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Price Gaps and Volatility: Do Weekend Gaps Tend to Close?

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Abstract: This study investigates weekend price gaps in three major stock market indices—the Dow Jones Industrial Average (DJIA), NASDAQ, and Germany's DAX—from 2013 to 2023, using high-frequency (5 min) data to explore whether gap movements arise from random volatility or reflect systematic market tendencies. We examine 205 weekend gaps in the DJIA, 270 in NASDAQ, and 406 in the DAX. Two principal hypotheses guide our inquiry as follows: (*i*) whether price movements into the gap are primarily driven by increased volatility and (*ii*) whether larger gaps are associated with heightened volatility. Employing Chi-square tests for the independence and linear regression analyses, our results show no strong, universal bias towards closing gaps at shorter distances across all three indices. However, at medium-to-large distances, significant directional patterns emerge, particularly in the DAX. This outcome challenges the assumption that weekend gaps necessarily "fill" soon after they open. Moreover, larger gap sizes correlate with elevated volatility in both the DJIA and NASDAQ, underscoring that gaps can serve as leading indicators of near-term price fluctuations. These findings suggest that gap-based anomalies vary by market structure and geography, raising critical questions about the universality of efficient market principles and offering practical insights for risk management and gap-oriented trading strategies.

Keywords: price gap anomaly; stock market; efficient market hypothesis; gap size; trade strategy; market volatility; high-frequency data

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1. Introduction

The Efficient Market Hypothesis (EMH) posits that asset prices incorporate all relevant information, thus making it infeasible to consistently achieve excess returns without taking on additional risk (Fama, 1970), while EMH has historically been foundational in explaining price movements, a growing body of empirical work identifies persistent market anomalies that deviate from core predictions (Alajbeg et al., 2012; Mandelbrot, 1972; Plastun et al., 2020). One such anomaly is the *price gap*—the abrupt discontinuity between the closing price on one day and the opening price on the next. Weekend gaps, specifically those arising from the close of trading on Friday to the open on Monday, have attracted considerable attention, as exogenous news or events during the non-trading period can spur significant jumps in price (Caporale et al., 2016; Caporale & Plastun, 2017; Dahlquist & Bauer, 2012; Woo et al., 2020).

Initial studies often focused on a seemingly predictable *gap-filling* pattern, wherein prices revert to the prior closing level after the market opens (Dahlquist & Bauer, 2012; Plastun et al., 2020). However, recent evidence from Janse van Rensburg and Van Zyl suggests that *weekend gaps* might instead move *in the direction of the gap*, and that the probability of this movement increases with the gap's size. Such findings pose the following intriguing question: does price truly exhibit a directional bias toward closing or extending the gap, or is it simply responding to heightened market volatility?

While (Plastun et al., 2020) explore gap anomalies in the US stock market over an extended historical period (1928–2018), their work relies primarily on daily price data and emphasises aggregate, long-term patterns. In contrast, our study leverages *high-frequency 5 min data* spanning 2013–2023, a resolution that allows for the detailed examination of *intraday* gap behaviour. This finer granularity not only provides insights into whether traders can exploit short-term movements, but also illuminates subtleties regarding gap formation and closure that remain obscured in studies relying on daily or lower-frequency observations. As a result, our approach diverges from prior research by focussing on real-time price dynamics and offering an enhanced perspective on the potential profitability and risk profiles of gap-based trading strategies. Additionally, we extend our scope beyond the United States by incorporating the German DAX index, a leading European benchmark renowned for its liquidity and diverse sector representation. Unlike US indices, the DAX operates under a distinct trading schedule, including pre-market sessions that may foster different intraday responses to overnight news and macroeconomic events. Germany's regulatory framework and unique economic backdrop further suggest that gap behaviours could differ markedly from those documented in American markets (Johann et al., 2019; Stapf & Werner, 2003). By comparing weekend gap dynamics across the DJIA, NASDAQ, and DAX, we ascertain whether patterns observed in the United States generalise internationally or whether regional factors—such as investor sentiment, industrial composition, or trading microstructure—induce varying outcomes. Specifically, we evaluate how frequently prices reach predefined points within and outside the gap (akin to *take-profit* and *stop-loss* levels, respectively), thus determining whether any directional bias reflects a genuine "gap-closing" phenomenon or is merely heightened volatility. The analysis spans a ten-year period (2013–2023) and focuses on three major indices as follows: the Dow Jones Industrial Average (DJIA), NASDAQ (US100), and the DAX. Our primary objective is to establish whether weekend price gaps systematically revert towards the previous closing level or if they predominantly signify random market fluctuations. By integrating a prominent European index into our framework, we offer a broader examination of gap-based anomalies and their potential implications for short-term trading decisions in diverse market environments.

The remainder of this paper is structured as follows: we review the relevant literature on market anomalies, weekend effects, and volatility in Section 2; describe our data and empirical methods in Section 3; present the findings in Section 4; and discuss implications for market participants in Section 5.

2. Literature Review

2.1. Market Anomalies and the EMH

The seminal work of (Fama, 1970) establishes the Efficient Market Hypothesis, contending that intense competition among rational investors ensures that asset prices incorporate all known information. Under strict EMH assumptions, any predictable patterns or *anomalies* should quickly be arbitraged away (Jensen, 1978; Lo, 1991). Nonetheless, numerous studies have documented return patterns, seasonality, and other irregularities that challenge the EMH's notion of randomness (Alajbeg et al., 2012; Mandelbrot, 1972; Schwert, 2003; Woo et al., 2020). Mandelbrot (1972) showed that price distributions often exhibit heavy tails and temporal dependence, suggesting departures from idealized Gaussian randomness. Behavioral finance frameworks further argue that emotional factors—such as investor overreaction or herding—give rise to market inefficiencies (Akerlof & Shiller, 2010; Ball, 2009; Shiller, 2000).

Price gaps are among the anomalies frequently discussed in the literature, particularly *inter-day gaps* in equity and futures markets. Research in the 1990s and 2000s expanded on short-term trading opportunities such as *gap fade* and *gap continuation* strategies, which were also highlighted in practical trading guides like *Day Trading with Short Term Price Patterns and Opening Range Breakout* (Crabel, 1990). According to this view, once a gap forms at the open, traders may either *fade* the gap (expecting a price retracement) or *trade in the gap's direction* (expecting a continued move). While such systematic strategies appear promising, the effectiveness of gap-based trading remains controversial, as some studies note the limited profitability once transaction costs and risk are fully accounted for (Plastun et al., 2020; Schwert, 2003).

2.2. Weekend Effects and Price Gaps

Weekend gaps merit special focus because the extended break between Friday's close and Monday's open can allow fundamental news, geopolitical events, or unexpected macroeconomic data to accumulate (Dahlquist & Bauer, 2012). Historically dubbed the *weekend effect*, this phenomenon extends beyond simple return patterns—researchers such as (Caporale et al., 2016; Cross, 1973; French, 1980) linked weekend price anomalies to asymmetric trading behaviour and heightened uncertainty. Dahlquist and Bauer (Dahlquist & Bauer, 2012) emphasize that pre-market orders on Monday may cause large deviations from Friday's final price, thereby forming a visible gap.

Conventional wisdom posits that the market "strives" to close or fill these gaps soon after the open, offering a short-term trading edge (Caporale & Plastun, 2017; Plastun et al., 2020). However, recent evidence questions whether this *filling* is genuinely systematic or simply reflects broader volatility dynamics. Janse van Rensburg and Van Zyl propose that weekend gaps often continue in their initial direction—particularly when the gap is large—thus contradicting the widely assumed reversion. This paper further explores whether such movements result from chance volatility spikes or reflect an exploitable, directionally biased market anomaly.

2.3. Other Prominent Anomalies: Momentum and Volume–Volatility

Price gaps are only one facet of the rich literature on market anomalies. Momentum effects, for instance, describe the empirical regularity that winners tend to keep winning and losers tend to keep losing over intermediate horizons (Jacobsen et al., 2005; Lo, 1991), while the mechanisms underlying momentum are debated, some argue that slow information diffusion or herding can perpetuate price trends, further undermining the EMH premise. Another strand investigates the relationship between *volume* and *volatility*. Fong and Wong (2006) showed that the unexpected trading volume explains a significant portion of realized volatility, and Xiao et al. (2009) found that this effect is particularly persistent in less active stocks. Gaps—weekend or otherwise—naturally intersect with this volume–volatility dynamic, as abrupt changes in price often come alongside spikes in trading activity (Plastun et al., 2020).

Together, these anomalies underscore that market mechanisms are multi-dimensional and can deviate from EMH under various conditions. Identifying whether observed price patterns are simply short-lived or represent genuine structural inefficiencies is essential for traders and researchers alike.

2.4. Fundamentals, Technicals, and the Price Gap Mechanism

Fundamentally driven news stories—such as earnings announcements, mergers, or macroeconomic releases—commonly underlie the creation of price gaps (Chordia et al., 2002). Over the weekend, markets are closed and cannot immediately incorporate significant news; thus, Monday's open may reflect a sudden adjustment to new information, producing a gap. In theory, this initial gap size could be explained by rational market participants updating their valuations in response to fundamental data (Chordia et al., 2002).

However, the subsequent intraday trajectory following a gap often appears less tied to fundamentals and more influenced by short-term technical trading. Toby Crabel's early work (Crabel, 1990) on opening range breakouts illustrates how technical traders frequently adopt rules to exploit perceived directional momentum or mean reversion once the gap occurs. Likewise, Dahlquist and Bauer (2012) argue that large weekend gaps can attract technical traders who focus on stop-loss and take-profit triggers near the gap boundaries, further amplifying non-fundamental price moves. These technical-driven dynamics imply that while fundamentals might spark the initial gap, the continuing price action on Monday is often shaped by liquidity, trader psychology, and mechanical trading strategies rather than new fundamental information (Plastun et al., 2020).

By distinguishing between *gap creation* (driven by fundamentals) and *post-gap price movement* (often dominated by technical or behavioural factors), researchers and practitioners can better assess whether weekend gaps represent true opportunities for abnormal returns or simply reflect heightened volatility in the absence of new fundamental updates.

3. Data and Methodology

This study investigates the behaviour of weekend price gaps in the following three major stock market indices: the Dow Jones Industrial Average (DJIA), NASDAQ, and the DAX (Germany), spanning a ten-year period from 2013 to 2023. The primary objective is to determine whether observed movements into these weekend gaps are driven by genuine market trends to "close" the gap or if they merely reflect heightened market volatility. To capture the nuanced price movements over weekends, we utilise 5 min high-frequency data for all three indices.

3.1. Data Scope and Limitations

We focus on the ten-year range from 2013 to 2023 for two main reasons. First, our use of 5 min frequency data aims to evaluate finer price movements, in contrast to prior studies relying on daily or lower-resolution data (Plastun et al., 2020). Processing such high-frequency data exponentially increases computational demands, making it impractical to extend the sample far beyond a single decade. Second, although we attempted to collect data as early as the year 2000, we found persistent gaps in historical intraday records, which undermines reliability for high-frequency analysis (Brownlees & Gallo, 2006). Consequently, our chosen horizon represents a trade-off, capturing modern trading conditions while retaining sufficient data integrity to investigate gap behaviour.

3.2. Gap Definition and Variables

A weekend price gap is identified whenever the opening price on Monday (MO) differs from the previous Friday's closing price (FC) by more than 20 points as follows:

$$GS = |MO - FC|, \tag{1}$$

where GS denotes the gap size and $|\cdot|$ is the absolute value. Over the full sample, we detect 205 such gaps in the DJIA, 270 in NASDAQ, and 406 in the DAX. Each gap is then scrutinised to determine the probability of prices reaching predefined fixed points in the gap's direction (Take Profit, TP) and against the gap (Stop Loss, SL).

If the prevailing literature holds—that prices commonly move to "fill" or close the gap (Caporale & Plastun, 2017; Dahlquist & Bauer, 2012; Plastun et al., 2020)—we would expect higher hit rates for points set inside the gap (TP) than those set equidistant beyond it (SL). Let $\text{sign}(MO - FC)$ capture the gap's direction. For distances $d = 10, 20, 30, \ldots, 190$, we define the following:

- **Take Profit (TP) calculation:**

$$TP_d = MO - d \cdot \text{sign}(MO - FC), \quad (2)$$

- **Stop Loss (SL) calculation:**

$$SL_d = MO + d \cdot \text{sign}(MO - FC). \quad (3)$$

Here, d denotes the incremental distance from Monday's opening. By observing whether the market reaches these TP or SL levels first (or at all), we can assess the direction of short-term price movement following a weekend gap.

3.3. Hypotheses and Statistical Approach

We define two sets of hypotheses as follows:

Hypothesis 1 (directional movement):

- $H_0^{(1)}$: There is no preferential directional movement towards closing weekend price gaps; observed movements arise solely from random volatility.
- $H_1^{(1)}$: Weekend gaps exhibit a systematic directional bias (e.g., a "fill" tendency) that cannot be explained purely by random volatility.

Hypothesis 2 (gap size and volatility):

- $H_0^{(2)}$: Larger weekend gaps do not lead to elevated volatility.
- $H_1^{(2)}$: Larger weekend gaps do coincide with higher volatility.

For Hypothesis 1, we compare the frequencies with which price hits TP points (inside the gap) versus SL points (beyond the gap), using Chi-square tests for independence to ascertain whether any directional bias exists. For Hypothesis 2, we use regression analysis to investigate whether larger gaps are associated with greater overall volatility, measured through hit rates and the subsequent price variability. This combined approach enables a comprehensive assessment of whether weekend gap movements stem from genuine gap-closing tendencies or are simply by-products of broader volatility in equity markets.

3.4. Hypothesis 1: Price Movements into the Gap Are a Result of Increased Market Volatility

This hypothesis explores the relationship between observed price movements into weekend price gaps and the underlying market volatility, challenging the assumption that prices tend to move predictably into the gap. We build upon the foundational work by (Caporale & Plastun, 2017) and extend our previous research, which focused on the movement's direction relative to the gap (Caporale & Plastun, 2017; Plastun et al., 2020). Our analysis introduces a nuanced approach, examining the frequency of price movements into the gap and comparing it against movements in the opposite direction. To test this hypothesis, we analysed a comprehensive dataset encompassing all observed weekend price gaps from 2013 to 2023. Our dataset tracks price movements starting from the Monday opening, with fixed points established at incremental distances in both directions—toward and away from the gap—up to a distance of 990 points. This examination aimed to determine the distance the hit rates for these fixed points begin to stabilise, indicating the limit of significant price movements related to weekend gaps. The initial visual analysis, depicted in Figures 1–3, revealed that hit rates begin to flatten at approximately 200 points from the opening for all three indices, establishing these as the boundary for meaningful price movements connected to weekend gaps.

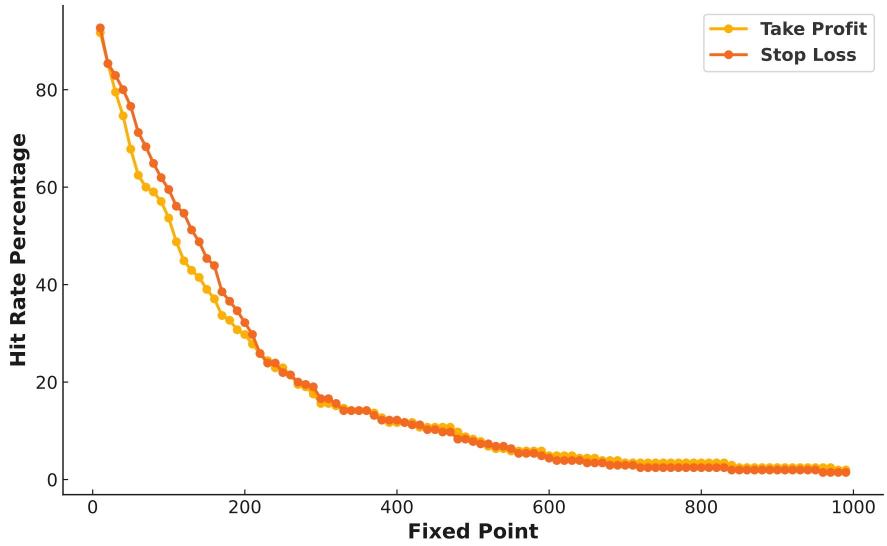

Figure 1. Hit rate comparison up to 990 points for DJIA (US30) showing flattening trends.

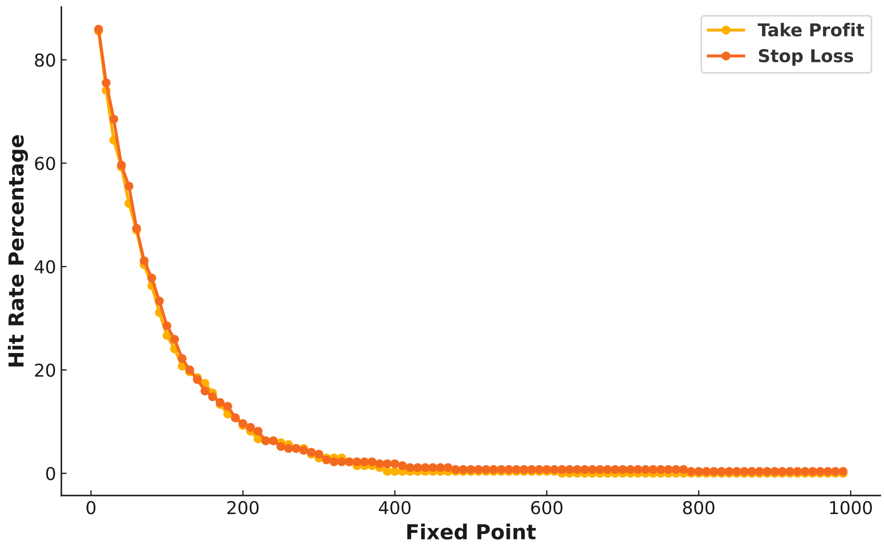

Figure 2. Hit rate comparison up to 990 points for NASDAQ (US100) showing flattening trends.

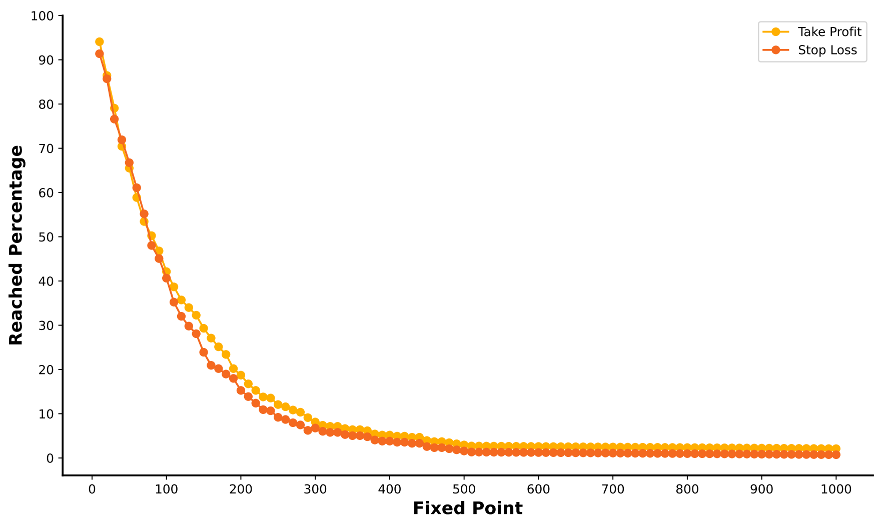

Figure 3. Hit rate comparison up to 990 points for Dax showing flattening trends.

Subsequently, we focused on a narrower view for meaningful analysis, considering the distance of only up to 190 points. This focused dataset provides a more practical range, as presented in Table 1 and Figures 4–6.

Table 1. Price reaching fixed point for DJIA (US30), NASDAQ (US100), and DAX.

Fixed Point	DJIA (US30)		NASDAQ (US100)		DAX	
	Take Profit %	Stop Loss %	Take Profit %	Stop Loss %	Take Profit %	Stop Loss %
10	91.71%	92.68%	85.56%	85.93%	94.09%	91.38%
20	85.37%	85.37%	74.07%	75.56%	86.45%	85.71%
30	79.51%	82.93%	64.44%	68.52%	79.06%	76.60%
40	74.63%	80.00%	59.26%	59.63%	70.44%	71.92%
50	67.80%	76.59%	52.22%	55.56%	65.52%	66.75%
60	65.85%	73.17%	46.67%	52.59%	58.87%	61.08%
70	60.00%	68.29%	42.96%	48.52%	53.45%	55.17%
80	57.32%	65.85%	37.78%	44.44%	50.25%	48.03%
90	54.63%	63.41%	34.07%	41.11%	46.80%	45.07%
100	51.22%	60.00%	30.00%	38.15%	42.12%	40.64%
110	47.56%	58.54%	26.30%	34.44%	38.67%	35.22%
120	45.37%	56.59%	24.44%	32.96%	35.71%	32.02%
130	42.68%	54.63%	22.22%	31.85%	33.99%	29.80%
140	40.00%	52.68%	19.63%	30.00%	32.27%	28.08%
150	38.05%	51.22%	18.15%	27.41%	29.31%	23.89%
160	36.59%	49.76%	16.67%	25.56%	27.09%	20.94%
170	34.63%	48.29%	14.81%	23.70%	25.12%	20.20%
180	32.20%	46.34%	13.33%	22.59%	23.40%	18.97%
190	30.73%	44.88%	11.85%	21.11%	20.20%	17.98%

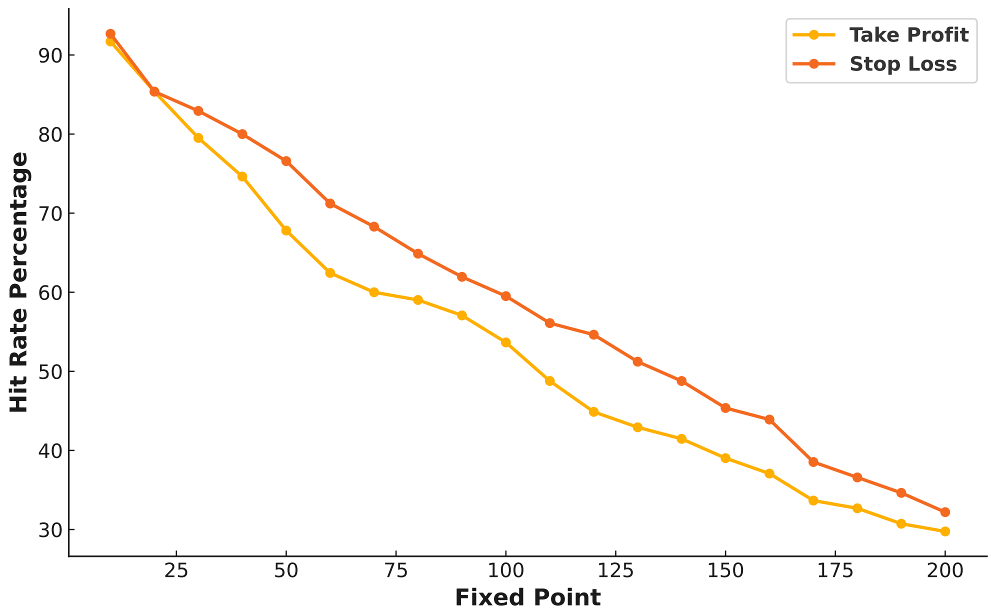

Figure 4. Focused view hit rate comparison for DJIA (US30).

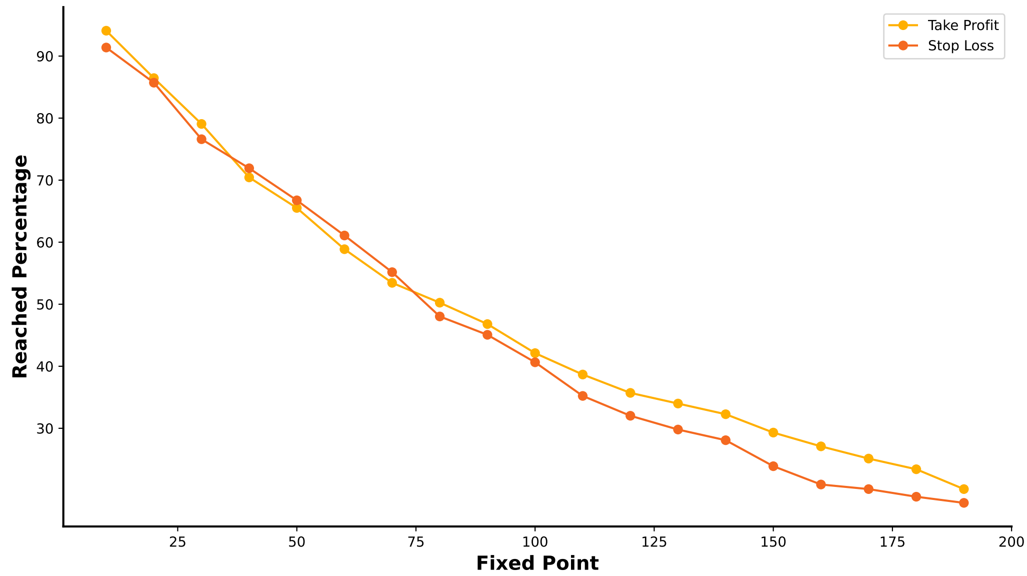

Figure 5. Focused view hit rate comparison for Dax.

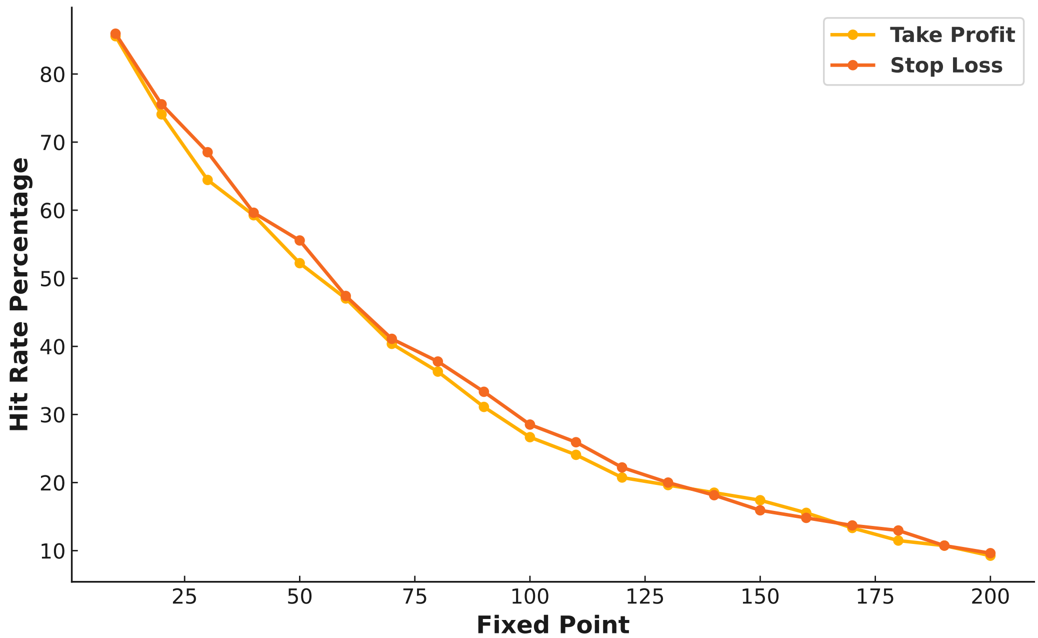

Figure 6. Focused view hit rate comparison for NASDAQ (US100).

3.4.1. H_1 Descriptive Statistics

Table 2 presents descriptive statistics for the DJIA (US30), NASDAQ (US100), and DAX, highlighting the behaviour of price movements into and away from weekend gaps.

Table 2. Combined descriptive statistics for US30 (DJIA), US100 (NASDAQ), and DAX price gaps.

	US30 (DJIA)		US100 (NASDAQ)		DAX	
Statistic	**TP %**	**SL %**	**TP %**	**SL %**	**TP %**	**SL %**
Mean	54.87%	60.69%	19.73%	20.31%	46.58%	44.24%
Median	53.66%	59.51%	10.00%	10.19%	40.39%	37.93%
Standard Deviation	18.43%	17.48%	22.30%	22.87%	22.66%	24.18%
Minimum	30.73%	34.63%	1.11%	1.85%	18.72%	15.27%
Maximum	91.71%	92.68%	85.56%	85.93%	94.09%	91.38%
Range	60.98%	58.05%	84.44%	84.07%	75.37%	76.11%

For all three indices, the mean probabilities of reaching Take Profit (TP) and Stop Loss (SL) points differ only modestly, although each index displays its own nuances. The DJIA shows a slight inclination towards hitting SL over TP, whereas the NASDAQ manifests nearly equal mean rates for TP and SL, implying a more balanced likelihood of price movement in either direction. The DAX, meanwhile, records the intermediate mean percentages (46.58% for TP and 44.24% for SL) along with the higher standard deviations, indicating that—much like the DJIA and NASDAQ—it is prone to unpredictable short-term fluctuations.

All three markets demonstrate a wide gap between their minimum and maximum hit rates, reflecting the natural variance in weekend gap outcomes rather than a uniform bias towards gap closure. For instance, the DJIA ranges from the mid-thirties to over ninety per cent for both TP and SL; the NASDAQ exhibits an even broader spread; and the DAX also spans a substantial range of more than seventy-five percentage points. These observations underscore the tendency for hit rates to decline as the distance from the Monday opening grows, a pattern consistent with standard market dynamics rather than deliberate gap-filling behaviour.

Overall, the analysis suggests there is no strong directional bias toward weekend gap closure across the DJIA, NASDAQ, or DAX. Instead, market volatility—shaped by global sentiment, economic news, and other external drivers—appears to be the main factor influencing whether a gap is traversed in one direction or the other. Consequently, traders and analysts should remain cognisant of this volatility when devising gap-oriented strategies, recognising that any perceived gap-closing tendency may be overshadowed by broader, often erratic, market forces.

3.4.2. Hypothesis 1: Chi-Square Test for Independence

We next assess whether there is a systematic directional movement towards closing the gap, or whether observed hits to Take Profit (TP) and Stop Loss (SL) points can be explained solely by random volatility. To this end, we conduct a Chi-square test for independence on the frequencies of TP and SL hits at each distance d (in increments of 10 points). The hypotheses are as follows:

- **Null Hypothesis $(\boldsymbol{H_0})$**: There is no preferential directional movement (i.e., TP and SL hits are independent), implying that the observed gap-related movements result entirely from general market volatility.

$$H_0 : \quad P(\mathrm{TP}_d) = P(\mathrm{SL}_d) \quad \text{(independent events)}.$$

- **Alternative Hypothesis $(\boldsymbol{H_1})$**: There is a preferential directional movement, indicating that TP and SL hits are not solely attributable to random volatility.

$$H_1 : \quad P(\mathrm{TP}_d) \neq P(\mathrm{SL}_d) \quad \text{(dependent events)}.$$

The Chi-square statistic for a 2×2 table of observed frequencies is computed as

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}, \tag{4}$$

where O_i and E_i denote the observed and expected counts in each cell, and the degree of freedom for a 2×2 test is 1. A low p-value (e.g., below 0.05) indicates that TP and SL events are not independent at that distance.

Table 3 reports the Chi-square statistics and p-values for each distance d across the following three major indices: DJIA (US30), NASDAQ (US100), and DAX. These values were calculated from contingency tables that track whether each gap hits both TP and SL, only one of them, or neither.

Table 3. Updated Chi-square test summary for US30 (DJIA), US100 (NASDAQ), and DAX.

Fixed Point	DJIA (US30)		NASDAQ (US100)		DAX	
	Chi-Square	*p*-Value	Chi-Square	*p*-Value	Chi-Square	*p*-Value
10	0.2913	0.5894	0.3931	0.5307	1.4048	0.2360
20	0.5897	0.4425	0.8567	0.3547	7.1806	0.0074
30	1.1620	0.2811	2.3775	0.1231	22.8682	0.0000
40	1.9809	0.1593	1.6698	0.1963	36.9225	0.0000
50	2.7782	0.0956	2.1623	0.1414	42.5289	0.0000
60	3.4724	0.0624	1.9398	0.1637	44.8155	0.0000
70	4.3358	0.0373	4.0493	0.0442	44.2515	0.0000
80	4.9641	0.0259	3.0444	0.0810	46.1064	0.0000
90	5.5242	0.0188	5.7185	0.0168	45.8522	0.0000
100	6.0507	0.0139	7.9573	0.0048	49.3082	0.0000
110	6.8168	0.0090	6.0096	0.0142	38.3508	0.0000
120	9.0662	0.0026	5.6721	0.0172	27.4242	0.0000
130	7.4265	0.0064	8.0702	0.0045	24.5751	0.0000
140	10.9253	0.0009	10.4996	0.0012	19.8953	0.0000
150	12.6871	0.0004	11.0499	0.0009	16.1642	0.0001
160	14.6095	0.0001	8.1615	0.0043	11.6124	0.0007
170	17.1091	0.0000	8.2284	0.0041	9.4044	0.0022
180	19.5564	0.0000	6.3032	0.0121	10.5324	0.0012
190	22.5440	0.0000	7.6934	0.0055	6.9438	0.0084
200	27.9624	0.0000	7.5883	0.0059	5.5949	0.0180

- **DJIA (US30):** At smaller distances (10–60), *p*-values exceed the 5% threshold, indicating that we fail to reject the null hypothesis of independence between TP and SL hits. However, at distances of 70 and above, the *p*-values drop below 0.05, suggesting a statistically significant association between whether a gap hits TP and SL at those intervals. This pattern implies that at larger distances from the opening price, the events "TP reached" and "SL reached" are not random.
- **NASDAQ (US100):** A similar behaviour emerges, though certain distances (e.g., 80) remain only marginally significant or are not significant. Overall, from around 70 or 90 points onward, the *p*-values become quite small, again indicating that TP and SL hits appear dependent at mid- to high-range distances.
- **DAX:** Already at shorter distances (from 20 onwards), *p*-values are very low, suggesting a strong non-independence between hitting TP and SL almost across the entire range (except for 10 points, which remains insignificant). This implies a more consistent directionality in how DAX price gaps evolve, even at moderate distances.

These findings reveal that at smaller tested distances from the Monday opening (10–60 points, depending on the index), hitting Take Profit (TP) and Stop Loss (SL) appears statistically random. However, at larger distances—beyond roughly 70 points for DJIA and NASDAQ, and from about 20 points upward for DAX—the probabilities of hitting TP versus SL deviate significantly from a purely random scenario. In practical terms, this indicates that price movements become increasingly systematic at medium-to-high distances from the Monday opening, suggesting a stronger directional component in how gaps evolve once a certain threshold is surpassed. Trading strategies based on gap continuation or reversal may therefore exhibit greater predictive power as these distance thresholds are exceeded.

3.5. Hypothesis 2: Market Volatility and Weekend Gap Size

Building on the conceptual framework of Janse van Rensburg and Van Zyl, this section examines the relationship between weekend gap size and market volatility across three major stock indices—the Dow Jones Industrial Average (DJIA), NASDAQ (US100), and Germany's DAX. Theoretically, larger gaps are often associated with heightened uncertainty and risk, as emphasised by (Hull & Basu, 2016), potentially triggering stronger price movements upon opening on Monday (Dahlquist & Bauer, 2012). Following the perspective of (Plastun et al., 2020), we hypothesise that larger weekend gaps correspond to greater volatility, thereby influencing the efficacy of gap-based trading strategies.

Hypotheses.

- **Null Hypothesis (H_0)**: Market volatility does *not* rise in tandem with weekend gap size.
- **Alternative Hypothesis (H_1)**: Larger weekend gaps *do* lead to increased volatility.

A crucial step in this analysis is categorising weekend gaps by their magnitudes. The frequency distributions of gap sizes differ across indices due to variations in their absolute price levels and trading characteristics. Consequently, a uniform categorisation would be unsuitable, as it might result in sparse or ill-defined categories. Instead, each index is grouped into bins that reflect its empirical distribution of gap sizes.

- **DJIA**: Uses 20-point increments up to 160 points, with larger gaps aggregated in a final category.
- **NASDAQ**: Employs narrower 10-point increments up to 80 points, reflecting its higher gap frequency.
- **DAX**: Uses 10-point increments up to 80 points, similar to NASDAQ, with larger gaps grouped together.

These tailored groupings ensure that each category is well-populated, allowing for meaningful statistical comparisons.

We operationalise volatility within each gap-size category by measuring the frequency with which price reaches a fixed Take Profit (TP) and Stop Loss (SL) level of 30 points from the Monday opening as follows:

$$TP_{30} = MO - 30 \cdot \text{sign}(MO - FC), \quad (5)$$

$$SL_{30} = MO + 30 \cdot \text{sign}(MO - FC). \quad (6)$$

where $\text{sign}(\cdot)$ ensures TP and SL are placed in the correct direction relative to the gap. The Hit Rate for each category is calculated as follows:

$$\text{Hit Rate} = \frac{\text{Number of times the point was hit}}{\text{Total instances in the category}} \times 100\%. \quad (7)$$

If prices frequently hit these levels within a category, we interpret that category as exhibiting greater volatility. Tables 4–6 summarise the observed frequencies for DJIA, NASDAQ, and DAX.

By segmenting weekend gaps into these distinct size categories, we assess whether larger gaps systematically exhibit higher volatility. If $\mathbf{H}_1$ holds, we expect a monotonic increase in these frequencies as gap size increases across all three indices.

Table 4. Combined hit rates for DJIA at a fixed point of 30 for all gap categories.

Category	Instances	TP %	TP Count	SL %	SL Count
0–20	213	76.53%	163	74.18%	158
20–40	62	70.97%	44	82.26%	51
40–60	43	69.77%	30	86.05%	37
60–80	25	84.00%	21	88.00%	22
80–100	17	88.24%	15	82.35%	14
100–120	10	90.00%	9	90.00%	9
120–140	11	100.00%	11	54.55%	6
140–160	2	100.00%	2	100.00%	2
>160	35	88.57%	31	82.86%	29

Table 5. Combined hit rates for NASDAQ at a fixed point of 30 for all gap categories.

Category	Instances	TP %	TP Count	SL %	SL Count
0–10	249	43.78%	109	42.57%	106
10–20	118	57.63%	68	61.86%	73
20–30	50	60.00%	30	72.00%	36
30–40	27	77.78%	21	55.56%	15
40–50	18	72.22%	13	72.22%	13
50–60	16	62.50%	10	87.50%	14
60–70	10	90.00%	9	60.00%	6
70–80	10	80.00%	8	100.00%	10
>80	21	71.43%	15	85.71%	18

Table 6. Combined hit rates for DAX at a fixed point of 30 for all gap categories.

Category	Instances	TP %	TP Count	SL %	SL Count
0–10	196	74.49%	146	67.86%	133
10–20	102	77.45%	79	74.51%	76
20–30	86	76.74%	66	80.23%	69
30–40	58	77.59%	45	72.41%	42
40–50	34	79.41%	27	73.53%	25
50–60	36	80.56%	29	83.33%	30
60–70	12	75.00%	9	75.00%	9
70–80	12	100.00%	12	41.67%	5
>80	66	81.82%	54	83.33%	55

3.5.1. Descriptive Statistics

Table 7 presents a comparative overview of the descriptive statistics for weekend gap behaviour in the DJIA, NASDAQ, and DAX. The DJIA exhibits the highest mean Take Profit (TP) rate of 85.34% and a similarly elevated Stop Loss (SL) rate of 82.25%. Despite these relatively large averages, the corresponding standard deviations (11.17% for TP and 12.53% for SL) indicate moderate variability across the nine observed gap categories. The DJIA data also show a notably high minimum (69.77% for TP and 54.55% for SL), suggesting that, even under less favourable conditions, the DJIA has a propensity to frequently hit the predefined price level.

In contrast, the NASDAQ demonstrates lower mean TP (68.37%) and SL (70.82%) percentages compared with the DJIA, alongside larger standard deviations (13.88% for TP and 17.97% for SL). These higher variances imply greater unpredictability and volatility in how NASDAQ gaps evolve intraday. The range of values for the NASDAQ is also more pronounced; although its minimum TP percentage is as low as 43.78%, the maximum can reach 90.00%, underscoring a wider behavioural spread relative to the DJIA.

Table 7. Descriptive statistics for DJIA, NASDAQ, and DAX data (fixed point = 30).

	DJIA		NASDAQ		DAX	
Statistic	**TP %**	**SL %**	**TP %**	**SL %**	**TP %**	**SL %**
Count	9	9	9	9	5	5
Mean	85.34	82.25	68.37	70.82	77.14	73.71
Standard Deviation	11.17	12.53	13.88	17.97	1.78	4.45
Minimum	69.77	54.55	43.78	42.57	74.49	67.86
25th Percentile	76.53	82.26	60.00	60.00	76.74	72.41
Median	88.24	82.86	71.43	72.00	77.45	73.53
75th Percentile	90.00	88.00	77.78	85.71	77.59	74.51
Maximum	100.00	100.00	90.00	100.00	79.41	80.23

The DAX occupies a middle ground in terms of mean values (77.14% for TP and 73.71% for SL) but stands out for its relatively narrow standard deviations, particularly for TP (1.78%). This limited variation suggests a more uniform response to weekend gaps, with TP percentages clustering between approximately 74.49% and 79.41%. The DAX's SL range is somewhat broader (67.86% to 80.23%), as reflected in a higher SL standard deviation of 4.45%, but it still remains narrower than the observed spread in the NASDAQ.

Taken together, these statistics highlight distinct gap dynamics across the three indices. The DJIA tends to show consistently high hit rates for both TP and SL points, implying relatively stable gap-closing or gap-extending behaviour. The NASDAQ's larger standard deviations suggest that gap outcomes are more sensitive to short-term market fluctuations, reflecting higher uncertainty or volatility. Lastly, the DAX presents a relatively clustered distribution of outcomes, indicating a more homogeneous reaction to weekend gaps. These observations provide a foundation for deeper investigation into how gap size, market volatility, and geographic factors might collectively influence trading opportunities in different global indices.

3.5.2. Pearson Correlation Coefficient and Regression Analysis

To assess whether larger weekend gaps predict higher hit rates for the Take Profit (TP) or Stop Loss (SL) points, we rely on both Pearson correlation and ordinary least squares (OLS) regression. The Pearson correlation coefficient r measures the linear association between gap size and TP/SL hit rates, defined as follows:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right]\left[n\sum y^2 - (\sum y)^2\right]}}, \quad (8)$$

where n is the number of gap-size categories, x is the midpoint of each category, and y is the observed TP or SL percentage. A positive, statistically significant r indicates that larger gaps align with higher hit rates. We complement the correlation analysis with a simple linear regression in the following form:

$$y = \beta_0 + \beta_1 x + \epsilon, \quad (9)$$

in which β_1 represents how much the hit rate changes for each additional point of gap size, and β_0 denotes the intercept. We report the coefficient of determination (R^2) to quantify the proportion of variance in hit rates explained by gap size.

3.5.3. Testing for Asymmetric Impact

To investigate whether the gap size exerts an asymmetric influence on the Take Profit (TP) and Stop Loss (SL) hit rates, we estimate separate robust regressions for each dependent variable and compare the resulting slopes. Let β_{TP} and β_{SL} denote the coefficient estimates obtained from regressing the TP and SL hit rates, respectively, on Gap Size. The null hypothesis of no asymmetric effect is as follows:

$$H_0^{(\text{asym})} : \beta_{TP} = \beta_{SL}, \quad (10)$$

whereas the alternative hypothesis asserts that $\beta_{TP} \neq \beta_{SL}$.

Following standard practice in financial econometrics, we perform a Z-test on the difference in slopes, as follows:

$$Z = \frac{(\beta_{TP} - \beta_{SL})}{\sqrt{(\text{SE}_{TP})^2 + (\text{SE}_{SL})^2}}, \quad (11)$$

where SE_{TP} and SE_{SL} are the heteroskedasticity-robust standard errors for β_{TP} and β_{SL}, respectively. Table 8 presents the results.

Table 8. Asymmetric impact test. Difference in slope coefficients (TP vs. SL) with heteroskedasticity-robust standard errors.

Index	β_{TP}	SE_{TP}	β_{SL}	SE_{SL}	$\Delta = \beta_{TP} - \beta_{SL}$	SE_Δ	Z	p-Value
DJIA	0.1681	0.0452	0.0224	0.0674	0.1456	0.0811	1.795	0.0727
NASDAQ	0.3707	0.1157	0.4915	0.1308	−0.1208	0.1746	−0.692	0.4890
DAX	0.1608	0.0867	−0.0603	0.1789	0.2211	0.1988	1.112	0.2662

Notably, for the DJIA we find $\beta_{TP} = 0.1681$ (SE = 0.0452) and $\beta_{SL} = 0.0224$ (SE = 0.0674), yielding a difference of 0.1456 ($Z = 1.795$, $p \approx 0.073$). Although this falls short of the conventional 5% threshold, it does indicate a tendency towards asymmetry at the 10% level. By contrast, for both the NASDAQ and the DAX, we fail to reject the null hypothesis (10), as slope differences are statistically insignificant.

These findings confirm our earlier intuition that the DJIA exhibits a modest asymmetric effect, whereby larger gaps strongly increase TP hit rates without exerting a comparable influence on SL rates. However, the slope-difference test suggests that NASDAQ and DAX do not share this pattern. Future research could reinforce these results by increasing the sample size or adopting alternative specifications (e.g., non-linear or interaction terms). Nevertheless, the Z-test outcomes are consistent with our descriptive evidence that gap size is more predictive of hitting a TP threshold in the DJIA than it is of triggering SL points.

Rationale for the Linear Specification

Equation (9) treats the hit rate (y) as a linear function of gap size (x), providing a tractable baseline model. This linear specification is commonly adopted in empirical finance when there is no compelling theoretical reason to assume a more complex (e.g., nonlinear) relationship (Campbell et al., 1997). Caporale and Plastun (2017) also employ linear regression techniques in their analysis of price gaps, using simple OLS models to capture the relationship between gap magnitude and the subsequent price behaviour. In our model, β_1 represents the average change in hit rate associated with a one-point increase in gap size, which offers a straightforward interpretation. While our baseline approach is similar to that used by Caporale and Plastun (2017),our analysis focuses specifically on the probability of hitting Take Profit or Stop Loss levels—expressed as hit rate percentages—rather than on abnormal returns per se. Moreover, the heteroskedasticity-robust regressions in Section 3.5.4 ensure that our inference remains valid, despite potential variations in residual variance, without altering the chosen linear functional form (Caporale & Plastun, 2017; Plastun et al., 2020). Although alternative specifications such as polynomial or piecewise-linear models could be considered if non-linearities became evident, the linear approach remains consistent with standard practices in financial econometrics.

DJIA (US30)

The Dow Jones Industrial Average (DJIA) exhibits a strong positive correlation between gap size and TP hit rates ($r = 0.824$, $p = 0.006$). The corresponding OLS model yields $R^2 = 0.679$, implying that approximately 67.9% of the variation in TP hit rates is attributable to gap size. By contrast, SL hit rates show little correlation with gap size ($r = 0.098$, $p = 0.802$), and the regression explains just 1.0% of the variance ($R^2 = 0.010$). These findings suggest an asymmetric effect, where larger gaps reliably increase the likelihood of hitting TP levels but do not exert a comparable influence on SL.

NASDAQ (US100)

In the NASDAQ, gap size correlates with both TP and SL hit rates. We observe positive and significant Pearson coefficients ($r = 0.735$ for TP and $r = 0.749$ for SL), with the corresponding p-values of 0.025 and 0.020, respectively. OLS models for TP and SL produce R^2 values of 0.535 and 0.561, indicating that gap size accounts for more than half of the variance in the observed hit rates. Consequently, NASDAQ's weekend gaps appear to amplify overall volatility, making both TP and SL levels more easily attainable when the gap is large.

DAX (Germany)

The Pearson correlation for TP is moderate in magnitude ($r \approx 0.57$) but not statistically significant at the 5% level. The corresponding OLS regression yields a slope of roughly 0.16 percentage points of TP per gap point ($\beta_1 \approx 0.16$), with $R^2 \approx 0.32$. Although the overall effect is sizeable, the higher p-value indicates we cannot rule out that sampling variation explains this pattern. For SL, the correlation is weak and negative ($r \approx -0.13$), and the regression model exhibits minimal explanatory power ($R^2 \approx 0.02$). Unlike the pronounced patterns seen in the DJIA or NASDAQ, the DAX results do not confirm a reliably linear link between gap size and hit rates, underscoring the need for further investigation into regional or structural factors that may moderate gap-related volatility in European markets.

Summary of Insights

These collective findings illuminate important differences in how the three indices respond to weekend gaps as follows:

- **DJIA:** Strong evidence of an asymmetric relationship, with larger gaps boosting TP probabilities but leaving SL levels largely unaffected.
- **NASDAQ:** Larger gaps significantly raise the likelihood of hitting both TP and SL thresholds, implying heightened volatility across the entire trading range.
- **DAX:** The data reveal a moderate but statistically inconclusive positive association for TP and no meaningful relationship for SL, suggesting that any gap-size effect may be weaker or more nuanced in the DAX compared with US indices.

3.5.4. Heteroskedasticity-Robust Regression Analysis

To further validate the linear relationships described in Section 3, we employ White's heteroskedasticity-robust standard errors (often referred to as HC0) to account for possible non-constant error variances in our cross-sectional gap-size regressions. Specifically, we re-estimate the linear models in (9)

$$y_i \ = \ \beta_0 + \beta_1 \, x_i \ + \ \epsilon_i, \tag{12}$$

but compute the covariance matrix of the parameter estimates using White's "sandwich" formula, expressed as follows:

$$\widehat{\Sigma}_{\text{White}} = (X'X)^{-1}\left(\sum_{i=1}^{n} \hat{\epsilon}_i^2 \, x_i \, x_i'\right)(X'X)^{-1}, \quad (13)$$

where x_i is the row vector of predictors (including the intercept), $\hat{\epsilon}_i$ is the OLS residual, and n is the total number of observations (in this case, the number of gap-size categories). Unlike the standard OLS variance estimator, expression (13) relaxes the assumption of homoskedasticity, making the inference on β_1 valid under more general conditions.

Motivation and Comparison with Newey–West

Since our dataset for testing *H2* comprises cross-sectional observations (i.e., different gap-size bins, rather than time-serially correlated data), the primary concern is heteroskedasticity across categories rather than autocorrelation in time. While Newey–West standard errors accommodate both heteroskedasticity and autocorrelation, they are more appropriately applied to time-series or panel contexts *with* potential serial dependence in the residuals. Given the structure of our data and the absence of such serial correlation, White's robust standard errors present a simpler and more suitable option.

Results and Consistency with OLS Findings

Tables 9–11 report the regression results for the Dow Jones Industrial Average (DJIA), NASDAQ, and DAX, respectively, using White's heteroskedasticity-consistent standard errors. The direction and magnitude of the estimated coefficients largely align with the original OLS analyses in Section 3, reaffirming our main conclusions.

Table 9. Robust regression results for DJIA (TP% on gap size).

	Coefficient	**Robust Std. Err.**	z	$p > \|z\|$	**[0.025, 0.975]**
Constant	70.2140	3.922	17.901	0.000	[62.526, 77.902]
Gap Mid	0.1681	0.045	3.721	0.000	[0.080, 0.257]

Table 10. Robust regression results for NASDAQ (TP% on gap size).

	Coefficient	**Robust Std. Err.**	z	$p > \|z\|$	**[0.025, 0.975]**
Constant	51.6889	5.263	9.821	0.000	[41.374, 62.004]
Gap Mid	0.3707	0.116	3.204	0.001	[0.144, 0.598]

Table 11. Robust regression results for DAX (TP% on gap size).

	Coefficient	**Robust Std. Err.**	z	$p > \|z\|$	**[0.025, 0.975]**
Constant	73.1055	2.095	34.899	0.000	[69.000, 77.211]
Gap Mid	0.1608	0.087	1.853	0.064	[-0.009, 0.331]

As before, the DJIA and NASDAQ exhibit strong positive and statistically significant correlations between gap size and the Take Profit (TP) hit rate (both $p < 0.01$), while the effect for the DAX remains weaker and only marginally significant ($p \approx 0.064$). In practical terms, a one-point increase in gap midpoint predicts roughly a 0.168 percentage point increase in the DJIA's TP hit rate versus 0.371 in the NASDAQ. These estimates corroborate our earlier OLS findings, thereby reinforcing the argument that larger gaps are associated with heightened intraday price movements (*H2*). Moreover, they confirm that heteroskedasticity does not materially distort our inference.

Limitations and Non-Causality

Although we have confirmed robust associations between gap size and subsequent hit rates (particularly in the DJIA and NASDAQ) exist, these analyses should not be interpreted as establishing strict causality. Our results show how gap size correlates with hitting specific price thresholds, rather than demonstrating larger gaps *cause* these outcomes. In principle, a rigorous test of the causal mechanisms would require more granular, non-aggregated time-series data, accompanied by additional diagnostics (e.g., for autocorrelation). While we have accounted for potential heteroskedasticity through White's robust standard errors, the small number of aggregated gap-size categories per index still constrains more extensive econometric testing (e.g., Durbin–Watson for serial correlation). Consequently, although our approach identifies meaningful correlations, it cannot definitively exclude the possibility that unobserved variables or market structures jointly influence gap size and price volatility. Future research incorporating higher-resolution data and expanded econometric methods could more thoroughly elucidate the causal pathways governing these gap-related phenomena.

4. Results

This section presents the empirical findings for our two core hypotheses, both of which revolve around the behaviour of weekend price gaps in three major stock market indices—the Dow Jones Industrial Average (DJIA), NASDAQ (US100), and the DAX (Germany). Specifically, we examine whether the observed gap-related price movements result chiefly from general market volatility (Hypothesis 1) and whether larger weekend gaps correspond to higher volatility (Hypothesis 2).

4.1. Results: Hypothesis 1–Price Movements into the Gap Are a Result of Increased Market Volatility

To evaluate whether markets systematically move to close weekend gaps or if such movements can be attributed to elevated volatility, we conducted Chi-square tests on the frequencies of hitting Take Profit (TP) and Stop Loss (SL) targets at incremental distances from the Monday opening. Contrary to the long-held notion that markets "fill" or close gaps shortly after they form (Caporale & Plastun, 2017; Dahlquist & Bauer, 2012; Plastun et al., 2020), our findings for the DJIA, NASDAQ, and DAX indicate that smaller distances show no statistically significant preference for TP over SL. In other words, prices at these narrower intervals appear to fluctuate in a manner indistinguishable from random volatility.

Notably, we observe that beyond specific distance thresholds, larger price moves begin to manifest a more pronounced directionality. For the DJIA and NASDAQ, these thresholds generally occur around 70–90 points, whereas the DAX exhibits non-random behaviour already from around 20 points onward. This divergence suggests that weekend gap dynamics in European markets may differ from those in the United States, potentially due to liquidity conditions, trading hours, or region-specific factors. Overall, the Chi-square tests consistently show that at closer ranges to the Monday open, gap closure is neither guaranteed nor universally favoured. Instead, short-term price movements in all three indices primarily reflect heightened market volatility rather than a deliberate mechanism to fill the gap.

These findings align with critiques of market efficiency (Caporale & Plastun, 2017; Mandelbrot, 1972; Plastun et al., 2020; Schwert, 2003), which posit that while markets may integrate fundamental information efficiently, certain anomalies—like weekend gaps—are shaped by sporadic external shocks and heterogeneous investor responses. Our results imply that gap-based trading strategies relying on a presumed "filling" bias may prove unreliable in many instances, as random volatility often dominates. Consequently, traders should remain vigilant about broader market conditions, particularly over weekends, when new information accumulates outside standard trading hours.

Cross-Market Observations and Practical Implications for Hypothesis 1

Our findings under Hypothesis 1 (see Section 4.1) suggest that while smaller distances from the Monday open often yield no discernible directional bias, medium-to-large distances exhibit significant movement into or away from the weekend gap in both the DJIA and NASDAQ. By contrast, the DAX demonstrates more immediate and consistent movement patterns, even at shorter distances (20–60 points). Several factors could explain these cross-market differences as follows:

- **Sector composition:** The NASDAQ is heavily tilted toward technology firms, which can exhibit sharper price reactions to weekend news or events. The DAX, with its broader industrial and manufacturing base, might respond more steadily to macroeconomic signals, causing a comparably earlier or more consistent gap-filling behaviour.
- **Trading hours and liquidity:** The German market's pre-market sessions and different regulatory windows can lead to earlier incorporation of overnight developments, whereas US markets (particularly the DJIA) may see more pronounced movement only once official trading begins. This difference in trading hours and liquidity contributes to distinct intraday volatility profiles across markets (Harris, 2003; O'Hara, 1995).
- **Investor profiles and sentiment:** Disparate levels of institutional and retail participation, along with cultural or behavioural factors, could affect how quickly traders in each market act on perceived anomalies. Momentum-driven strategies may manifest differently in the US compared to Europe.

For traders, recognising these cross-market disparities is crucial. In US indices, strategies aiming to capture gap-related movements may require patience, waiting for more robust directional signals at larger distances. In the DAX, by contrast, potential trading opportunities could emerge sooner after Monday's open, warranting tighter risk controls and active monitoring of news flow. Trading across both US and European equities should tailor their gap-based strategies to each market's volatility pattern and sector tilt, potentially hedging overnight exposures more aggressively in indices prone to delayed but pronounced gap adjustments.

4.2. Hypothesis 2: Gap Size and Volatility

Our second hypothesis investigates whether larger weekend gaps coincide with increased volatility across the DJIA, NASDAQ, and DAX. Using Pearson correlation coefficients and OLS regressions, we measure how frequently prices reach standardised TP and SL targets within each gap-size category. Under the assumption that higher hit rates reflect heightened volatility, we test whether more substantial gaps lead to greater price excursions on Mondays.

DJIA (US30)

The DJIA exhibits a pronounced relationship between gap size and TP hit rates, but not SL. In particular, larger gaps systematically increase the likelihood of reaching TP thresholds, indicating elevated volatility in a direction aligned with the gap. This asymmetric outcome suggests that when the DJIA opens substantially above or below Friday's close, it tends to move further in the same direction, reinforcing the idea that the initial gap magnitude can act as a catalyst for amplified price swings.

NASDAQ (US100)

Conversely, the NASDAQ reveals a more balanced increase in both TP and SL probabilities as weekend gaps widen. Thus, larger gaps in the NASDAQ appear to fuel overall volatility rather than favouring a single directional move. This result may stem from the composition of the NASDAQ, which is weighted heavily towards technology firms that often demonstrate higher beta and react strongly to weekend news events.

DAX (Germany)

Analysis of the DAX suggests a moderate, albeit statistically inconclusive, correlation between gap size and hitting TP levels. We detect no meaningful association for SL, while this pattern may point to rising volatility in response to bigger gaps, the effect is weaker than in the two US indices, possibly reflecting differences in sector composition, liquidity, or overnight news flow relative to the US market. As with H_1, the DAX thus emerges as less predictable from a purely gap-based perspective and may require more granular studies to unravel its unique structural attributes.

Overall Implications

These findings broadly corroborate the premise that bigger weekend gaps tend to magnify short-term volatility (Hull & Basu, 2016; Schwert, 2003), creating more pronounced intraday movements on Mondays. The effect is especially clear in the DJIA (for TP) and NASDAQ (for both TP and SL), suggesting that gap size can serve as a proxy for imminent volatility in these US indices. By contrast, the DAX offers only tentative support for the hypothesis, underscoring the possibility that market characteristics, time zone differences, or region-specific trading patterns moderate the volatility–gaps relationship.

Importantly, we refrain from inferring causality from these statistical relationships. Our methodology reveals a consistent association between gap size and next-day volatility but does not eliminate the possibility that unobserved factors (e.g., weekend macroeconomic shocks, news announcements, or cross-market spillovers) may jointly drive both gap magnitude and price volatility. As a result, while our evidence points to a robust correlation, we do not assert that large gaps *cause* increased volatility. Future research employing more granular data and advanced econometric diagnostics (including tests for autocorrelation and heteroscedasticity) could more definitively establish whether the gap size exerts a causal effect on Monday trading dynamics.

Cross-Market Observations and Practical Implications for Hypothesis 2

Under Hypothesis 2, we observe that larger weekend gaps tend to coincide with greater short-term volatility in the DJIA and NASDAQ, whereas the DAX exhibits a more moderate, and at times statistically inconclusive, relationship between gap size and heightened price swings. Several reasons may underlie these contrasts as follows:

- **Regulatory and macroeconomic factors:** The US indices may be more sensitive to weekend announcements or geopolitical developments due to the global prominence of US markets. Germany's regulatory landscape, along with its industrial economy, could temper the extremes of gap-induced volatility.
- **Information flow:** Technology-heavy indices (e.g., NASDAQ) are susceptible to large moves when critical tech-sector information accumulates over the weekend. Meanwhile, the DAX might digest news more evenly through its extended or pre-market sessions, diffusing the volatility impact.
- **Exchange microstructure:** Different order execution systems, liquidity provisions, and opening auction mechanisms can lead to distinct volatility patterns when markets open on Monday(Harris, 2003; O'Hara, 1995).

For market participants employing gap-based strategies, these disparities imply that larger gaps in the DJIA or NASDAQ are strong indicators of imminent volatility, potentially increasing the odds of hitting both stop-loss and take-profit levels. In the DAX, traders may need additional technical or fundamental signals to validate a volatility-based strategy. Risk managers who oversee multinational portfolios should calibrate gap risk differently across regions, potentially adopting more conservative hedging strategies for US markets and focusing on broader macroeconomic indicators when assessing European exposures.

4.3. Comparison with the Existing Literature

A number of prior studies have documented that price gaps can create short-lived, but exploitable, market inefficiencies. In particular, Caporale and Plastun (2017); Plastun et al. (2020) and Plastun et al. (2020) highlight that stock indices often exhibit a short-term momentum effect on gap days, a phenomenon our findings confirm on both the Dow Jones Industrial Average (DJIA) and NASDAQ. Consistent with their results, the present study reveals that prices typically continue in the gap's direction for at least several hours after Monday's open, indicating that weekend gaps can generate abnormal intraday returns. Our trading simulations and statistical tests provide direct evidence of this momentum effect, albeit one that subsides relatively quickly and varies in intensity across indices.

Some earlier work suggests that gaps tend to "fill," i.e., to reverse toward the previous close (Dahlquist & Bauer, 2012; Woo et al., 2020), whereas our high-frequency analysis indicates that immediate gap-filling is less common in the short intraday window. This aligns more closely with the assertion by (Plastun et al., 2020) that gaps frequently continue in the original direction, rather than filling right away. We believe our use of five-minute resolution data is an important factor in detecting these intraday continuation patterns; daily close-to-close measures may aggregate away much of the early-session momentum, thereby understating the gap-day follow-through reported here.

Moreover, while previous research on US indices typically focuses on the NASDAQ, S&P 500, or DJIA exclusively (Caporale & Plastun, 2017; Plastun et al., 2020), we expand this lens to the German DAX, a major European market. Our results for the DAX broadly support the proposition that weekend gaps can signal near-term volatility spikes, echoing the rationale presented in (Johann et al., 2019; Stapf & Werner, 2003), who note that Europe's distinct trading hours and broader macroeconomic environment can yield region-specific inefficiencies. We do, however, observe subtler gap effects in the DAX, suggesting that European regulatory conditions or investor behaviour may moderate the intraday gap momentum that is pronounced in certain US indices.

In summary, our findings strengthen a growing consensus that weekend gaps constitute a meaningful anomaly in both US and European markets, while furnishing new perspectives on how such anomalies manifest in a high-frequency setting. By examining multiple indices in tandem, we highlight cross-market variations consistent with the argument that market microstructure and institutional frameworks can shape the visibility and persistence of gap-related returns. These results offer a basis for more granular cross-regional comparisons, building upon earlier gap research and refining our understanding of how short-lived price discontinuities challenge strict market efficiency.

4.4. Synthesis of Hypothesis 1 and Hypothesis 2 Findings

Taken together, the evidence from Hypothesis 1 and Hypothesis 2 suggests that weekend gap patterns primarily reflect general market volatility rather than a universally systematic move to close gaps. Yet, larger gaps do appear to exacerbate short-term volatility and directional behaviour, particularly in the US indices, raising the potential for higher-profit but also higher-risk trading strategies. The DAX's comparatively subdued or inconsistent patterns highlight that gap effects can vary across regions, stressing the importance of tailoring gap-based analyses and trading strategies to each market's structural nuances.

Finally, while these results shed light on weekend gap anomalies and their implications for volatility and price direction, they do not constitute definitive proof of market inefficiency in the strict Fama sense (Fama, 1970). The growing literature on anomalies underscores that rationality alone may not explain every price pattern, particularly when markets transition from Friday's close to Monday's open under evolving information sets (Caporale & Plastun, 2017; Dahlquist & Bauer, 2012; Plastun et al., 2020). Our findings reinforce calls for further research—especially with high-frequency and cross-market data—to discern whether observed gap patterns arise from temporary "mispricings" that can be exploited, or whether they primarily reflect compensation for heightened weekend risk.

5. Conclusions

This study offers a comprehensive examination of weekend price gaps in three major stock indices—the Dow Jones Industrial Average (DJIA), NASDAQ (US100), and the DAX (Germany)—over a ten-year window. Building on the body of work that challenges the Efficient Market Hypothesis (EMH) (Fama, 1970; Lo, 1991; Mandelbrot, 1972; Schwert, 2003), our analysis highlights two key dimensions of gap behaviour as follows: whether such gaps systematically close (Hypothesis 1) and whether their magnitude affects subsequent volatility (Hypothesis 2).

Directional Movement vs. Volatility (H1)

While our findings do not support a universal tendency for markets to revert to the prior closing price at *short* distances, they reveal that more pronounced movements at larger thresholds may indicate a partial gap-filling mechanism. This nuanced outcome echoes the perspective of (Plastun et al., 2020) and (Dahlquist & Bauer, 2012), where gap dynamics are shaped by a combination of volatility shocks and opportunistic trading. Although our descriptive statistics and Chi-square tests show minimal evidence of a predictable "fill-the-gap" bias within ranges closer to the Monday open, there is suggestive evidence for directional price movements further away from the gap, reflecting possible longer-horizon effects. Such findings challenge the simplistic view that *all* gaps inevitably fill (Caporale et al., 2016; Caporale & Plastun, 2017), underscoring instead that weekend anomalies cannot be straightforwardly exploited without considering market microstructure, volatility regimes, and distance from the opening price. Behavioural finance factors—such as investor overreaction and herding (Akerlof & Shiller, 2010; Ball, 2009; Shiller, 2000)—likely intensify this complexity, as short-term randomness may give way to more patterned movements once markets absorb weekend news flows and liquidity normalises.

Gap Size and Volatility (H2)

Our regression and correlation analyses reveal that larger gaps typically coincide with higher short-term volatility, reinforcing the argument that weekend price discontinuities signal an increased uncertainty or risk (Hull & Basu, 2016; Mandelbrot, 1972; Plastun et al., 2020). This effect is particularly pronounced for the DJIA and NASDAQ, where an expanded gap size correlates with a greater likelihood of hitting the Take Profit and Stop Loss thresholds alike. These findings resonate with theoretical and empirical discussions on how exogenous shocks—often accumulating over weekends—magnify intraday price swings (Cross, 1973; French, 1980; Woo et al., 2020). In the NASDAQ, which comprises many high-beta technology firms, the effect extends to both bullish and bearish directions, indicating that larger gaps can enhance overall volatility rather than favouring one side of the market. Meanwhile, the DAX, though hinting at a moderate positive association between gap size and Take Profit rates, presents less robust evidence—highlighting how regional factors, sectoral composition, or liquidity conditions may temper volatility responses to weekend gaps.

Implications and Future Directions

Taken together, these results confirm the multi-faceted nature of weekend price gaps and underscore the complex interplay between market inefficiencies, investor sentiment, and macroeconomic triggers (Lo, 1991; Plastun et al., 2020; Schwert, 2003). While a gap itself may not imply a systematic closing bias, its magnitude emerges as a signal of heightened volatility in certain markets, potentially informing risk management and trading strategies. Notably, the cross-market divergence—particularly between European (DAX) and US (DJIA, NASDAQ) indices—reinforces that gap-driven anomalies are contingent upon local market structures and should not be generalised without caution.

Nevertheless, our study also recognises important limitations. The aggregated gap-size methodology precludes rigorous tests for autocorrelation and heteroscedasticity at the category level, rendering our correlation and OLS findings indicative rather than definitive. Moreover, we do not claim a causal mechanism, as unobserved variables could jointly drive both gap formation and subsequent price dynamics. Future work could explore intraday or gap-by-gap observations in larger samples, enabling robust diagnostic checks (e.g., Durbin–Watson, Newey–West corrections) and more granular causal inference. Additionally, integrating alternative explanatory variables—such as overnight news flow, order-book microstructure, or investor sentiment indices—might offer richer insights into how and why weekend gaps arise and evolve (Brownlees & Gallo, 2006; Chordia et al., 2002).

Concluding Remarks

Our investigation contributes to the growing literature that questions the universality of market efficiency—particularly regarding overnight or weekend dynamics (Alajbeg et al., 2012; Caporale et al., 2016; Plastun et al., 2020). In line with earlier studies (Dahlquist & Bauer, 2012; Woo et al., 2020), we find that weekend gaps can yield short-lived but significant price movements; however, our intraday evidence refines these observations by illustrating a more complex interplay of gap-filling and volatility expansion. By extending earlier gap research to five-minute price data and using an additional European index (DAX), we confirm that gap anomalies are not strictly confined to the US market and may reflect market-specific structures, news cycles, and behavioural biases. Going forward, a high-frequency, cross-market viewpoint could help reconcile daily-level results with intraday momentum effects, further illuminating how trading activity and regulatory conditions interact to shape this persistent anomaly.

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