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Neuroscience and Market Dynamics: The Impact of Smoking Withdrawal Syndrome on the Stock Performance of Tobacco Companies

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This study investigates the effect of the annual 'No-Smoking Day' on the stock performance of British American Tobacco (BATS) and Imperial Brands (IMB) from 1997 to 2023. Our findings reveal a significant negative impact of No-Smoking Wednesdays on BATS, with a moderate but statistically significant effect on IMB. To enhance robustness, we also perform a panel data analysis, which underscores the consistent negative effect of No-Smoking Day on the tobacco sector as a whole. These results suggest that No-Smoking Day generates a calendar-based effect on stock prices, challenging the Efficient Market Hypothesis. Beyond the behavioral effects tied to the anti-smoking campaign, this study introduces a novel perspective by linking investor behavior with neurological factors, particularly Nicotine Withdrawal Syndrome (NWS). NWS, characterized by irritability, anxiety, and mood disturbances, may influence investor sentiment, even among smokers who do not intend to quit. These withdrawal symptoms could induce stress and emotional responses, thereby affecting investor behavior and contributing to negative returns. Our findings align with prior behavioral studies and highlight the role of both psychological and neurobiological factors in shaping market dynamics. Future research should examine the combined effects of anti-smoking campaigns and NWS on investor behavior and

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market outcomes. Additionally, the varying statistical significance across firms suggests that the diversification of tobacco companies into non-traditional products warrants further investigation.

Keywords: Neuro-Finance; Behavioral Finance; Rationality; Tobacco Industry; Market Efficiency; Investors Decision Making

JEL Classifications: D9; G12; G20; G41

1 Introduction

Cristiano Ronaldo, the famous Portuguese football (soccer) player removed two bottles of Coca-Cola during a pre-match conference and encouraged the audience to "drink more water" (instead of soft drinks). The next day Coca-Cola suffered a 1.6% price decline (or $4 billions from its market value)[1]. Some analysts suggest that Ronaldo's comment led to this price decline, but others suggest that it was not the only reason[2]. All analysts though agree that the incident with Cristiano Ronaldo at the very least triggered the price decline. Is this market behavior in line with the Efficient Market Hypothesis (EMH, Fama (1970))? Does the information that water is healthier than soft drinks is something new that influences the market? It is widely known that that water is healthier than soft drinks, so Ronaldo's statement should not have impact on Coca-Cola's prices.

How can this behavior, which is not aligned with the EMH, be explained? In finance, the relationship between media coverage and stock prices is heavily studied in financial literature (Dyck and Zingales (2003), Scheufele, Haas, and Brosius (2011), Solomon (2012), Dang, Dang, Hoang, Nguyen, and Phan (2020)), as well as the importance of contemporary social media on asset prices (Teti, Dallocchio, and Aniasi (2019), Huang and Liu (2020), Vasileiou (2022)). Thus, taking into consideration the aforementioned, it can be posited that during specific campaigns, there exists a discernible impact on companies within the corresponding sector, attributable to the nature and objectives of the campaign.

Our case study looks at the performance of tobacco companies in the UK during the "UK's No Smoking Day", which is a national health awareness day in the UK. Smokers who want to quit smoking are encouraged to abstain from smoking for the whole day. The "No Smoking Day" began on Ash Wednesday in 1984, and it has an annual periodicity on the second Wednesday of each March (https://www.todayistheday.co.uk/).

Assessing the precise impact of smoking campaigns on tobacco consumption presents a challenge in quantification. Empirical studies indicate that anti-tobacco campaigns contribute to a decrease in tobacco consumption (Warmer (1977), Goldman and Glantz (1998)). However, it is imperative to account for other influential factors that may drive similar behavioral

[1] https://www.hindustantimes.com/business/cocacola-responds-after-cristiano-ronaldo-gesture-cost-it-4-billion-101623830150314.html

[2] https://www.nasdaq.com/articles/did-ronaldo-really-cost-coca-cola-ko-%244-billion-2021-06-23

changes, such as increases in tobacco taxes (Hu, Sung, and Keeler (1995)). Additionally, the net effect of these campaigns must consider the potential impact of counterproductive messaging (Farrelly et al. (2002)). Thus, while empirical literature confirms the negative impact of campaigns on tobacco consumption, a comprehensive evaluation of their net effect requires careful consideration of various contributing factors and potential counteracting influences.

This paper examines the impact of anti-smoking campaigns and tobacco withdrawal syndrome on financial markets—an area that, to the best of our knowledge, remains unexplored. Previous studies on tobacco companies have analyzed the types of investors in "sin stocks" (including tobacco companies) and their performance (e.g., Hong and Kacperczyk, 2009; Blitz and Swinkels, 2021; Han, Li, and Onishchenko, 2022), as well as trade issues (Ensor, 1992) and demographic factors (Keshavarz Haddad, Habibi, and Rafiee, 2019). However, no study has specifically investigated how No-Smoking Day and the effects of nicotine withdrawal might influence investor behavior. This paper aims to fill that gap, offering new insights into the intersection of public health initiatives and financial market dynamics.

Thus, this work contributes to the international literature by addressing issues of rationality and neuroscience in investor decision-making. Investors are typically regarded as rational actors, suggesting that the impact of seasonal events, such as anti-smoking campaigns, should be reflected in asset pricing. Specifically, returns during such events should not differ significantly from those on other days (Schwert (2003), Vasileiou (2018)), since no-smoking days are well known in advance. Furthermore, rationality is a core assumption in EMH models. However, could nicotine withdrawal symptoms experienced by investors during and/or around no-smoking days lead to irrational decision-making?

In order to empirically support our hypothesis, we examine the behavior of the stock prices of the dominant tobacco companies in the UK, namely British American Tobacco (BATS) and Imperial Brand (IMB), during the period 1997-2023[3]. We employ three distinct approaches to examine our hypotheses regarding the impact of No-Smoking Day. Firstly, we analyze the effect of No-Smoking Day across the entire sample to capture its overall influence. Secondly, we specifically compare data from only the Wednesdays to mitigate potential weekday effects, ensuring that any observed impact is not confounded by typical day-of-the-week variations. Thirdly, we test the robustness of our findings using panel data techniques on the daily returns, Wednesday returns, and weekly returns of tobacco companies' stock prices. This multifaceted approach ensures a thorough and robust examination of the No-Smoking Day's effects on the

[3] For our analysis, we utilize data from Yahoo Finance, which is available from January 1995 for BATS and from October 1996 for IMB. To avoid potential biases from period and calendar effects, we standardize our study period to January 1997 through December 2023. This approach ensures that our empirical evidence is consistent and comparable, covering full calendar years within a common timeframe for both datasets.

financial metrics under study. The results suggest that the 'No Smoking Day' has a negative impact on the daily returns of the tobacco companies.

The remainder of this paper is structured as follows: Section 2 delineates the theoretical framework. Section 3 examines the descriptive statistics, providing an overview of the data characteristics and initial observations on the daily and weekly returns of BATS and IMB. Section 4 presents the empirical results, Section 5 assesses the robustness of the empirical findings through panel data analysis, and Section 6 discusses the results and concludes the study.

2 Theoretical Framework

There is a vast literature that examines the relationship between advertising and campaigns on consumption (Taylor and Weiserbs (1972), Saffer and Dave (2006)). Campaigns that promote healthier choices have been shown to have a statistically significant impact on consumer choices (Rekhy and McConchie (2014)). Similar results can be found in studies that examine campaigns against products considered harmful to people's health, such as sugar-sweetened beverages (Jou et al., (2014), Bleakley et al., (2018)), alcohol (Saffer and Dave (2006), Young et al. (2018)), and tobacco (Hu, Sung, and Keeler (1995)), Wakefield et al. (2008)), among others. These studies suggest that campaigns may indeed impact consumer behavior by increasing awareness of health benefits and risks. However, in the long term, various other factors such as pricing strategies and tax policies for both healthy and risky products may also play significant roles.

For the tobacco campaign, we could also focus on the neuroscience aspect, particularly through the lens of nicotine dependence and withdrawal. When an individual tries to quit tobacco, they often experience Nicotine Withdrawal Symptoms (NWS). These symptoms typically produce effects opposite to those of nicotine consumption, as withdrawal represents a negative reaction to the absence of the drug (Garrett & Hough (2017)). NWS arise because the nervous system adapts to nicotine's effects, leading to a rebound response when nicotine is removed. Nicotine exerts a complex influence on the brain: when tobacco is smoked in short puffs, it produces a stimulating effect, while deep inhalation has a calming or depressant effect (Schelling (1992)).

Thus, nicotine withdrawal can trigger significant physiological and psychological stress, leading to symptoms such as nervousness, anxiety, drowsiness, lightheadedness, and headaches, which may impair focus and attention (Garrett and Hough (2017)). Waters, Jarvis, and Sutton (1998), in a quasi-experiment, found that non-fatal workplace accidents increased significantly during No Smoking Day week compared to the weeks before and after. However, a similar analysis of car accidents on No Smoking Day showed no statistically significant increase (Knowles, 1999). This motivates our investigation into the specific impact of nicotine withdrawal on the stock prices of tobacco industry.

Our study focuses on the stock prices of the tobacco industry, particularly in the context of the UK's 'No Smoking Day' campaign, which began in 1984 and has been held annually on the second Wednesday of March. This raises an important question: should the anti-smoking campaign have a meaningful influence on stock market behavior? According to prevailing financial theory, the answer is likely no—at least for the following reasons.

Firstly, according to the dominant EMH (Fama (1970), prices change when significant new information arises. What new information pertains to smoking? Is it not widely known that smoking is detrimental to people's health? Indeed, it is. According to the World Health Organization (2008), approximately 100 million deaths were linked to smoking in the 20th century, with a projected 1 billion people affected in the 21st century (World Health Organization, 2017). Additionally, numerous studies have established a correlation between smoking and various types of cancer, including those by: Loeb, Emster, Warner, Abbotts, and Laszlo (1984), Carbone (1992), Sasco, Secretan, and Straif (2004), Gandini, Botteri, Iodice, Boniol, Lowenfels, Maisonneuve, and Boyle (2008) amongst others. Thus, if markets exhibit full rationality, the occurrence of the No-Smoking day should not yield any discernible impact. This assertion stems from the widespread understanding that smoking poses significant health risks.

Secondly, the periodic nature of the No-Smoking campaign suggests that its effects should diminish over time, akin to a calendar anomaly (Schwert (2003)). If the smoking campaign is not sufficiently integrated into the asset pricing mechanism, or if the influence of social media and media coverage is particularly pronounced, it is expected that the anti-smoking campaign will exert a negative effect on the stock prices of tobacco companies. This effect is anticipated to be most pronounced during the "No Smoking Day," which represents the pinnacle of the campaign's intensity.

Hence, if the "No Smoking Day" exhibits a negative and statistically significant impact on the prices of publicly listed tobacco companies in the UK, such an outcome would signify irrational investment behavior for another one reason. It is imperative to underscore that investors typically adopt long-term perspectives regarding companies, including considerations of alternative products to traditional smoking, such as vaping technologies[4]. While consumer behavior may undergo transient shifts on that particular day[5], akin to a celebratory occasion, such behavior does not align with rational investor conduct. However, our research may offer an alternative explanation for potential deviations from market efficiency: a negative market

[4] For an analysis of the sales performance of traditional products versus alternatives or new technologies, please refer to the annual reports available at the following links: https://www.bat.com/investors-and-reporting/reporting/combined-annual-and-esg-report and https://www.imperialbrandsplc.com/creating-shareholder-value/annual-report-2023.

[5] See Evans and McCormack (2008), Murphy and Dweck (2016) Slater and Flora (2019), amongst others for consumer behavior.

response to No Smoking Day may be more plausibly driven by the effects of NWS rather than market inefficiency. These findings could open the door for future studies that shift the focus from behavioral finance to neuroscience-based explanations.

3 Descriptive Statistics

In order to provide empirical evidence for our assumptions, we examine the daily returns of BATS and IMB for the period 1997-2023. We employ two distinct approaches, each presented in its own sub-section. Firstly, we analyze the daily data for individual samples, providing a comprehensive overview of the general dataset. Secondly, we focus specifically on the returns from Wednesdays to control for potential weekday effects. Each sub-section includes a detailed presentation of the descriptive statistics. This encompasses the overall sample statistics, the descriptive statistics for the No-Smoking Days and the Smoking Days (the remaining days within the total sample) groups, and the results of mean equality tests between these groups.

(a) Impact of No-Smoking days on daily returns sample

We conducted an analysis of the descriptive statistics for the daily returns (dr) of BATS and IMB stocks, encompassing a dataset of 6,894 observations for each. The results indicate that the daily return distributions for both BATS and IMB exhibit positive skewness and leptokurtosis. Furthermore, the Jarque-Bera test confirms that neither time series conforms to a normal distribution. Additionally, the Augmented Dickey-Fuller test verifies that both time series are stationary (Table 1(a)).

To deepen our analysis, we categorize the data into two distinct groups: Smoking Days and No-Smoking Days. There are 27 No-Smoking Days and 6,867 Smoking Days in our sample. The data shows that No-Smoking Days tend to have negative mean returns for both BATS and IMB, while Smoking Days exhibit positive mean returns. Furthermore, 62.69% of No-Smoking Days for BATS and 59.26% for IMB are negative, compared to only 47.55% for BATS and 46.21% for IMB on Smoking Days (as detailed in Table 1(b)).

We conducted a two-sample t-test to determine if there is a significant difference between the mean returns of two distinct groups: No-Smoking Days and Smoking Days. For BATS, the analysis reveals a statistically significant difference in mean returns between the two groups at the 1% confidence level. This strong significance suggests that the returns on No-Smoking Days differ markedly from those on Smoking Days for BATS. In the case of IMB, the t-test results also indicate a significant difference in mean returns, albeit at the 10% confidence level. These findings, as detailed in Table 1(c), confirm that the market behavior on No-Smoking Days is distinct from regular Smoking Days for both stocks, with a higher level of confidence in the results for BATS compared to IMB.

Table 1: Descriptive Statistics of the daily sample 1997-2023: individual firm analysis.

(a) Time series

	BATS dr	IMB dr
Mean	0.000379	0.000582
Median	0.000000	0.000353
Maximum	0.127820	0.122881
Minimum	-0.114894	-0.129412
Std. Dev.	0.016905	0.015197
Skewness	0.265153	0.094344
Kurtosis	9.137708	8.228901
Jarque-Bera	10,900.33***	7,864.045***
ADF	-52.78197***	-83.99475***
Observations	6,894	6,894

(b) Grouped Descriptive Statistics

	BATS		IMB	
	No-Smoking dr	Smoking dr	No-Smoking dr	Smoking dr
Mean	-0.011813	0.000427	-0.004299	0.000602
Median	-0.006982	0.000000	-0.004196	0.000388
Maximum	0.028030	0.127820	0.034519	0.122881
Minimum	-0.059537	-0.114894	-0.057063	-0.129412
Std. Dev.	0.023030	0.016862	0.020058	0.015173
Skewness	-0.274624	0.279149	-0.371240	0.101063
Kurtosis	2.025536	9.209168	3.529855	8.264169
Jarque-Bera	1.407662	11,118.76***	0.936025	7,940.634***
Positive returns [%]	10 [37.04%]	3,602 [52.45%]	11 [40.74%]	3,694 [53.79%]
Negative returns [%]	17 [62.96%]	3,265 [47.55%]	16 [59.26%]	3,173 [46.21%]
Observations	27	6,867	27	6,867

(c) t-test Means Equality

	Value	p-value
BATS	-3.758199	0.0002
IMB	-1.672601	0.0945

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

(b) Impact of No-Smoking Days on Wednesday Returns

Since 'No Smoking Day' always falls on Wednesdays, we want to avoid any possible counterarguments regarding the impact of weekday effects (Jaffe and Westerfield (1985), Kiymaz and Berument (2003), Vasileiou (2015)). Therefore, we include in our data only the Wednesday returns of the time span.

Table 2 presents descriptive and preliminary statistics, organized into three sections, similar to Table 1Section (a) includes statistics for the time series of Wednesday's daily returns, labeled as BATS_W and IMB_W, respectively. Section (b) provides descriptive statistics for two distinct sub-groups: No-Smoking Wednesdays (No-Smoking_W) and Smoking Wednesdays (Smoking_W). Finally, Section (c) presents a comparative analysis of the mean returns between these two sub-groups. Based on the results from each subsection, we can draw similar conclusions to those from the daily returns analysis:

- the time series of Wednesday's daily returns does not follow a normal distribution but exhibits stationarity, indicating that the time series can be used in our econometric analysis without the need for further modifications or adjustments.
- for both BATS and IMB, No-Smoking Wednesdays show negative returns, as indicated by both the mean and median values. In contrast, the remaining Wednesdays in the sample period demonstrate positive returns. Additionally, the proportion of Wednesdays with negative returns is notably higher on No-Smoking days compared to other Wednesdays throughout the year—62.96% versus 48% for BATS and 59.26% versus 45.24% for IMB.
- the two-sample t-test results reveal significant differences in mean returns for BATS between No-Smoking Wednesdays and other Wednesdays (p-value = 0.001). However, for IMB, the statistical significance is weaker (p-value = 0.0660).

Table 2: Descriptive Statistics of the Wednesdays' sample 1997-2023: individual firm analysis.

(a) Whole Sample

	BATS_W	IMB_W
Mean	0.000371	0.000921
Median	0.000144	0.000561
Maximum	0.125486	0.078759
Minimum	-0.083618	-0.073017
Std. Dev.	0.016837	0.014904
Skewness	0.504459	-0.001145
Kurtosis	8.011506	5.916987
Jarque-Bera	1,526.609***	497.0569***
ADF	-39.01266***	-37.40452***
Observations	1,402	1,402

(b) Grouped Descriptive Statistics

	BATS_W		IMB_W	
	No-Smoking_W	Smoking_W	No-Smoking_W	Smoking_W
Mean	-0.011813	0.000610	-0.004299	0.001023
Median	-0.006982	0.000228	-0.004196	0.000584
Maximum	0.028030	0.125486	0.034519	0.078759
Minimum	-0.059537	-0.083618	-0.057063	-0.073017
Std. Dev.	0.023030	0.016614	0.020058	0.014776
Skewness	-0.274624	0.593456	-0.371240	0.033063
Kurtosis	2.025536	8.280601	3.529855	5.974272
Jarque-Bera	1.407662	1,678.274***	0.936025	507.0694***
Positive returns [%]	10 [37.04%]	715 [52%]	11 [40.74%]	753 [54.76%]
Negative returns [%]	17 [62.96%]	660 [48%]	16 [59.26%]	622 [45.24%]
Observations	27	1,375	27	1,375

(c) Means Equality

	Value	p-value
BATS_W	-3.815227	0.0001
IMB_W	-1.839137	0.0661

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

These preliminary findings suggest that our results are consistent regarding the impact of No-Smoking Day and that any potential weekday effect may not significantly influence them.

4 Econometric Analysis

Regarding the econometric analysis, we follow a dummy variable approach similar to that used in calendar effects studies (Jacobs and Levy (1988), Vasileiou (2018)). The mean equation is described by the following formula:

$$dr_t = c + c_1 \times No - Smoking\ dr_t + \varepsilon_t \quad (1)$$

where dr_t represents the daily returns, and $No - Smoking\ dr_t$ is a dummy variable that takes value 1 if it is the No-Smoking day of the year, and 0 otherwise. If c_1 is negative and statistically

significant, it suggests that the UK's No-Smoking Day has a negative effect on the stock market, as c_1 indicates how much greater or lower the returns are on No-Smoking Wednesdays compared to other Wednesdays.

The results for the daily sample are presented in Table 3 and show that "No Smoking Day" has a negative impact on the stock returns of the tobacco companies. In the BATS case, this is extremely strong at 0.01% confidence level (c.l.), but in the IMB case, its statistical significance is at 6.6% c.l.. The autocorrelation (Durbin-Watson) and Heteroscedasticity (Breusch-Pagan-Godfrey test) confirm the econometric validity of the econometric model.

To mitigate the potential influence of the weekday effect, we repeated our analysis using a sample comprised exclusively of daily returns from Wednesdays. In this case, the mean equation is described by the following formula:

$$W\_dr_t = c + c_1 \times No - Smoking\_W_t + \varepsilon_t \quad (2)$$

where $W\_\, dr_t$ represents the daily returns for each Wednesday in our sample, and $No - Smoking\_W_t$ is a dummy variable that takes value 1 if it is the No-Smoking Wednesday of the year, and 0 otherwise. This approach ensures that the comparison remains focused and unbiased by the typical fluctuations observed on other weekdays. The results, presented in Table 4, closely align with those from the daily returns analysis. Specifically, for BATS, the impact of No-Smoking Days on returns is negative and statistically significant at the 1% level, reinforcing the robustness of our earlier conclusions. Similarly, for IMB, the effect remains negative and statistically significant, though at the 10% level. These outcomes underscore the consistent influence of No-Smoking Days across both daily and Wednesday-only samples.

Table 3: Econometric Analysis of daily returns (individual samples)

	BATS	IMB
	Mean Equation	
c	0.000427** (0.000204)	0.000602*** (0.002930)
c_1	-0.012239*** (0.004355)	-0.004901* (0.002930)
	Autocorrelation and Heteroscedasticity Tests	
Durbin-Watson	2.036826	2.023319
Breusch-Pagan-Godfrey (F-Statistic)	2.083740	1.726380

Note: ***, **, and * denote the statistical significance at the 1%, 5%, and 10% levels, respectively. The standard deviations of the coefficients are presented in parentheses.

Table 4: Econometric Analysis of weekly returns (individual samples)

	BATS_W	IMB_W
	Mean Equation	
c	0.000610 (0.000452)	0.001023** (0.000402)
c_1	-0.012423*** (0.003256)	-0.005322* (0.002894)
	Autocorrelation and Heteroscedasticity Tests	
Durbin-Watson	2.089153	1.996420
Breusch-Pagan-Godfrey (F-Statistic)	2.660973	2.161280

Note: ***, **, and * denote the statistical significance at the 1%, 5%, and 10% levels, respectively. The standard deviations of the coefficients are presented in parentheses.

5 Robustness test using panel data analysis

In the initial phase of our analysis, both the descriptive statistics and econometric modeling provided strong statistical evidence confirming the impact of No-Smoking Day on the stock returns of British American Tobacco (BATS) and Imperial Brands (IMB). To further validate the robustness of these findings, we extend our analysis using panel data methods to examine the issue from an industry-wide perspective rather than at the individual company level. In addition to testing robustness, this approach offers a more nuanced understanding of the broader impact of No-Smoking Day on the tobacco industry as a whole.

We conduct three additional tests to strengthen our analysis. First, we examine the effect of No-Smoking Day on tobacco industry returns using the full sample of daily returns. Second, to account for potential seasonality effects, such as weekday patterns, we focus solely on Wednesday returns, addressing possible day-of-the-week biases[6]. Third, we evaluate the impact using weekly returns (wr) by comparing the returns during the No-Smoking week to the average weekly returns for the rest of the year, following a methodology similar to that of Waters, Jarvis, and Sutton (1998) and Knowles (1998).

Tables 5, 6, and 7 present the preliminary statistics for the daily, Wednesday, and weekly returns panel data, respectively. These results consistently align with those observed in the individual stock analyses:

[6] The first two tests are similar to those conducted for the individual companies.

Table 5: Descriptive Statistics for daily panel data

(a) Whole Sample

	Panel Sample dr
Mean	0.000481
Median	0.000146
Maximum	0.127820
Minimum	-0.129412
Std. Dev.	0.016073
Skewness	0.192064
Kurtosis	8.874169
Jarque-Bera	19,906.95***
ADF	212.399***
Observations	13,788

(b) Grouped Descriptive Statistics

	No-Smoking days dr	Smoking days dr
Mean	-0.008056	0.000514
Median	-0.004603	0.000169
Maximum	0.034519	0.127820
Minimum	-0.059537	-0.129412
Std. Dev.	0.021724	0.016039
Skewness	-0.370696	0.203191
Kurtosis	2.656111	8.929509
Jarque-Bera	1.502826	20,212.82***
Positive returns [%]	21 [38.89%]	7,296 [53.12%]
Negative returns [%]	33 [61.11%]	6,438 [46.88%]
Observations	54	13,734

(c) Means Equality

	Value	p-value
Smoking vs No-Smoking days	-3.912406	0.0001

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

Table 6: Descriptive Statistics for Wednesday returns panel data

(a) Wednesday returns

	Wednesdays Panel Sample
Mean	0.000646
Median	0.000494
Maximum	0.125486
Minimum	-0.083618
Std. Dev.	0.015899
Skewness	0.292598
Kurtosis	7.297515
Jarque-Bera	2,197.762***
ADF	328.059***
Observations	2,804

(b) Grouped Descriptive Statistics

	No-Smoking Wednesdays	Smoking Wednesdays
Mean	-0.008056	0.000817
Median	-0.004603	0.000531
Maximum	0.034519	0.125486
Minimum	-0.059537	-0.083618
Std. Dev.	0.021724	0.015721
Skewness	-0.370696	0.359188
Kurtosis	2.656111	7.474405
Jarque-Bera	1.502826	2353.125
Positive returns [%]	21 [38.89%]	1,468 [53.38%]
Negative returns [%]	33 [61.11%]	1,282 [46.62%]
Observations	54	2,750

(c) Means Equality

	Value	p-value
Smoking vs No-Smoking days	-4.072397	0.0000

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

Table 7: Descriptive Statistics for weekly panel data

(a) Whole Sample

	Weekly Panel Sample
Mean	0.002332
Median	0.002276
Maximum	0.277834
Minimum	-0.249482
Std. Dev.	0.034861
Skewness	-0.080502
Kurtosis	8.108228
Jarque-Bera	3,066.914***
ADF	350.788***
Observations	2,818

(b) Grouped Descriptive Statistics

	No-Smoking weeks	Smoking weeks
Mean	-0.008548	0.002544
Median	-0.001383	0.002318
Maximum	0.083598	0.277834
Minimum	-0.160312	-0.249482
Std. Dev.	0.046072	0.034583
Skewness	-1.229649	-0.014509
Kurtosis	5.581954	8.115052
Jarque-Bera	28.60792***	3,013.289***
Positive returns [%]	27 [50%]	1,485 [53.73%]
Negative returns [%]	27 [50%]	1,279 [46.27%]
Observations	54	2,764

(c) Means Equality

	Value	p-value
Smoking vs No-Smoking days	-2.317519	0.0205

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

- Negative average returns on No-Smoking Days – All tests show that No-Smoking Days, whether analyzed on a daily, Wednesday, or weekly basis, exhibit negative average returns. In contrast, the rest of the smoking periods, whether analyzed daily, weekly, or specifically on Wednesdays, show positive average returns.
- Significance of Differences – The t-tests for equality of means reveal highly significant differences in returns between Smoking and No-Smoking periods, with a confidence level of 1% for the daily and Wednesday returns, and 5% for the weekly returns. This robust finding underscores the substantial impact of No-Smoking Days on the stock performance of BATS and IMB, reaffirming the earlier results of our analysis.

These consistent outcomes across different analytical approaches highlight the reliability of our conclusions regarding the influence of No-Smoking Day on the stock returns of tobacco companies.

The subsequent phase of our robustness analysis involves a detailed econometric evaluation. We employed the Hausman test to determine the appropriate model for our panel data. The results from the Hausman test indicate that the random effects model is preferred over the fixed effects model for both the daily and weekly data. The mean equation is described by the following formula:

$$Xr_{it} = c + c_1 \times No - Smoking\_X_{it} + v_i + \varepsilon_{it} \quad (3)$$

where Xr_{it}represents the return for entity *i* (BATS, IMB), at time *t* which can be daily (dr), Wednesday (W), or weekly (w). c is the constant term, c_1 is the coefficient of the dummy variable No_Smoking X period, where X can be day, Wednesday, or week for entity i. The dummy variable takes the value 1 if *t* is in the No-Smoking period, and 0 otherwise. v_i = unobserved individual-specific effect (or random effect) with mean zero and variance σ_v^2, and ε_{it} is idiosyncratic error term with mean zero and variance σ_ε^2.

Table 8 presents the empirical findings from our random effects model analysis. These results robustly confirm, with high statistical significance (at the 1% confidence level), that No-Smoking Days have a negative impact on the stock prices of the UK's tobacco sector, for both the daily and Wednesday returns. We also find strong evidence at the 5% confidence level when testing the weekly returns. This substantial evidence further supports the initial findings from our individual stock analyses, reinforcing the conclusion that No-Smoking Day adversely affects the returns of these tobacco stocks.

The robustness tests confirm that the tobacco industry experiences significant losses on No-Smoking Day, suggesting a potential violation of the Efficient Market Hypothesis (EMH). Despite the well-documented adverse effects of smoking and the predictable, annual recurrence of the No-Smoking campaign, the stock prices of UK-listed tobacco companies do not appear to preemptively factor in this information. According to Schwert (2003), such "calendar" effects

should be absorbed and dissipate over time within an efficient market. However, the persistent negative impact observed on No-Smoking Day indicates that these effects are not fully integrated into stock valuations, challenging the assumptions of market efficiency. Beyond seasonality and the campaign effect, a neuroscience perspective, such as the NWS theory, may offer an explanation for why the EMH fails in this case.

Table 8: Econometric Analysis of panel data robustness tests

	Daily Returns	Wednesday Returns	Weekly Returns
c_0	0.000514*** (0.000168)	0.000817*** (0.000303)	0.002544*** (0.000663)
c_1	-0.008570*** (0.002689)	-0.008873*** (0.002179)	-0.011093** (0.004787)
Autocorrelation and Heteroscedasticity Tests			
Durbin-Watson	2.030352	2.045853	2.079255
Hausman test	0.000000	0.000000	0.000000

Note: ***, **, and * denote the statistical significance at the 1%, 5%, and 10% levels, respectively. The values in brackets represent the percentages of positive and negative returns.

6 Concluding Remarks and Discussion

This study investigates the impact of the annual "No-Smoking Day" on the stock performance of the UK's listed tobacco companies, British American Tobacco (BATS) and Imperial Brands (IMB), over the period from 1997 to 2023. Given that anonymous investors are often the largest holders of stocks in the tobacco industry (Blitz and Swinkels, 2021), the UK No Smoking Day presents a valuable natural experiment for investigating the impact of the no-smoking campaign and the behavioral effects of nicotine withdrawal.

To rigorously analyze the effects, we employ two distinct approaches in handling our data: (a) examining daily returns across the entire sample period, and (b) comparing the daily returns of Smoking Wednesdays to those of No-Smoking Wednesdays. Preliminary statistical analysis indicates that 'No-Smoking Day' has a negative impact on the stock prices of UK-listed tobacco companies. On average, the returns on No-Smoking Days are negative, in contrast to the generally positive returns observed on other days. This pattern holds consistent both when analyzing daily returns across the entire sample and when focusing specifically on Wednesday daily returns.

The t-tests for mean equality reveal significant differences in average returns between No-Smoking Days and Smoking Days for BATS. The results show that returns on No-Smoking Days are, on average, negative, while returns on Smoking Days are positive, with this

distinction being statistically significant. For IMB, the differences in mean returns are also notable, with statistical significance observed at the 10% confidence level. The econometric analysis empirically confirms the strong negative impact of No-Smoking Day on BATS returns and suggests a moderately strong negative effect on IMB stock.

The empirical evidence from panel data analysis demonstrates the negative impact of No-Smoking Day on BATS and IMB stock performance, reinforcing the robustness of our findings and showing that this widely recognized anti-smoking campaign affects tobacco sector in general. When linked to our previous analyses, these results suggest that No-Smoking Day has a pervasive influence on the market performance of tobacco companies. However, the varying impact observed across firms may be tied to their respective diversification strategies into alternative smoking products. While the panel data reveals a consistent negative pattern across the industry, the individual company analysis shows varying levels of statistical significance. This suggests the need for further investigation into how each company's shift from traditional smoking products to alternatives might influence their vulnerability to such campaigns and future declines in the smoking population. Understanding these differences could provide valuable insights into the resilience of tobacco companies against anti-smoking initiatives.

These findings challenge the EMH, as they reflect a predictable, calendar-based effect on stock prices that the market does not seem to efficiently price in advance. The seasonality and predictability of No-Smoking Day's impact suggest that investor behavior might be driven more by psychological and behavioral factors than by purely rational economic considerations. Thus, our findings not only reinforce the empirical evidence but also contribute to the understanding of how psychological campaigns can influence market dynamics and investor behavior.

However, as this study demonstrates, the explanation may not be solely behavioral due to the anti-smoking campaign, but also related to neurological effects such as Nicotine Withdrawal Syndrome (NWS). Beyond suggesting a new seasonal inefficiency, this study offers a novel connection between investor behavior and neuroscience. A key consideration for future research is whether the results reflect the dual impact of the anti-smoking campaign and the neurological effects of quitting smoking, particularly NWS. Characterized by symptoms like irritability, anxiety, difficulty concentrating, and mood disturbances, NWS contrasts with the effects of nicotine. These withdrawal symptoms may lead to heightened nervousness and low mood, potentially influencing market behavior and contributing to negative returns. This view is supported by the empirical studies of Hirshleifer and Shumway (2003) and Kamstra, Kramer, and Levi (2003).

To isolate the impact of NWS from the effects of the No-Smoking campaign, we propose two methodological approaches:

- neuroscience Techniques: Utilizing advanced tools like whole-body scanning and functional imaging, as detailed by Chandrasekhar Pammi et al. (2015), to assess how NWS affects

investors' brain activity during withdrawal, providing insights into its direct influence on investment decisions.

- comparative Market Analysis: Analyzing the returns of other sectors or the broader market during No-Smoking Days. If both non-tobacco sectors and the overall market show negative returns, it suggests a broader NWS impact. Conversely, if only the tobacco sector is affected, the anti-smoking campaign is likely the main driver.

This dual approach helps distinguish between the neurological and campaign effects on stock performance. A thorough examination of these factors is essential to determine whether the observed negative impacts are primarily due to the psychological and behavioral responses triggered by the anti-smoking campaign or the physiological and neurological effects of nicotine withdrawal. Future research should aim to disentangle these influences to provide a clearer understanding of the primary drivers behind the negative stock returns observed on No-Smoking Days.

We have no conflicts of interest to declare.

Data supporting the findings of this study are available at https://finance.yahoo.com/. The data is available and free for use. Data are available at the URL with permission from Yahoo.com.

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