated, temporally uneven, and sensitive to currency fluctuations. USD denominated returns overstate

the extremity of NQ's behavior relative to gold-denominated returns, this highlights the role of monetary conditions in shaping perceived volatility. The forward-weighted patterns suggest that recent years have been characterized by more clustered small moves punctuated by larger shocks, consistent with a post-COVID regime defined by outsized return patterns, tech-driven rallies, and rapid repricing events. The skew inversion in gold terms reinforces the view that the distribution of extreme events has shifted directionally, making a structural evolution in how the index responds to macro and sector-specific catalysts.

6. Conclusion

Overall, the analysis shows that NQ's return distribution has become increasingly symmetric while maintaining elevated tail-risk characteristics, particularly related to USD. Gold-denominated results reveal that a large proportion of the observed extremity is currency related and not intrinsic to the index, underscoring the presence of genuine, currency-independent gains. Together, these findings establish a clear foundation for understanding the evolving structure of NQ return behavior and the role of monetary conditions in shaping perceived risk.