Santa Claus Rally Replication Paper

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1 Context

The Santa Claus Rally refers to a calendar anomaly in stock market returns, where the last five trading days of December and the first two trading days of January are believed to produce significantly higher average returns than other days of the year. This phenomenon has been studied as part of broader research on stock market anomalies, such as the January effect and the day-of-the-week effect, which challenge the efficient market hypothesis.

In the paper by Patel (2023), the existence of the Santa Claus Rally was investigated using data from January 2000 to December 2021, focusing on two major U.S. stock indices: the S&P 500 and NASDAQ. The study aimed to validate whether this anomaly persists in recent decades, across varying economic conditions, and within sub-periods defined by economic cycles. The study utilized statistical tests such as t-tests, Mann-Whitney U tests, and ordinary least squares (OLS) regressions to compare daily returns during the Santa Claus Rally period with the rest of the year.

2 Restitution

2.1 Data and Methodology

The study utilized daily returns of two major U.S. stock indices—S&P 500 and NASDAQ—from January 1, 2000, to December 31, 2021, totaling 5,536 observations per index. The primary objective was to evaluate whether the Santa Claus Rally (SCR)—defined as the last five trading days of December and the first two of January—yielded statistically higher returns compared to the rest of the year.

The methodology involved:

- **Descriptive Analysis:** Summary statistics for all returns to identify trends and variability (Table 1).
- **Statistical Tests:** T-tests and Mann-Whitney U tests assessed whether SCR returns differed significantly from other trading days.
- **OLS Regression:** A dummy variable approach measured the specific impact of SCR days.
- **Sub-Period and Cycle Analysis:** Data was segmented into two sub-periods (2000–2009 and 2010–2021) and classified by economic expansions and recessions.

Table 1: Summary Statistics of Daily Returns (2000–2021)

Statistic	**S&P 500**	**NASDAQ**
Mean	0.0289	0.0369
Standard Deviation	1.2369	1.5826
Minimum	-11.9841	-12.3213
Maximum	11.5800	14.1732
Range	23.5641	26.4945
Observations	5536	5536

2.2 Key Results and Analysis

Overall Period Analysis (2000–2021): Table 2 compares the mean daily returns for SCR days and non-SCR days. While SCR days exhibit higher average returns, the differences are not statistically significant based on the p-values from t-tests and Mann-Whitney U tests.

Table 2: Mean Daily Returns During SCR and Non-SCR Days

Period	S&P 500	NASDAQ
SCR Days	0.1063	0.1806
Non-SCR Days	0.0267	0.0327
T-Test (p-value)	0.431	0.253
Mann-Whitney U (p-value)	0.927	0.829

Sub-Period and Economic Cycle Analysis: Returns were further analyzed across two sub-periods (2000–2009 and 2010–2021) and during economic expansions and recessions. Results indicated:

- **Sub-Periods:** The difference in SCR and non-SCR returns was more pronounced during 2000–2009 when markets performed poorly. However, statistical significance remained absent.
- **Economic Cycles:** During recessions, SCR days yielded substantially higher returns than non-SCR days. For example, during recessions, the S&P 500 had an average SCR return of 0.6481% versus -0.0669% for other days (Table 3). Yet, p-values again indicated no significant effect.

Table 3: Mean Returns During SCR Days by Economic Cycles

Cycle	Period	S&P 500	NASDAQ
Expansion	2000–2021	0.0727	0.1572
Recession	2001, 2008–2009	0.6481	0.5566

2.3 Diagnostic Tests

To strengthen the robustness and reliability of the analysis, we propose incorporating additional diagnostic tests and advanced regression techniques. These enhancements address potential issues of autocorrelation, non-normality, and heteroskedasticity, which are common in financial time series data.

Ljung-Box Test for Autocorrelation The Ljung-Box test assesses whether the residuals from the regression model are autocorrelated over multiple lags. This is particularly relevant for stock returns, as serial correlation can distort statistical inference. The test statistic is computed as:

$$Q = n(n+2)\sum_{k=1}^{m}\frac{\hat{\rho}_k^2}{n-k},$$

where n is the sample size, m is the number of lags, and $\hat{\rho}_k$ represents the autocorrelation at lag k. A significant p-value indicates the presence of autocorrelation, requiring adjustments such as Newey-West standard errors or generalized least squares (GLS).

Jarque-Bera Test for Normality The Jarque-Bera test evaluates whether the residuals of a regression model follow a normal distribution. It is based on skewness and kurtosis, with the test statistic defined as:

$$JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4}\right),$$

where S is the skewness, K is the kurtosis, and n is the sample size. A significant p-value suggests non-normality. If the residuals are non-normal, transformations or robust regression techniques (e.g., quantile regression) may be considered.

ARCH LM Test for Heteroskedasticity The ARCH (Autoregressive Conditional Heteroskedasticity) LM test checks for conditional heteroskedasticity, a common feature in financial time series where variance changes over time. The test involves regressing the squared residuals on their lagged values:

$$\epsilon_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + u_t,$$

where ϵ_t are the residuals, and p is the lag order. The null hypothesis of no ARCH effects is rejected if the lagged terms are jointly significant. If ARCH effects are detected, GARCH (Generalized ARCH) models or robust standard errors can be employed.

2.4 Correction for Misspecification Linear Regression

To address potential violations of standard OLS assumptions, we propose the following enhancements:

Heteroskedasticity-Consistent Estimators Using White's robust standard errors can correct for heteroskedasticity without altering the coefficients of the model. This approach ensures reliable t-statistics and p-values.

HAC (Heteroskedasticity and Autocorrelation Consistent) Estimators The Newey-West estimator adjusts standard errors to account for both autocorrelation and heteroskedasticity, providing robust inference in time series regressions.

For the S&P 500 index over the full period (2000–2021), we applied the HAC correction to the regression model. Table 4 summarizes the results.

Table 4: Results of HAC Regression on S&P 500 Index (2000–2021)

Variable	**Value**
β_0 (Mean of non-rally days)	0.02671%
β_1 (Difference between rally and non-rally days)	0.07961%
Standard Error (β_0)	0.0169%
Standard Error (β_1)	0.1011%
t-stat (β_0)	1.584
t-stat (β_1)	0.787
p-value (β_0)	0.113
p-value (β_1)	0.431
Corrected p-value (β_1)	0.353
Selected Method	HAC

Bootstrap Methods Bootstrap resampling can generate empirical distributions for parameter estimates, offering robust p-values and confidence intervals. This approach is particularly useful when residuals deviate from normality or when the sample size is small.

3 Extension 1 - Short versus long periods, size effect and extended size datasets with different countries comparison

3.1 Comparison of Short and Long Periods of the SCR on US, Australian, and UK Indices

As part of the extension of J. Patel's paper, our first approach was to examine whether the duration of the Santa Claus Rally (SCR) period and its modulation by the days considered significantly influenced the observed returns. In fact, a hypothesis from the study by Nippani, Washer, and Johnson (2015) suggests that the January effect plays an important role in the performance of the rally. Several prior studies, such as those by Keim (1983) and Rozeff and Kinney (1976), have shown that the first days of January concentrate a significant portion of the excess monthly returns, reinforcing the idea that the SCR could capture part of this effect. To test this hypothesis, two periods were compared: a short period of 5 days (from December 24 to December 31) and a long period of 7 days (from December 24 to January 2), the latter including the first two trading days of January. The idea was to test, on the base period set, whether the inclusion of these January days affected SCR returns and whether the January effect was truly significant.

The analysis was therefore conducted on data covering the period from January 1, 2000, to December 31, 2022, adding other indices such as Nasdaq, S&P500, FTSE (UK), and ASX (Australia) to make the results comparable. By observing returns both during and outside the SCR, the empirical results show higher average returns over 7 days than over 5 days for all indices studied, except for Australia. However, for returns outside of SCR, the results are reversed: the 5-day period generates higher returns than the 7-day period due to the negative impact of the first two days of January included in the latter. The distribution of returns also shows notable differences. In particular, the kurtosis (measures of concentration of returns) are lower during SCR days compared to non-SCR days and over 5 days, except for the Nasdaq index (which shows greater dispersion on SCR days). The skewness (symmetry of returns) is also less negative during SCR days, indicating less-extensive returns towards the left side of the distribution, with this effect being more pronounced for the 5-day period. Thus, we observe a lower average performance of SCR on 5 days but with more stable values.

Descriptive Statistics							
Ticker	**Nature**	**Days Type**	**Mean**	**Std**	**Skew.**	**Kurt.**	**Obs.**
S&P500	Long Period (7d)	Santa Claus Rally Days	0.1063%	1.1228%	0.8781	5.2841	154
		Remaining Days	0.0267%	1.2400%	-0.1822	10.9365	5382
	Short Period (5d)	Santa Claus Rally Days	0.0852%	0.8711%	1.5881	9.3293	110
		Remaining Days	0.0278%	1.2432%	-0.1717	10.7789	5426
NASDAQ	Long Period (7d)	Santa Claus Rally Days	0.1806%	1.8983%	2.6584	21.7705	154
		Remaining Days	0.0327%	1.5726%	-0.0634	5.8863	5382
	Short Period (5d)	Santa Claus Rally Days	0.0738%	1.2423%	2.7691	15.4801	110
		Remaining Days	0.0361%	1.5888%	0.0431	6.7481	5426
FTSE	Long Period (7d)	Santa Claus Rally Days	0.2482%	0.9357%	-0.0754	1.2961	154
		Remaining Days	0.0020%	1.1881%	-0.1530	7.8343	5404
	Short Period (5d)	Santa Claus Rally Days	0.2321%	0.8108%	0.0322	2.2076	110
		Remaining Days	0.0043%	1.1884%	-0.1532	7.7626	5448
ASX	Long Period (7d)	Santa Claus Rally Days	0.1622%	0.7742%	-0.3351	0.5910	154
		Remaining Days	0.0169%	1.0195%	-0.5765	7.9518	5404
	Short Period (5d)	Santa Claus Rally Days	0.1786%	0.7190%	-0.3143	0.3518	110
		Remaining Days	0.0178%	1.0186%	-0.5756	7.9199	5448

Statistical tests, particularly the Mann-Whitney U (MWU) tests to compare the medians of returns between SCR and non-SCR days, yield interesting results. For US indices (Nasdaq and S&P500), no significant differences were observed in each period, confirming the results of J. Patel. However, for the FTSE and ASX indices, a significant SCR is found in both periods, with p-values more significant over the 7-day period,

especially for the FTSE index (1% significance). These results show that SCR is not only significant for these indices but is more significant over a 7-day period. Furthermore, OLS regression tests on the betas confirm the presence of SCR for the FTSE and ASX indices with HAC correction, regarding the residuals test, through significant results at 1% for both the UK and 5% for the Australian index, with greater significance over 7 days. This suggests that the January effect is indeed present for some indices and that its influence on SCR performance varies depending on the indices and the SCR period considered.

Statistics Tests							
Index	**Nature**	**SCR Mean**	**Obs.**	**Non-SCR Mean**	**Obs.**	**T-test p-value**	**MWU p-value**
S&P500	Long Period (7d)	0.1063%	154	0.0267%	5382	0.431	0.927
	Short Period (5d)	0.0852%	110	0.0278%	5426	0.630	0.838
NASDAQ	Long Period (7d)	0.1806%	154	0.0327%	5382	0.253	0.829
	Short Period (5d)	0.0738%	110	0.0361%	5426	0.805	0.267
FTSE	Long Period (7d)	0.2482%	154	0.0020%	5404	0.011	0.002
	Short Period (5d)	0.2321%	110	0.0043%	5448	0.045	0.015
ASX	Long Period (7d)	0.1622%	154	0.0169%	5404	0.080	0.028
	Short Period (5d)	0.1786%	110	0.0178%	5448	0.099	0.032

Dummy Regression Statistics					
Index	**Nature**	β_0	**Adj.** β_0 **p-value**	β_1	**Adj.** β_1 **p-value**
S&P500	Long Period (7d)	0.02671%	0.093	0.07961%	0.353
	Short Period (5d)	0.02778%	0.08	0.05737%	0.483
NASDAQ	Long Period (7d)	0.03274%	0.115	0.14784%	0.264
	Short Period (5d)	0.0361%	0.083	0.03771%	0.74
FTSE	Long Period (7d)	0.00203%	0.898	0.24613%	0.001
	Short Period (5d)	0.00434%	0.783	0.22776%	0.002
ASX	Long Period (7d)	0.01694%	0.204	0.14522%	0.024
	Short Period (5d)	0.01778%	0.181	0.16086%	0.029

Residuals Tests					
Index	**Nature**	**Ljung-Box p-val**	**Jarque-Bera p-val**	**ARCH LM p-val**	**Corr. Method**
S&P500	Long Period (7d)	0.0	0.0	0.0	HAC
	Short Period (5d)	0.0	0.0	0.0	HAC
NASDAQ	Long Period (7d)	0.0	0.0	0.0	HAC
	Short Period (5d)	0.0	0.0	0.0	HAC
FTSE	Long Period (7d)	0.001	0.0	0.0	HAC
	Short Period (5d)	0.002	0.0	0.0	HAC
ASX	Long Period (7d)	0.0	0.0	0.0	HAC
	Short Period (5d)	0.0	0.0	0.0	HAC

This first extension clearly shows that the duration of the SCR period has a significant impact on the observed returns. The inclusion of the first two days of January seems to strengthen the significance of SCR, especially for the FTSE index. However, the 5-day period yields more moderate and less significant results, particularly for US indices during J. Patel's period. Moreover, the January effect is confirmed to be an influential factor in the returns of SCRs, although it does not always suffice to determine the existence of the rally. This underscores the importance of maintaining a 7-day period to observe a more significant SCR and not neglect the impact of January days when analyzing year-end returns.

3.2 Analysis of the Size Effect in SCR on US and UK Stock Markets

A second extension approach focuses on the effect of size within the Santa Claus Rally (SCR), based on indices composed of companies of varying sizes. By using the S&P500, S&P600, S&P400 indices, as well as the British indices FTSE, FTSE Mid Cap and FTSE Small Cap, the objective is to observe whether smaller companies generate higher returns than larger companies during this specific period.

The analysis of descriptive statistics is not unanimous and shows that, for returns outside of SCR, the average increases as company size decreases, except for the FTSE Mid Cap index in the UK, which shows significantly higher returns. SCR returns also present some disparity depending on company size, but the effect is less pronounced for the US market. Regarding SCR returns, the kurtosis is always significantly lower, indicating fewer extremes compared to non-SCR returns, and the skewness is less negative or even positive, suggesting more right-skewed distributions for SCR, although there is no common significance of the size effect at this level.

Descriptive Statistics						
Index	**Days Type**	**Mean**	**Std**	**Skewness**	**Kurtosis**	**Observations**
S&P500	Santa Claus Rally Days	0.1063%	1.1228%	0.878116	5.284068	154.0
	Remaining Days	0.0267%	1.2400%	-0.182194	10.936529	5382.0
S&P400	Santa Claus Rally Days	0.0943%	1.2074%	0.397267	3.023305	154.0
	Remaining Days	0.0417%	1.3928%	-0.392184	9.067030	5382.0
S&P600	Santa Claus Rally Days	0.0785%	1.3386%	0.456290	2.054200	154.0
	Remaining Days	0.0457%	1.4987%	-0.313599	6.536634	5382.0
FTSE	Santa Claus Rally Days	0.2482%	0.9357%	-0.075411	1.296067	154.0
	Remaining Days	0.0020%	1.1881%	-0.153031	7.834297	5404.0
FTMC	Santa Claus Rally Days	0.3301%	0.7642%	0.898104	4.296913	154.0
	Remaining Days	0.0205%	1.0776%	-0.396086	6.761504	5405.0
FTSC	Santa Claus Rally Days	0.3074%	0.4422%	0.579824	3.047302	154.0
	Remaining Days	0.0106%	0.7763%	-1.112005	16.051926	5367.0

However, the results of the Mann-Whitney tests reveal the greater significance of SCR for indices composed of smaller companies. Although U.S. indices (S&P500, S&P600, S&P400) do not show significant results over the period, the p-values improve with smaller size, and SCR becomes significant at 1% for British indices, regardless of size categories (Small Cap, Mid Cap, or Large Cap). These results are also confirmed by OLS regression tests, where the betas 1 confirm significance at 1% for all three British indices, with slightly improved significance for Mid & Large Cap. These results confirm a more significant presence of SCR in smaller British companies and suggest that this characteristic has a positive influence on the existence of SCR.

Statistics Tests						
Index	**SCR Mean**	**Obs.**	**Non-SCR Mean**	**Obs.**	**T-test p-value**	**MWU p-value**
S&P 500	0.1063%	154	0.0267%	5382	0.431	0.927
S&P 400	0.0943%	154	0.0417%	5382	0.643	0.877
S&P 600	0.0785%	154	0.0457%	5382	0.788	0.733
FTSE 100	0.2482%	154	0.0020%	5404	0.011	0.002
FTSE MidCap	0.3301%	154	0.0205%	5405	0.000	0.000
FTSE SmallCap	0.3074%	154	0.0106%	5367	0.000	0.000

Dummy Regression Statistics				
Index	β_0	**Adj.** β_0 **p-value**	β_1	**Adj.** β_1 **p-value**
S&P500	0.02671%	0.093	0.07961%	0.353
S&P400	0.04172%	0.023	0.05261%	0.643

Dummy Regression Statistics (cont.)				
Index	β_0	**Adj. β_0 p-value**	β_1	**Adj. β_1 p-value**
S&P600	0.04567%	0.020	0.03284%	0.788
FTSE	0.00203%	0.898	0.24613%	0.001
FTMC	0.02047%	0.182	0.30959%	0.000
FTSC	0.01063%	0.354	0.29675%	0.000

Residuals Tests				
Index	**Ljung-Box p-val**	**Jarque-Bera p-val**	**ARCH LM p-val**	**Corr. Method**
S&P500	0.0	0.0	0.0	HAC
S&P400	0.0	0.0	0.0	HAC
S&P600	0.0	0.0	0.0	HAC
FTSE	0.001	0.0	0.0	HAC
FTMC	0.0	0.0	0.0	HAC
FTSC	0.0	0.0	0.0	HAC

To support this extension, we analyze whether the size effect could explain the presence of SCR through comparisons between different size groups, such as S&P Small-Mid, S&P Mid-Large, S&P Small-Large, or FTSE Small-Mid, FTSE Mid-Large, FTSE Small-Large. Based on the analysis of Nippani and Shetty (2021) on the Indian market, we did not observe significant results regarding the presence of SCR linked to the size effect. Empirical return differences between these size groups were either negative or close to zero, and the p-values of betas 1 moved far from the rejection zone.

Statistics Tests						
Ticker	**Nature**	SCR Mean	SCR Obs	Non-SCR Mean	Non-SCR Obs	MWU p-value
S&P600-S&P400	US SMALL-MID	-0.0158%	154	0.0040%	5382	0.646
S&P600-S&P500	US SMALL-LARGE	-0.0278%	154	0.0190%	5382	0.441
S&P400-S&P500	US MID-LARGE	-0.0120%	154	0.0150%	5382	0.445
FTSC-FTMC	UK SMALL-MID	-0.0325%	141	-0.0094%	5338	0.490
FTSC-FTSE	UK SMALL-LARGE	0.0485%	141	0.0101%	5337	0.509
FTMC-FTSE	UK MID-LARGE	0.0819%	154	0.0182%	5404	0.101

Dummy Regression Statistics					
Index	**Nature**	β_0	β_1	**Adj. β_0 p-value**	**Adj. β_1 p-value**
S&P600-S&P400	US SMALL-MID	0.00395%	-0.01977%	0.461	0.483
S&P600-S&P500	US SMALL-LARGE	0.01896%	-0.04677%	0.043	0.363
S&P400-S&P500	US MID-LARGE	0.01501%	-0.0270%	0.029	0.47
FTSC-FTMC	UK SMALL-MID	-0.00937%	-0.02315%	0.244	0.516
FTSC-FTSE	UK SMALL-LARGE	0.01014%	0.03833%	0.363	0.489
FTMC-FTSE	UK MID-LARGE	0.01821%	0.0637%	0.050	0.1

Residuals Tests					
Index	**Nature**	Ljung-Box p-value	Jarque-Bera p-value	ARCH LM p-value	Corr. Method
S&P600-S&P400	US SMALL-MID	0.0	0.0	0.0	HAC
S&P600-S&P500	US SMALL-LARGE	0.002	0.0	0.0	HAC
S&P400-S&P500	US MID-LARGE	0.033	0.0	0.0	HAC
FTSC-FTMC	UK SMALL-MID	0.0	0.0	0.0	HAC
FTSC-FTSE	UK SMALL-LARGE	0.0	0.0	0.0	HAC
FTMC-FTSE	UK MID-LARGE	0.033	0.0	0.0	HAC

The conclusion is therefore mixed: although there is a significant SCR effect for our British indices improving with size, the overall analysis of the effect size shows that, for the indices studied, the presence of SCR cannot be conclusively and systematically linked to the size effect. The observed returns between different company sizes do not justify such a link for the analyzed periods, whether for individual US. indices or in the context of comparisons between different size indices in the UK and the US.

3.3 Impact of the Santa Claus Rally in an international context with different periods

Inspired by the work of Nippani, Washer, and Johnson (2015), this further extension of J. Patel's paper explores the impact of the Santa Claus Rally (SCR) in an international context. While J. Patel had focused exclusively on the U.S. from January 2000 to December 2021, this study expands the framework to a set of 18 countries divided into two groups: 10 countries with a Christian majority (United States: S&P 500 – NASDAQ – RUSSELL 2000, France: CAC40, United Kingdom: FTSE, Australia: ASX, Canada: TSX, Germany: DAX, Brazil: BOVESPA, Mexico: IPC) and 8 countries with a non-Christian majority (Japan: NIKKEI225, Indonesia: JSX, India: SENSEX, Hong Kong: HSI, Singapore: STI, South Korea: KOSPI, Taiwan: TWSE, China: SSE). The goal is to examine whether the SCR, already documented in Western countries, also shows significance in other cultural and religious contexts, while considering variations in the start dates of the indices studied and observation periods. This approach allows us to explore the hypothesis that a behavioral effect related to the end-of-year holidays influences markets, depending on the dominant culture and the efficiency of local markets, along with the impact of period choices on the presence of SCR. This analysis was divided into three groups: a first dataset matching the characteristics of J. Patel's paper for these different countries, a second replicating the data used by Nippani and Washer ending in 2014, and a third dataset using the full available data for each index from Yahoo Finance until 2025, compared to 2022. We will present directly the results obtained from the Mann-Whitney U median comparison tests and the OLS regression of each index's returns on the SCR days dummy variable to synthesize the results, with descriptive statistics provided in the annex.

3.3.1 Dataset corresponding to the Period of J. Patel's study (2000-2021)

Descriptive Statistics							
Index	**Nature**	**Days Type**	**Mean**	**Std**	**Skewness**	**Kurtosis**	**Obs**
NASDAQ	Christian Based	Santa Claus Rally Days	0.1806%	1.8983%	2.658393	21.770457	154.0
		Remaining Days	0.0327%	1.5726%	-0.063401	5.886265	5382.0
S&P 500	Christian Based	Santa Claus Rally Days	0.1063%	1.1228%	0.878116	5.284068	154.0
		Remaining Days	0.0267%	1.2400%	-0.182194	10.936529	5382.0
Russell 2000	Christian Based	Santa Claus Rally Days	0.0714%	1.3653%	0.499607	2.262794	154.0
		Remaining Days	0.0381%	1.5549%	-0.351769	6.498337	5382.0
TSX	Christian Based	Santa Claus Rally Days	0.2391%	0.9633%	0.257298	3.968504	154.0
		Remaining Days	0.0168%	1.1188%	-0.660061	16.394006	5373.0
Mexican IPC	Christian Based	Santa Claus Rally Days	0.2111%	1.1717%	-0.082732	6.690450	154.0
		Remaining Days	0.0398%	1.2697%	0.091471	5.469994	5366.0
Bovespa	Christian Based	Santa Claus Rally Days	0.4771%	1.7426%	0.377599	3.980657	154.0
		Remaining Days	0.0372%	1.7927%	-0.139575	6.247940	5287.0
FTSE 100	Christian Based	Santa Claus Rally Days	0.2482%	0.9357%	-0.075411	1.296067	154.0
		Remaining Days	0.0020%	1.1881%	-0.153031	7.834297	5404.0
DAX	Christian Based	Santa Claus Rally Days	0.1777%	1.3457%	0.314356	6.622851	154.0
		Remaining Days	0.0218%	1.4727%	-0.008938	5.963632	5427.0

CAC 40	Christian Based	Santa Claus Rally Days	0.1312%	1.1961%	-0.072056	2.804950	154.0
		Remaining Days	0.0102%	1.4300%	-0.032358	6.466904	5467.0
ASX 200	Christian Based	Santa Claus Rally Days	0.1622%	0.7742%	-0.335050	0.590978	154.0
		Remaining Days	0.0169%	1.0195%	-0.576513	7.951827	5404.0
Nikkei 225	Non-Christian Based	Santa Claus Rally Days	0.1501%	1.3423%	-0.286082	1.801629	154.0
		Remaining Days	0.0147%	1.4774%	-0.187309	6.337758	5236.0
HSI	Non-Christian Based	Santa Claus Rally Days	0.1530%	1.3259%	-1.029058	6.400921	154.0
		Remaining Days	0.0120%	1.4519%	0.111270	8.015383	5270.0
SSE Composite	Non-Christian Based	Santa Claus Rally Days	0.2755%	1.4688%	-0.035395	4.841419	154.0
		Remaining Days	0.0222%	1.5240%	-0.207602	5.159504	5171.0
STI	Non-Christian Based	Santa Claus Rally Days	0.2322%	1.0258%	-0.185359	9.923066	154.0
		Remaining Days	0.0032%	1.1123%	-0.267023	6.560771	5349.0
BSE SENSEX	Non-Christian Based	Santa Claus Rally Days	0.3469%	1.1063%	0.164893	1.351552	154.0
		Remaining Days	0.0460%	1.4606%	-0.135933	9.667414	5269.0
IDX	Non-Christian Based	Santa Claus Rally Days	0.3349%	1.1040%	0.574852	5.761524	154.0
		Remaining Days	0.0422%	1.3235%	-0.463962	6.844429	5197.0
TWSE	Non-Christian Based	Santa Claus Rally Days	0.2941%	1.1113%	0.591228	2.434647	154.0
		Remaining Days	0.0143%	1.3256%	-0.195671	3.811856	5253.0
KOPSI	Non-Christian Based	Santa Claus Rally Days	-0.0016%	1.4277%	-0.551723	4.256642	154.0
		Remaining Days	0.0308%	1.4728%	-0.375938	6.759241	5273.0

Dummy Regression Statistics				
Index	β_0	β_1	**Adj. β_0 p-value**	**Adj. β_1 p-value**
NASDAQ	0.03274%	0.14784%	0.115	0.264
S&P 500	0.02671%	0.07961%	0.093	0.353
Russell 2000	0.03809%	0.03336%	0.06	0.755
TSX	0.0168%	0.22228%	0.257	0.005
Mexican IPC	0.03982%	0.17129%	0.028	0.063
Bovespa	0.03716%	0.43995%	0.125	0.002
FTSE 100	0.00203%	0.24613%	0.898	0.001
DAX	0.02184%	0.15582%	0.275	0.156
CAC 40	0.01021%	0.12103%	0.592	0.220
ASX 200	0.01694%	0.14522%	0.204	0.024
Nikkei 225	0.01473%	0.13541%	0.463	0.229
HSI	0.01198%	0.14097%	0.549	0.193
SSE	0.02216%	0.25331%	0.296	0.035
STI	0.00323%	0.22896%	0.832	0.006
BSE SENSEX	0.04598%	0.30092%	0.026	0.002
IDX	0.04219%	0.29269%	0.028	0.002
TWSE	0.01432%	0.27977%	0.442	0.002
KOPSI	0.03084%	-0.03243%	0.188	0.781

Residuals Tests				
Index	**Ljung-Box p-value**	**Jarque-Bera p-value**	**ARCH LM p-value**	**Correction Method**
NASDAQ	0.0	0.0	0.0	HAC
S&P 500	0.0	0.0	0.0	HAC
Russell 2000	0.0	0.0	0.0	HAC
TSX	0.0	0.0	0.0	HAC
Mexican IPC	0.0	0.0	0.0	HAC
Bovespa	0.02	0.0	0.0	HAC
FTSE 100	0.001	0.0	0.0	HAC
DAX	0.149	0.0	0.0	HC0
CAC 40	0.032	0.0	0.0	HAC
ASX 200	0.0	0.0	0.0	HAC
Nikkei 225	0.022	0.0	0.0	HAC
HSI	0.346	0.0	0.0	HC0
SSE	0.171	0.0	0.0	HC0
STI	0.102	0.0	0.0	HC0
BSE SENSEX	0.0	0.0	0.0	HAC
IDX	0.0	0.0	0.0	HAC
TWSE	0.01	0.0	0.0	HAC
KOPSI	0.188	0.0	0.0	HC0

Regarding the first data group from Patel's paper period, for Christian-majority countries, beta regression significance tests show the presence of significant rallies at 1% with HAC & White corrections for Canada, Brazil, and the United Kingdom, with Australia significant at 5%, **for a total of 4 out of 10 countries (3+1)**[1]. It should be noted that the results confirm those of J. Patel for S&P 500 and NASDAQ, although the Russell 2000 shows no notable improvement. Overall, the return expectation gap (the value of the estimated beta 1) remains insufficient to produce generalized significance. However, non-Christian-majority countries show significance at 1% for Indonesia, Taiwan, Singapore, and India, with China at 5%, **for a total of 5 out of 8 countries (4+1)**.

[1]first value representing 1% significant rallies versus 5% significant rallies

Statistics Tests				
Index	**SCR Mean**	**Non-SCR Mean**	**T-Test p-value**	**MWU p-value**
NASDAQ	0.1806%	0.0327%	0.253	0.829
S&P 500	0.1063%	0.0267%	0.431	0.927
Russell 2000	0.0714%	0.0381%	0.792	0.657
TSX	0.2391%	0.0168%	0.015	0.012
Mexican IPC	0.2111%	0.0398%	0.098	0.053
Bovespa	0.4771%	0.0372%	0.003	0.001
FTSE 100	0.2482%	0.0020%	0.011	0.002
DAX	0.1777%	0.0218%	0.194	0.143
CAC 40	0.1312%	0.0102%	0.298	0.245
ASX 200	0.1622%	0.0169%	0.080	0.028
Nikkei 225	0.1501%	0.0147%	0.261	0.253
HSI	0.1530%	0.0120%	0.234	0.087
SSE	0.2755%	0.0222%	0.042	0.045
STI	0.2322%	0.0032%	0.012	0.001
BSE SENSEX	0.3469%	0.0460%	0.011	0.004
IDX	0.3349%	0.0422%	0.007	0.003
TWSE	0.2941%	0.0143%	0.010	0.005
KOPSI	-0.0016%	0.0308%	0.787	0.741

The Mann-Whitney U test corroborates these observations with greater robustness. For Christian-majority countries, significance is noted at 1% for Canada, Brazil, and the United Kingdom, and at 5% for Australia, giving **a total of 4 out of 10 countries (2+2)**. For non-Christian-majority countries, significance at 1% is found for Indonesia, Taiwan, Singapore, and India, at 5% for China, for **a total of 5 out of 8 countries (4+1)**. These initial results, aligned across both tests, suggest that the presence of a rally can be effective in different markets outside the U.S., and counterintuitively, indices with a non-Christian character are more likely to show a significant SCR, here at 62.5%. **The score for this panel of indices stands at a rally significance of 9/18**, with 4 Christian and 5 non-Christian countries.

3.3.2 Dataset corresponding to the Nippani, Washer and Johnson 2015 study (up to 2014)

Below is a summary of the start dates for various market indices, as cited in the paper by Nippani, Washer, and Johnson.

Index	Start Date
NASDAQ	1971-02-04
S&P 500	1950-01-02
Russell 2000	1987-09-09
TSX	1979-06-28
Mexican IPC	1991-11-07
Bovespa	1993-04-26
FTSE 100	1984-01-02
DAX	1990-11-25
CAC 40	1990-02-28
ASX 200	1992-11-22
Nikkei 225	1984-01-03
HSI	1987-01-01
SSE Composite	1990-12-18
STI	1987-12-27
BSE SENSEX	1997-06-30
IDX	1997-06-30
TWSE	1997-07-01
KOPSI	1997-06-30

Descriptive Statistics							
Index	**Nature**	**Days Type**	**Mean**	**Std**	**Skewness**	**Kurtosis**	**Obs**
NASDAQ	Christian Based	Santa Claus Rally Days	0.3095%	1.3960%	3.039416	37.543325	300.0
		Remaining Days	0.0346%	1.2464%	-0.196740	8.695818	10525.0
S&P 500	Christian Based	Santa Claus Rally Days	0.2144%	0.8721%	0.552255	4.143082	449.0
		Remaining Days	0.0288%	0.9742%	-0.672600	21.563436	15654.0
Russell 2000	Christian Based	Santa Claus Rally Days	0.2812%	1.2207%	0.019441	2.265829	188.0
		Remaining Days	0.0307%	1.3330%	-0.400050	8.253664	6445.0
TSX	Christian Based	Santa Claus Rally Days	0.2789%	0.8237%	0.196249	4.764460	244.0
		Remaining Days	0.0223%	0.9898%	-0.660752	12.354989	8422.0
Mexican IPC	Christian Based	Santa Claus Rally Days	0.3098%	1.4511%	0.138773	3.808481	160.0
		Remaining Days	0.0666%	1.5724%	0.203936	5.844170	5375.0
Bovespa	Christian Based	Santa Claus Rally Days	0.6764%	2.0508%	0.140648	2.179851	146.0
		Remaining Days	0.1635%	2.4310%	0.967785	13.677178	4971.0
FTSE 100	Christian Based	Santa Claus Rally Days	0.2849%	0.9873%	-0.234991	3.563768	211.0
		Remaining Days	0.0242%	1.1198%	-0.301793	8.929835	7367.0
DAX	Christian Based	Santa Claus Rally Days	0.3088%	1.4623%	0.621031	4.705223	167.0
		Remaining Days	0.0346%	1.4508%	0.019949	5.039494	5672.0
CAC 40	Christian Based	Santa Claus Rally Days	0.3430%	1.2562%	0.439133	2.469168	167.0
		Remaining Days	0.0148%	1.4224%	0.109930	4.759097	5864.0
ASX 200	Christian Based	Santa Claus Rally Days	0.2510%	0.7372%	-0.237225	0.848764	153.0
		Remaining Days	0.0227%	0.9775%	-0.358492	5.552997	5182.0
Nikkei 225	Non-Christian Based	Santa Claus Rally Days	0.1451%	1.2531%	0.049720	1.265445	210.0
		Remaining Days	0.0136%	1.4603%	-0.110214	7.795264	7179.0
HSI	Non-Christian Based	Santa Claus Rally Days	0.2979%	1.4128%	0.075514	1.844120	190.0
		Remaining Days	0.0410%	1.7255%	-1.254771	33.675227	6482.0
SSE Composite	Non-Christian Based	Santa Claus Rally Days	0.2714%	1.3321%	0.362739	0.480064	118.0
		Remaining Days	0.0196%	1.6138%	0.039913	4.344361	3872.0
STI	Non-Christian Based	Santa Claus Rally Days	0.3810%	1.0895%	1.321932	5.033247	185.0
		Remaining Days	0.0184%	1.2689%	0.096882	8.693869	6306.0
BSE SENSEX	Non-Christian Based	Santa Claus Rally Days	0.5374%	1.4201%	0.885485	3.994145	118.0
		Remaining Days	0.0379%	1.6557%	0.097097	6.139783	3958.0
IDX	Non-Christian Based	Santa Claus Rally Days	0.4582%	1.2708%	0.688470	3.908814	118.0

		Remaining Days	0.0472%	1.7343%	0.036033	6.994523	3911.0
TWSE	Non-Christian Based	Santa Claus Rally Days	0.3466%	1.3235%	0.232166	1.985755	118.0
		Remaining Days	0.0006%	1.5357%	-0.036269	2.641540	3949.0
KOPSI	Non-Christian Based	Santa Claus Rally Days	0.1799%	2.1809%	-0.073565	3.159837	118.0
		Remaining Days	0.0386%	1.9374%	-0.030014	4.295567	3961.0

Dummy Regression Statistics				
Index	β_0	β_1	**Adj. β_0 p-value**	**Adj. β_1 p-value**
NASDAQ	0.03463%	0.27488%	0.000	0.000
S&P 500	0.02876%	0.18567%	0.000	0.000
Russell 2000	0.03071%	0.25048%	0.064	0.006
TSX	0.02225%	0.25663%	0.046	0.000
Mexican IPC	0.06657%	0.24324%	0.003	0.038
Bovespa	0.1635%	0.51287%	0.000	0.006
FTSE 100	0.02417%	0.26073%	0.064	0.000
DAX	0.03461%	0.27422%	0.072	0.017
CAC 40	0.01484%	0.32814%	0.424	0.001
ASX 200	0.02266%	0.22831%	0.095	0.000
Nikkei 225	0.01357%	0.13152%	0.431	0.135
HSI	0.04098%	0.25696%	0.056	0.014
SSE	0.01962%	0.25178%	0.450	0.044
STI	0.01844%	0.36252%	0.269	0.000
BSE SENSEX	0.03795%	0.49942%	0.163	0.000
IDX	0.04719%	0.41106%	0.112	0.001
TWSE	0.00061%	0.34597%	0.980	0.005
KOPSI	0.03864%	0.14124%	0.223	0.525

Residuals Tests				
Index	**Ljung-Box p-val**	**Jarque-Bera p-val**	**ARCH LM p-val**	**Corr. Method**
NASDAQ	0.0	0.0	0.0	HAC
S&P 500	0.001	0.0	0.0	HAC
Russell 2000	0.643	0.0	0.0	HC0
TSX	0.0	0.0	0.0	HAC
Mexican IPC	0.0	0.0	0.0	HAC
Bovespa	0.0	0.0	0.0	HAC
FTSE 100	0.67	0.0	0.0	HC0
DAX	0.535	0.0	0.0	HC0
CAC 40	0.309	0.0	0.0	HC0
ASX 200	0.178	0.0	0.0	HC0
Nikkei 225	0.066	0.0	0.0	HC0
HSI	0.239	0.0	0.0	HC0
SSE	0.52	0.0	0.0	HC0
STI	0.0	0.0	0.0	HAC
BSE SENSEX	0.0	0.0	0.0	HAC
IDX	0.0	0.0	0.0	HAC
TWSE	0.005	0.0	0.0	HAC
KOSPI	0.0	0.0	0.0	HAC

For the Nippani and Washer group study, it should be noted that the interpretations for China (SSE)

differ because Yahoo Finance data starts in 1997, compared to 1990 in their study. Regarding Christian-majority countries, beta regression significance tests show highly significant results at 1% for most countries, except for Germany, which presents results at 5%, **giving a perfect score of 10/10 (8+2)**. These results confirm the presence of a substantial SCR effect in most Christian-majority countries during this period, at 90%. In contrast, for non-Christian-majority countries, significance is observed at 1% for Singapore, India, Indonesia, and Taiwan, and at 5% for Hong Kong and China, **for a score of 6/8 (4+2)**. However, this significance is more limited compared to Christian-majority countries, with less robustness at 62.5%.

Statistics Tests				
Index	**SCR Mean**	**Non-SCR Mean**	**T-Test p-value**	**MWU p-value**
NASDAQ	0.3095%	0.0346%	0.000	0.000
S&P 500	0.2144%	0.0288%	0.000	0.000
Russell 2000	0.2812%	0.0307%	0.011	0.006
TSX	0.2789%	0.0223%	0.000	0.000
Mexican IPC	0.3098%	0.0666%	0.053	0.025
Bovespa	0.6764%	0.1635%	0.012	0.001
FTSE 100	0.2849%	0.0242%	0.001	0.000
DAX	0.3088%	0.0346%	0.016	0.015
CAC 40	0.3430%	0.0148%	0.003	0.002
ASX 200	0.2510%	0.0227%	0.004	0.001
Nikkei 225	0.1451%	0.0136%	0.197	0.155
HSI	0.2979%	0.0410%	0.042	0.012
SSE	0.2714%	0.0196%	0.094	0.105
STI	0.3810%	0.0184%	0.000	0.000
BSE SENSEX	0.5374%	0.0379%	0.001	0.000
IDX	0.4582%	0.0472%	0.011	0.003
TWSE	0.3466%	0.0006%	0.016	0.006
KOPSI	0.1799%	0.0386%	0.437	0.351

The Mann-Whitney U test supports these findings, with 1% significance for all Christian-majority countries except Germany and Mexico at 5%, **giving a perfect score of 10/10 (8+2)**. For non-Christian-majority countries, significance at 1% is found for Indonesia, India, Singapore, and Taiwan, and at 5% for Hong Kong, while China, Japan, and South Korea show no clear significance, **giving a score of 5/8 (4+1)**. These results illustrate greater robustness of SCR in Christian-majority countries, highlighting a more pronounced significant effect in these markets.

In summary, this group of Christian-majority countries achieves a rally score of 10/10, showing a strong presence of the SCR effect in these countries. In contrast, for non-Christian-majority countries, it stands at 5.5/8, with weaker significance but still present in markets like India, Singapore, Indonesia, and Taiwan, compared to Japan and South Korea even with new datasets. **The overall score for this panel is 15.5/18**. These results would tend to support the hypothesis that the year-end period of index returns is more marked in Christian-majority countries.

3.3.3 Dataset from the Yahoo Finance Data (up to 2022 and 2025)

Below are the start dates for the market indices based on the data from Yahoo Finance.

Index	Start Date
NASDAQ	1971-02-04
S&P 500	1927-12-30
Russell 2000	1987-09-10
TSX	1979-06-28
Mexican IPC	1991-11-07
Bovespa	1993-04-27
FTSE 100	1984-01-03
DAX	1987-12-30
CAC 40	1990-02-28
ASX 200	1992-11-22
Nikkei 225	1965-01-04
HSI	1986-12-31
SSE Composite	1991-12-19
STI	1987-12-27
BSE SENSEX	1997-06-30
IDX	1990-04-05
TWSE	1997-07-01
KOPSI	1996-12-10

2022 / (2025) Dummy Regression Statistics				
Index	β_0	β_1	**Adj.** β_0 **p-value**	**Adj.** β_1 **p-value**
NASDAQ	0.04111% / (0.04136%)	0.21982% / (0.19468%)	0.000 / (0.000)	0.003 / (0.003)
S&P 500	0.02496% / (0.02529%)	0.21247% / (0.20415%)	0.001 / (0.001)	0.0 / (0.000)
Russell 2000	0.03404% / (0.03207%)	0.17687% / (0.16332%)	0.018 / (0.022)	0.043 / (0.026)
TSX	0.02302% / (0.02302%)	0.21333% / (0.20339%)	0.019 / (0.014)	0.0 / (0.000)
Mexican IPC	0.05292% / (0.04863%)	0.19025% / (0.1393%)	0.003 / (0.003)	0.044 / (0.114)
Bovespa	0.12987% / (0.12037%)	0.45151% / (0.38012%)	0.000 / (0.000)	0.002 / (0.005)
FTSE 100	0.02051% / (0.02001%)	0.23058% / (0.22584%)	0.072 / (0.063)	0.0 / (0.000)
DAX	0.03543% / (0.03561%)	0.23455% / (0.21359%)	0.020 / (0.013)	0.015 / (0.016)
CAC 40	0.01994% / (0.01904%)	0.22839% / (0.21329%)	0.197 / (0.190)	0.006 / (0.006)
ASX 200	0.02143% / (0.02079%)	0.19581% / (0.18767%)	0.058 / (0.050)	0.000 / (0.000)
Nikkei 225	0.02665% / (0.02778%)	0.13193% / (0.13004%)	0.014 / (0.009)	0.031 / (0.027)
HSI	0.03256% / (0.02812%)	0.21699% / (0.23116%)	0.065 / (0.098)	0.012 / (0.005)
SSE	0.02404% / (0.02048%)	0.22111% / (0.18393%)	0.235 / (0.270)	0.043 / (0.064)
STI	0.01432% / (0.01514%)	0.29609% / (0.28752%)	0.291 / (0.231)	0.0 / (0.000)
BSE SENSEX	0.04364% / (0.04271%)	0.37244% / (0.35647%)	0.030 / (0.019)	0.0 / (0.000)
IDX	0.02986% / (0.02762%)	0.3554% / (0.34812%)	0.089 / (0.089)	0.000 / (0.000)
TWSE	0.01378% / (0.01662%)	0.2529% / (0.21918%)	0.450 / (0.327)	0.007 / (0.010)
KOPSI	0.03697% / (0.03207%)	0.02246% / (-0.00593%)	0.097 / (0.117)	0.887 / (0.967)

2022 / (2025) Residuals Tests				
Index	**Ljung-Box p-val**	**Jarque-Bera p-val**	**ARCH LM p-val**	**Corr. Method**
NASDAQ	0.137 / (0.155)	0.0 / (0.0)	0.0 / (0.0)	HC0 / (HC0)
S&P 500	0.014 / (0.018)	0.0 / (0.0)	0.0 / (0.0)	HAC / (HAC)
Russell 2000	0.0 / (0.002)	0.0 / (0.0)	0.0 / (0.0)	HAC / (HAC)
TSX	0.003 / (0.0)	0.0 / (0.0)	0.0 / (0.0)	HAC / (HAC)
Mexican IPC	0.0 / (0.0)	0.0 / (0.0)	0.0 / (0.0)	HAC / (HAC)
Bovespa	0.008 / (0.004)	0.0 / (0.0)	0.0 / (0.0)	HAC / (HAC)
FTSE 100	0.473 / (0.423)	0.0 / (0.0)	0.0 / (0.0)	HC0 / (HC0)
DAX	0.189 / (0.149)	0.0 / (0.0)	0.0 / (0.0)	HC0 / (HC0)
CAC 40	0.319 / (0.219)	0.0 / (0.0)	0.0 / (0.0)	HC0 / (HC0)

Finally, the analysis of indices from the entire Yahoo Finance dataset until 2022 (and 2025) allows us to observe the influence of more recent data on the significance of SCR returns. By comparing the results from early 2025 with those from early 2022, several trends emerge. Regarding the indices from the first group, the results of the beta 1 tests show the presence of a significant rally at 1% for all countries except Russell 2000, France, Germany, and Mexico at 5% for 2022 (respectively significant at 1% for all countries except Germany and Russell 2000 at 5%, Mexico not significant for 2025), **giving a perfect overall score of 10/10 (7+3)** until 2022 (**respectively 9/10 (7+2) until 2025**). A slight loss of significance between 2022 and 2025 is observed, due to the reduction of performance gaps between these periods, both for SCR and non-SCR days.

For non-Christian countries, the results show non-significance for South Korea, which remains largely non-significant in each dataset. On the other hand, Japan becomes significant at 5% with 19 additional years of data, along with China (non-significant by the end of 2025) and Hong Kong. Singapore, India, Indonesia, and Taiwan show significance at 1%, and Hong Kong at the end of 2025, **giving a score of 7/8 (4+3)** (**respectively 6/8 (5+1)** by the end of 2025). The results until 2025 are largely the same, with slightly reduced significance linked to a loss of average returns on SCR days and an increase outside SCR.

2022 / (2025) Statistics Tests				
Index	**SCR Mean**	**Non-SCR Mean**	**T-Test p-value**	**MWU p-value**
NASDAQ	0.2609% / (0.2360%)	0.0411% / (0.0414%)	0.001 / (0.003)	0.003 / (0.013)
S&P 500	0.2374% / (0.2294%)	0.0250% / (0.0253%)	0.000 / (0.000)	0.000 / (0.000)
Russell 2000	0.2109% / (0.1954%)	0.0340% / (0.0321%)	0.043 / (0.053)	0.054 / (0.062)
TSX	0.2364% / (0.2264%)	0.0230% / (0.0230%)	0.000 / (0.000)	0.000 / (0.000)
Mexican IPC	0.2432% / (0.1879%)	0.0529% / (0.0486%)	0.055 / (0.130)	0.023 / (0.078)
Bovespa	0.5814% / (0.5005%)	0.1299% / (0.1204%)	0.005 / (0.009)	0.000 / (0.001)
FTSE 100	0.2511% / (0.2458%)	0.0205% / (0.0200%)	0.001 / (0.000)	0.000 / (0.000)
DAX	0.2700% / (0.2492%)	0.0354% / (0.0356%)	0.011 / (0.013)	0.011 / (0.015)
CAC 40	0.2483% / (0.2323%)	0.0199% / (0.0190%)	0.014 / (0.014)	0.011 / (0.012)
ASX 200	0.2172% / (0.2085%)	0.0214% / (0.0208%)	0.004 / (0.003)	0.001 / (0.001)
Nikkei 225	0.1586% / (0.1578%)	0.0267% / (0.0278%)	0.041 / (0.039)	0.035 / (0.037)
HSI	0.2496% / (0.2593%)	0.0326% / (0.0281%)	0.037 / (0.021)	0.010 / (0.005)
SSE	0.2452% / (0.2044%)	0.0240% / (0.0205%)	0.062 / (0.088)	0.052 / (0.065)
STI	0.3104% / (0.3027%)	0.0143% / (0.0151%)	0.000 / (0.000)	0.000 / (0.000)
BSE SENSEX	0.4161% / (0.3992%)	0.0436% / (0.0427%)	0.001 / (0.001)	0.000 / (0.000)
IDX	0.3853% / (0.3757%)	0.0299% / (0.0276%)	0.000 / (0.000)	0.000 / (0.000)
TWSE	0.2667% / (0.2358%)	0.0138% / (0.0166%)	0.016 / (0.024)	0.005 / (0.010)
KOPSI	0.0594% / (0.0261%)	0.0370% / (0.0321%)	0.861 / (0.960)	0.844 / (0.921)

The Mann-Whitney U test results corroborate these findings, with 1% significance for all Christian countries

except for Mexico, France, and Germany at 5%, and Russell 2000 no longer significant until 2022 (respectively 1% for all except France at 5%, Mexico and Russell 2000 no longer significant by the end of 2025), **giving a score of 9/10 (6+3)** (**respectively 8/10 (5+3)**, showing less robustness than Nippani's data. For non-Christian countries, significance is observed at 1% for Singapore, India, Indonesia, and Taiwan, and at 5% for Japan and Hong Kong at the end of 2022 (respectively Taiwan and Japan by the end of 2025), while China and South Korea remain non-significant, **giving respective scores of 6/8 (4+2)**. These results confirm consistency with those obtained by beta 1 regression and show a slight loss of robustness for Christian countries but better robustness for non-Christian countries compared to Nippani's dataset. **The overall score for this panel is 16/18 at the end of 2022 and 14.5/18 at the end of 2025**, highlighting the greater validity of SCR in these two groups of indices as more data is considered.

In general, the results show greater significance for Christian countries compared to non-Christian countries, though the latter often still show significance, partially confirming the influence of the Christmas event on SCR returns. This presence seems to be conditioned more by the availability of sufficient historical data in the initial datasets than by the mere inclusion of recent data, which primarily influences the significance of results through the observed average performance of returns. This suggests that these conditions challenge the efficient market hypothesis, at least in its weak form, since the integration of past information in the samples appears to strengthen the observed anomaly, contrary to the results outlined in J. Patel's paper that included only part of the available information. However, exceptions remain, as seen in cases like China, Brazil, the United Kingdom, or India (according to Nippani and Shetty's 2021 study on the post-liberalization period since 1979 and the numerous anomalies verified in the literature on this market), where SCR remains valid even after omitting many years and rally days. Additionally, South Korea never validates this hypothesis and tends to improve as more recent data is considered, suggesting that SCR could be linked to behavioral factors of agents in non-Christian markets, and therefore does not systematically affect the rally.

3.4 SCR breaking date with Chow Test

In addition to these observations, we sought to examine the impact of the chosen dataset period on the significance of the OLS regression results on the dummy variable across different countries. We reviewed the datasets over progressively more recent periods and observed the significance results of our coefficients in the regressions of different countries, across different timeframes. The results confirm that the significance of (β_1), and thus the presence of the SCR (Santa Claus Rally) on each index, diminishes as the starting date moves forward in time. Since the SCR results were specific to the samples selected in the literature and for each index, we were prompted to conduct an analysis on these moments, which we call "SCR breaking date": the starting date after which (β_1) is no longer significant.

We started with the global samples of data provided by Yahoo Finance for each index in the study (both Christian-based and non-Christian-based countries) and reviewed the starting dates year by year, observing the p-value of (β_1) from the regression. Once the p-value exceeds the 5% significance threshold, we consider this date as the SCR breaking date. To determine whether these thresholds bring structural changes between the pre- and post-breaking date datasets, we conducted Chow tests at these dates on our series, all tested for stationarity using the ADF test.

SCR breaking date with Chow results							
Index Name	**Break_Date**	**p_value (β_1)**	**Chow_p_value**	**RSS_part1**	**RSS_part2**	**n_part1**	**n_part2**
NASDAQ	1979-02-02	0.059	0.153	0.11	2.06	2018.0	11579.0
S&P 500	1975-12-18	0.073	0.023	1.98	1.48	12003.0	12368.0
Russell 2000	1989-09-09	0.053	0.613	0.07	1.65	505.0	8900.0
TSX	2009-06-20	0.150	0.347	0.75	0.33	7529.0	3902.0
Mexican IPC	1991-11-07	0.114	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data
Bovespa	2004-04-24	0.097	0.000	2.2	1.42	2721.0	5128.0
FTSE 100	2011-12-27	0.054	0.657	0.91	0.29	7070.0	3291.0
DAX	1998-12-27	0.071	0.459	0.42	1.34	2751.0	6610.0
CAC 40	1999-02-26	0.084	0.291	0.34	1.25	2241.0	6610.0
ASX 200	2010-11-18	0.130	0.525	0.43	0.32	4554.0	3567.0
Nikkei 225	1970-01-03	0.060	0.628	0.1	2.29	1224.0	13532.0
HSI	2011-12-25	0.051	0.536	1.92	0.53	6179.0	3206.0
SSE Composite	1991-12-19	0.064	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data
STI	2013-12-20	0.071	0.232	1.04	0.18	6484.0	2766.0
BSE SENSEX	2010-06-27	0.054	0.087	1.4	1.0	3206.0	3574.0
IDX	2017-03-29	0.084	0.443	1.41	0.17	6592.0	1881.0
TWSE	2007-06-29	0.053	0.626	0.63	0.58	2456.0	4294.0
KOSPI	1996-12-10	0.967	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data	Insuf. Data

The results generally do not suggest any structural change in (β_1) for most of the indices studied. However, we found that only the S&P 500 from the end of 1974 and the Brazilian Bovespa from 2004 show a structural change in the value of beta 1 from these dates onward. In other words, using start dates later than these years would significantly influence the SCR results for these two indices.

This interpretation is contrasted by certain conditions of analysis that affect the results of the study, such as the fact that most results on the indices and their global samples depend on the availability of Yahoo Finance data, which starts the series later than the historical publication date of the indices, thus reducing the test data set. It is also important to note that the interpretation of the Chow test results may be subject to bias due to the potential presence of heteroskedasticity in the return series considered. In this regard, Nippani's 2021 study on the Indian market, for instance, showed the significance of the SCR on the SENSEX post-financial liberalization period in 1991, and its absence from 1979 to 1991, whereas we conducted the analysis after 1997. Some of these breaking dates are close to the initial starting date of the samples, quickly rendering beta 1 non-significant and preventing us from obtaining sufficiently exhaustive subperiods for the Chow test (such as for the Russell 2000, Mexican IPC, Chinese SSE, or Korean KOPSI indices).

4 Extension 2: Addition of market explanatory variables

As part of the previous analysis, we explored the Santa Claus effect on a broader range of financial indices by extending the time sample since the creation date of each index. This study showed that year-end returns were statistically significant for certain indices, particularly during their early years of existence. We now propose a new extension that seeks to further break down the potential underlying factors of these returns by incorporating market variables into an enhanced econometric analysis.

We deliberately chose here to maintain the analysis dates as those used in Jayen B. Patel's research in order to facilitate a comparison of our results. The analysis will therefore cover the period from 12/31/1999 to 01/01/2022.

4.1 Empirical Exploration

First, let us begin with an empirical observation of the annual returns of four indices: two American indices, the S&P 500 and the Nasdaq, and two European indices, the CAC 40 and the STOXX 600. The objective

is to compare the annual returns (excluding the days of the Santa Claus Rally) with the cumulative returns during the period of the Santa Claus Rally.

In these graphs, the annual returns are calculated by excluding the first two days of the year (included in the return of the previous year's Santa Claus Rally), the last five days of the year, as well as the first two days of the following year, which together make up the returns of the current year's Santa Claus Rally. The returns of the Santa Claus Rally are crossed out when they show a return opposite to that of the annual return.

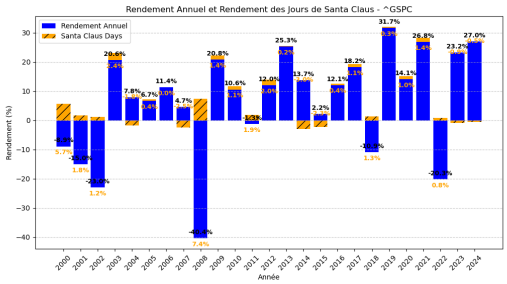


Figure 1: S&P 500

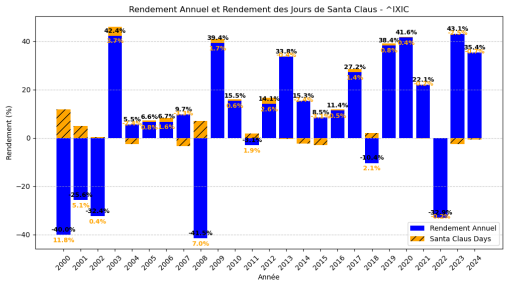


Figure 2: NASDAQ 100

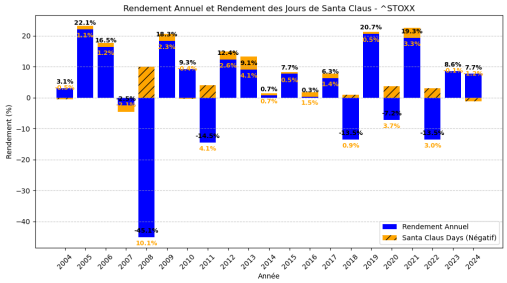


Figure 3: STOXX 600

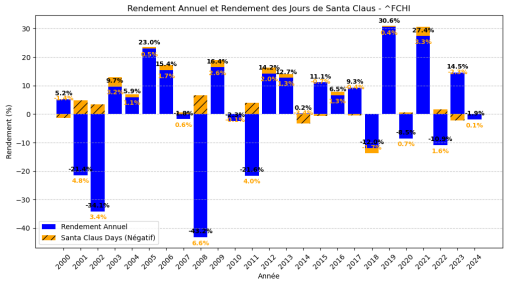


Figure 4: CAC 40

Figure 5: Index performances

The obtained graphs reveal an interesting trend: periods where annual returns were low seem to be associated with relatively high returns during the Santa Claus Rally. This preliminary observation suggests that there may be a relationship between the returns during the Santa Claus Rally period and the market's performance throughout the year. The hypothesis is that a behavioral effect could be behind these year-end returns. Indeed, investor optimism at the end of the year, driven by positive expectations for the following year, could play a key role. This might be true, but it remains challenging to establish a statistical relationship based on behavioral phenomena. To provide a statistical explanation, we propose studying the returns during the Santa Claus Rally period while considering market variables.

4.2 Main Hypothesis and Explanatory Variables

Based on this behavioral hypothesis, we have designed an econometric analysis aimed at better understanding the variables influencing the returns of the Santa Claus Rally. Our goal is to identify whether these returns become significant once key variables are included in the model. We have selected three representative variables:

1. Implied Volatility (VIX): This indicator measures the market's perception of risk. A relationship with the VIX could be explained by the reflection of a climate of confidence, favorable to positive returns during the Santa Claus period.
2. Maximum Drawdown (Max DD): This variable measures the maximum losses sustained by the market over a given year. A high drawdown could indicate a challenging year, amplifying the behavioral effects of investors.
3. EUR/USD Exchange Rate: This variable represents the relative differences between economic regions. It may reflect macroeconomic dynamics affecting capital flows and, indirectly, year-end returns.

4.3 Methodology

To test our hypotheses, we replicated the regressions presented in the original paper, sequentially adding each of the explanatory variables mentioned. We conduct a simple regression for each variable in order to extract its impact on returns and observe if the effect of the Santa Claus Rally becomes statistically significant when isolating the effect of the variable.

We then modify the regression model to regress the index returns on a dummy variable equal to 1 on the days of the Santa Claus Rally and 0 on other days (in the same way as before), multiplied by the value of the variable for the same day. In this way, we test the effect of the variable on returns during the days of the Santa Claus Rally, allowing us to draw conclusions about the relationship between the variable and the Santa Claus Rally.

In the case where, with a variable, both of our models show significant results, we will conclude on the significance of the excess return during the Santa Claus Rally period and on the positive or negative relationship with that variable.

Methodology for Time Series Creation and Econometric Correction

Since our variables are not stationary time series, we worked with daily variations for the VIX and EUR/USD exchange rate series. For the MaxDrawdown, we chose to create a rolling window series. The MaxDrawdown series is calculated over a 1-year window, with a 1-day shift each time. This method of constructing our time series introduces strong autocorrelation and heteroscedasticity in our residuals, which we correct by using the HAC and White corrections presented earlier.

In this way, we are ready to apply our model.

Model 1 :

$$r_t = \beta_0 + \beta_1 D_t + \beta_2 \text{Var}_t + \epsilon_t$$

$$D_t = \begin{cases} 1 & \text{if } t \text{ belongs to the period of the Santa Claus Rally} \\ 0 & \text{else} \end{cases}$$

Model 2 :

$$r_t = \beta_0 + \beta_1 D_t + \beta_2 \text{Var}_t D_t + \epsilon_t$$

$$D_t = \begin{cases} 1 & \text{if } t \text{ belongs to the period of the Santa Claus Rally} \\ 0 & \text{else} \end{cases}$$

4.4 Interpretation of the US Results :

1. Impact of the VIX: When the VIX is added to the first model, the significance of the Santa Claus variable increases for both indices, suggesting that incorporating implied volatility into the returns improves the detection of the Santa Claus effect. Moreover, this effect is even more evident in our second model, where the p-value of our Santa Claus return variable is highly significant. These results demonstrate the significance of the excess return during the Santa Claus period and its negative relationship with the VIX. The higher the uncertainty, the less significant the excess return during the Santa Claus period will be.

2. Impact of Max DD: The addition of the maximum drawdown does not have a notable effect on the coefficients or their significance. Indeed, this variable is not a major determinant of returns and, therefore, does not improve the detection of the Santa Claus effect. However, in our second model, the impact of Max DD on the excess return during the Santa Claus period proves to be significant. This phenomenon is quite interesting and supports our behavioral hypothesis that the excess return during the Santa Claus period is linked to varying degrees of optimism among investors during this time. We observe a negative relationship between the maximum drawdown and the excess return during the Santa Claus period, meaning that this seasonal effect in returns appears to be more pronounced when the maximum drawdown of the year has been high.

3. Impact of EUR/USD: The exchange rate is the underperformer in our analysis for the US region, as it fails to show any signs of significance. However, this variable may still be interesting in a more granular analysis, grouping companies by market capitalization, or it might prove more relevant in a different geographic region.

US Results Tables :

Variable	β_0 **(Constante)**	β_1 **(Santa Claus)**	β_2 **(VIX)**	β_2 **(Max DD)**	β_2 **(EUR/USD)**
Santa Claus seul	0.0003 (0.0093)	0.0008 (0.369)	-	-	-
VIX	0.0006 (0.000)	0.0014 (0.025)	-0.1183 (0.000)	-	-
Max DD	-0.0003 (0.496)	0.0009 (0.279)	-	-0.0028 (0.247)	-
EUR/USD	0.0003 (0.094)	0.0007 (0.428)	-	-	0.1361 (0.001)

Table 18: Regression Results for the S&P 500 (1st Model)

Variable	β_0 **(Constante)**	β_1 **(SCR Dummy X VIX)**	β_1 **(SCR Dummy X Max DD)**	β_1 **(SCR Dummy X EUR/USD)**
SCR Dummy * Maxdd	0.0003 (0.086)	-	-0.0067 (0.050)	-
SCR Dummy * VIX	0.0003 (0.044)	-0.1207 (0.000)	-	-
SCR Dummy * EUR/USD	0.0003 (0.063)	-	-	-0.0906 (0.640)

Table 19: Regression Results for the S&P 500 (2nd Model)

Variable	β_0 **(Constante)**	β_1 **(Santa Claus)**	β_2 **(VIX)**	β_2 **(Max DD)**	β_2 **(EUR/USD)**
Santa Claus seul	0.0003 (0.115)	0.0015 (0.291)	-	-	-
+ VIX	0.0007 (0.000)	0.0022 (0.056)	-0.1370 (0.000)	-	-
+ Max DD	0.0005 (0.436)	0.0014 (0.288)	-	0.0001 (0.950)	-
+ EUR/USD	0.0003 (0.116)	0.0014 (0.305)	-	-	0.0645 (0.182)

Table 20: Regression Results for the NASDAQ 100 (1st Model)

Variable	β_0 **(Constante)**	β_1 **(SCR Dummy X VIX)**	β_1 **(SCR Dummy X Max DD)**	β_1 **(SCR Dummy X EUR/USD)**
SCR Dummy * Maxdd	0.0004 (0.045)	-	-0.0081 (0.158)	-
SCR Dummy * VIX	0.0004 (0.049)	-0.1676 (0.000)	-	-
SCR Dummy * EUR/USD	0.0004 (0.070)	-	-	-0.1499 (0.636)

Table 21: Regression Results for the NASDAQ 100 (2nd Model)

4.5 Interpretation of the European Results :

1. Impact of the VIX: Once again, the same observation as with the US region: accounting for implied volatility in the returns allows us to isolate the volatility effect and improve the detection of the Santa Claus effect. This effect is also verified in our second model, thus demonstrating the significance of the excess return during the Santa Claus period when isolating the volatility effect, as well as its negative relationship with the VIX.

2. Impact of Max DD: The addition of Max Drawdown has a more significant impact on European indices, as isolating this variable improves the significance of the excess return during the Santa Claus period, whereas its impact was minimal for the US. This effect is particularly important for the CAC40, where isolating the effect of Max Drawdown in the returns leads to the conclusion that the excess return during the Santa Claus period is significant. The impact in our second model is even more pronounced, allowing us to conclude that, for the European region, the annual rolling Max Drawdown appears to be a positively correlated measure (the higher the drawdown, the greater the excess return) with the excess return during the Santa Claus period. This increased significance for the European region supports our behavioral phenomenon hypothesis, which suggests that when a significant low point has been reached, investors tend to become more optimistic toward the end of the year, anticipating the next year.

3. Impact of EUR/USD: The exchange rate proves to be disappointing once again. Although it does not undermine the significance of the excess return already present on the STOXX 600 without isolating the contribution of this variable, it does not improve it either, preventing us from concluding that the evolution of the exchange rate plays a role in the analysis of the Santa Claus returns.

European Results Tables :

Variable	β_0 **(Constante)**	β_1 **(Santa Claus)**	β_2 **(VIX)**	β_2 **(Max DD)**	β_2 **(EUR/USD)**
Santa Claus seul	0.0001 (0.399)	0.0025 (0.009)	-	-	-
+ VIX	0.0003 (0.018)	0.0031 (0.000)	-0.0703 (0.000)	-	-
+ Max DD	-0.0004 (0.496)	0.0028 (0.006)	-	-0.0024 (0.404)	-
+ EUR/USD	0.0001 (0.410)	0.0026 (0.009)	-	-	0.1918 (0.000)

Table 22: Regression Results for the STOXX 600 (1st Model)

Variable	β_0 (Constante)	β_1 (SCR Dummy X VIX)	β_1 (SCR Dummy X Max DD)	β_1 (SCR Dummy X EUR/USD)
SCR Dummy X Max DD	0.0001 (0.483)	-	-0.0155 (0.003)	-
SCR Dummy X VIX	0.0002 (0.165)	-0.0715 (0.000)	-	-
SCR Dummy X EUR/USD	0.0002 (0.217)	-	-	-0.6198 (0.066)

Table 23: Regression Results for the STOXX 600 (2nd Model)

Variable	β_0 (Constante)	β_1 (Santa Claus)	β_2 (VIX)	β_2 (Max DD)	β_2 (EUR/USD)
Santa Claus seul	0.0001 (0.592)	0.0012 (0.225)	-	-	-
+ VIX	0.0003 (0.064)	0.0017 (0.055)	-0.0857 (0.000)	-	-
+ Max DD	-0.0006 (0.324)	0.0016 (0.075)	-	-0.0026 (0.304)	-
+ EUR/USD	0.0001 (0.597)	0.0012 (0.233)	-	-	0.0852 (0.121)

Table 24: Regression Results for the CAC 40 (1st Model)

Variable	β_0 (Constante)	β_1 (SCR Dummy X VIX)	β_1 (SCR Dummy X Max DD)	β_1 (SCR Dummy X EUR/USD)
SCR Dummy X Max DD	7.497e-05 (0.700)	-	-0.0090 (0.018)	-
SCR Dummy X VIX	0.0002 (0.417)	-0.0806 (0.000)	-	-
SCR Dummy X EUR/USD	0.0001 (0.468)	-	-	-0.1901 (0.342)

Table 25: Regression Results for the CAC 40 (2nd Model)

4.6 Conclusion of the Extension :

The results of this analysis extension show varied effects depending on the variables studied, while providing additional insights into the factors influencing returns during the Santa Claus period.

Firstly, the inclusion of the VIX in our models helped improve the detection of the Santa Claus effect, particularly by increasing the significance of the variable associated with this effect for both European and American indices. More specifically, the introduction of implied volatility into the returns appears to play a crucial role in explaining this seasonal excess return. We also observe a negative relationship between the VIX and the excess return during this period, suggesting that the higher the uncertainty, the smaller the excess return during the Santa Claus period.

Regarding the impact of Max Drawdown, the results were less conclusive in the initial model, with few notable effects on the significance of American returns. However, they proved to be much more conclusive for the European market. In the second model, a more pronounced impact was observed, particularly for European indices. The risk aversion effect, calculated through Max Drawdown, appears to be more relevant in the European market, where it is positively correlated with the excess return during the Santa Claus period. This phenomenon supports our behavioral hypothesis that investor optimism during this period is

amplified by the significant market movements they experienced throughout the year. Indeed, both empirical and econometric results suggest that in years when a low point was reached, investors tend to become more optimistic towards the end of the year, likely because they believe that after hitting this low, the market will recover.

Finally, the impact of the EUR/USD exchange rate did not show significance in this analysis and therefore did not allow us to conclude that it has a notable effect on the excess return during the Santa Claus period. However, this variable may warrant further exploration, particularly by studying other market segments or adjusting the analysis based on company size or specific geographic regions.

Overall, our analysis confirms the idea that the excess return observed during the Santa Claus period is primarily the result of behavioral phenomena among investors. This excess return is negatively related to market uncertainty (VIX), reducing investor optimism during this period, and positively related to Max Drawdown, demonstrating a tendency to be more optimistic when the market has experienced significant declines during the year. Moreover, as this period is characterized by a sharp decrease in trading volume, the effects of behavioral phenomena are amplified.

It is important to note, however, that these statistical studies can be debatable due to the difficulty in meeting the assumptions of the regression models used, as well as the methodology employed for data construction, which is not without its shortcomings.

5 Extension 3 : The Santa Claus Rally (and December Rally): An International Factor Approach

5.1 Abstract

This 'Factor' extension of the SRC contributes threefold to the literature. First, the SCR analysis (we conducted as well the December Rally (DR) analysis – including all trading days of December) is conducted on 5 factors (MKT, SMB, HML FF, HML Devil and UMD as defined and provided by AQR) across 24 countries and 5 geographical zones (aggregating countries). Second, we conducted the SCR and DR analyses on the overall period (1998-2023) as well as year by year, trying to quantify the proportion of years where the SCR and DR materialized. Thirdly, we assessed the statistical significance of the SCR and DR across factors according to different tests: non-parametric (T-test, Mann-Whiney U test) and parametric ('standard' p-values of regression coefficients but also the ones corrected with the robust standard errors provided by White and Newey-West (HAC)) to measure the effects of test choices.

Summary Results

We found that the proportion (measured as the number of positive years during the period 1998-2023 divided by the total number of years) of positive (without significance) calendar effect (SCR and DR), for all factors (except HML FF: -0.13%) is stronger for the SR than the DR on average across all countries and regions. The MKT factor shows the highest proportion of positive years (75.59%), followed by the SMB factor (71.88%). The UMD factor ranked below 50% at 40.98%.

When we assessed the significance (with the corrected p-values) of these results, for the SCR, the proportion being significant decreases 12 times on average across factors (14.5 times for the DR). The MKT and SMB factors stay ahead (SMB taking the lead) with a significant positive proportion of respectively 8.48% and 11.27%.

When we dive deeper into the results at the country/region level, CAN stands out as the country with the highest proportion of positive years at 96.15% for the SMB factor and for the SCR and DR. When looking at the significant positive proportion, CAN exhibits the highest proportion for the SR at 30.76% (still for

the SMB factor), but Global USA and USA take over for the DR respectively for the UMD and HML FF factors jointly at 19.23%.

To conclude, the SCR is present internationally for some factors (MKT, SMB, HML FF & Devil, if we set the proportion without significance threshold at 50%) and is specifically stronger for some countries such as CAN, NZL, USA, and North America, approaching 97% for the SMB factor (CAN). Unfortunately, when assessing the statistical significance of the SCR, the results diminish by 12 times on average across factors. One explanation might be the disproportionate sample size between the SCR days and the remaining days (97.3% of the sample). Nevertheless, CAN shows a positive significant proportion of the SCR effect up to 30.76% for the SMB factor.

Mean excess daily return (SCR days - non-SCR days) across time										
	MKT	country	SMB	country	HML FF	country	HML Devil	country	UMD	country
average	0.24%		0.11%		0.04%		0.08%		-0.07%	
median	0.23%		0.09%		0.03%		0.07%		-0.07%	
min	0.09%	USA	-0.07%	IRL	-0.04%	AUS	-0.04%	JPN	-0.31%	CAN
max	0.50%	GRC	0.33%	CAN	0.19%	ISR	0.19%	NOR	0.09%	
Mean excess daily return (DR days - non-DR days) across time										
	MKT	country	SMB	country	HML FF	country	HML Devil	country	UMD	country
average	0.11%		0.01%		0.02%		0.02%		0.02%	
median	0.11%		0.01%		0.02%		0.00%		0.02%	
min	0.02%	JPN	-0.08%	PRT	-0.04%	DNK	-0.02%	DNK	-0.06%	CAN
max	0.16%	DNK	0.09%	CAN	0.09%	HKG	0.08%	HKG	0.10%	JPN

Table 26: Mean excess daily returns across time

Proportion of positive (without significance) SCR years					
	MKT	**SMB**	**HML FF**	**HMF Devil**	**UMD**
average	**75.59%**	**71.88%**	59.81%	60.07%	40.98%
median	76.92%	69.23%	57.69%	57.69%	42.31%
min	61.53%	42.31%	42.31%	34.61%	23.07%
max	88.46%	96.15%	80.76%	88.41%	61.53%
Proportion of positive (without significance) DR years					
	MKT	**SMB**	**HML FF**	**HMF Devil**	**UMD**
average	**68.96%**	**57.69%**	59.94%	58.09%	57.29%
median	69.23%	57.69%	57.69%	57.69%	57.69%
min	53.84%	30.76%	42.31%	42.31%	38.46%
max	80.76%	80.76%	76.92%	76.92%	73.07%

Table 27: Comparison of SCR and DR years proportions across factors

Proportion of positive (significant) SCR years					
	MKT	**SMB**	**HML FF**	**HMF Devil**	**UMD**
average	**8.48%**	**11.27%**	3.18%	4.90%	3.05%
median	7.69%	11.53%	0%	3.84%	3.84%
min	0.00%	0%	0%	0%	0.00%
max	23.07%	30.76%	15.38%	15.38%	15.38%
Proportion of positive (significant) DR years					
	MKT	**SMB**	**HML FF**	**HMF Devil**	**UMD**
average	**4.24%**	**3.18%**	4.64%	4.64%	4.64%
median	3.84%	3.84%	3.84%	3.84%	3.84%
min	0.00%	0.00%	0.00%	0.00%	0.00%
max	11.53%	11.53%	19.23%	15.38%	19.23%

Table 28: Comparison of significant SCR and DR years proportions across factors

Top and Worst 5 country/region by proportion of positive SCR years								
	MKT		SMB		HML FF		UMD	
	country/region		country/region		country/region		country/region	
top 5	NZL	88.46%	CAN	96.15%	USA	80.76%	JPN	61.53%
	Pacific	84.61%	FIN	84.61%	North America	76.92%	Pacific	57.69%
	DNK	84.61%	Global	84.61%	ISR	73.07%	ESP	57.69%
	GBR	84.61%	SWE	84.61%	Global	73.07%	GRC	57.69%
	Global Ex USA	80.76%	NLD	84.61%	NLD	73.07%	SGP	53.84%
worst 5	ISR	61.53%	IRL	42.31%	AUT	42.31%	NOR	23.07%
	IRL	65.38%	PRT	53.84%	CHE	42.31%	BEL	23.07%
	North America	69.23%	ISR	61.53%	SWE	46.15%	North America	26.92%
	USA	69.23%	DNK	61.53%	DNK	50.00%	USA	26.92%
	JPN	69.23%	GBR	61.53%	BEL	50.00%	Global	30.76%

Table 29: Top and Worst 5 country/region by proportion of positive SCR years

Top and Worst 5 country/region by proportion of positive significant SCR years								
	MKT		SMB		HML FF		UMD	
	country/region		country/region		country/region		country/region	
top 5	Global Ex USA	23.07%	CAN	30.76%	North America	15.38%	Global Ex USA	15.38%
	NOR	19.23%	Global Ex USA	23.07%	ISR	11.53%	Pacific	11.53%
	GRC	19.23%	FRA	19.23%	HKG	11.53%	ESP	7.69%
	DNK	15.38%	NOR	19.23%	USA	11.53%	FRA	7.69%
	AUS	11.53%	ITA	15.38%	Global	7.69%	AUS	7.69%
worst 5	USA	0.00%	NZL	0.00%	AUS	0.00%	ISR	0.00%
	FIN	0.00%	BEL	3.84%	IRL	0.00%	CAN	0.00%
	BEL	0.00%	DNK	3.84%	AUT	0.00%	HKG	0.00%
	HKG	3.84%	PRT	3.84%	FIN	0.00%	IRL	0.00%
	SWE	3.84%	CHE	7.69%	JPN	0.00%	AUT	0.00%

Table 30: Top and Worst 5 country/region by proportion of positive significant SCR years

Top and Worst 5 country/region by proportion of positive DR years								
	MKT		SMB		HML FF		UMD	
	country/region		country/region		country/region		country/region	
top 5	BEL	80.76%	CAN	80.76%	AUS	76.92%	GRC	76.92%
	AUT	80.76%	SWE	73.07%	USA	76.92%	Pacific	69.23%
	DNK	80.76%	FRA	69.23%	HKG	73.07%	SWE	69.23%
	PRT	80.76%	Global	69.23%	North America	73.07%	JPN	69.23%
	GBR	73.07%	NLD	69.23%	USA	73.07%	GBR	65.38%
worst 5	JPN	53.84%	PRT	30.76%	FIN	42.31%	NOR	38.46%
	Pacific	57.69%	ISR	42.31%	DNK	50.00%	AUT	42.31%
	Global	57.69%	GRC	42.31%	BEL	50.00%	BEL	50.00%
	North America	61.53%	AUT	42.31%	Europe	50.00%	FIN	50.00%
	USA	61.53%	AUS	42.31%	FRA	50.00%	AUS	53.84%

Table 31: Top and Worst 5 country/region by proportion of positive DR years

Data

We used AQR datasets to retrieve the factors. We constrained the analysis from 1998 to 2023 included because the first full year of all factors available across all countries starts in 1998 and AQR, as of 15/01/2025, has not provided yet the factors for December 2024.

Detailed Results

5.2 The Santa Claus Rally (SCR) and The December Rally (DR): Overall Period (1998-2023) Analysis

5.2.1 SCR Analysis

For the overall period (1998-2023), all countries and geographic areas (GA) exhibit significance of the SCR except for the USA and North America (93% of the population) concerning the MKT factor. The mean daily (median, min, max) return between the SCR and non-SCR days across all countries and GA is 0.25% (0.23%, 0.09%, 0.50%).

For all factors, the statistical significance is assessed with the corrected p-values of the coefficient β_1 of the linear regression. The corrections are the following: we test the presence of heteroscedasticity and autocorrelation with Engle's test and Ljung-Box test (up to lag 1). If heteroscedasticity and autocorrelation are detected, we use the robust variance-covariance of the estimated parameters using Newey-West (Heteroscedasticity and Autocorrelation Consistent, 'HAC' cov_type of statsmodels). If autocorrelation is detected (but no heteroscedasticity), we still use this same correction. However, if there is no evidence of autocorrelation but heteroscedasticity, we use White correction ('HC0' cov_type of statsmodels). If neither heteroscedasticity nor autocorrelation is detected, then standard OLS is kept.

For the SMB factor, the following countries/geographic areas exhibit statistical significance for the evidence of the SCR: AUS, CAN, FIN, FRA, ITA, JPN, NLD, NOR, SGP, SWE, Global, Global Ex USA, Europe, and Pacific (48% of the population). The mean daily (median, min, max) return between the SCR and non-SCR days across all countries and GA is 0.11% (0.09%, -0.07%, 0.33%).

For the HML FF factor, only HKG, ISR, NLD, and Global exhibit a significant SCR (13%).

Finally, for the UMD factor, CAN, DEU, DNK, FRA, NOR, USA, Global, and North America exhibit a significant (negative! Where it is not indicated, default is positive) SCR (27%). The mean daily (median, min, max) return between the SCR and non-SCR days across all countries and GA is -0.08% (-0.07%, -0.31%, 0.09%).

5.2.2 DR Analysis

For the MKT factor, AUT, BEL, CHE, DEU, DNK, GBR, NLD, NZL, PRT, Global Ex USA, and Europe (38%) exhibit evidence of the DR. The mean daily (median, min, max) return between the DR and non-DR days across all countries and GA is 0.09% (0.09%, 0.02%, 0.15%).

For the SMB factor, only CAN and PRT (7%) exhibit evidence of the DR. The mean daily (median, min, max) return between the DR and non-DR days across all countries and GA is 0.003% (0.005%, -0.11%, 0.08%).

For the HML FF factor, only AUS, JPN, and Pacific (10%) exhibit evidence of the DR. The mean daily (median, min, max) return between the DR and non-DR days across all countries and GA is 0.008% (0.008%, -0.08%, 0.06%).

For the UMD factor, AUS, ESP, GBR, JPN, SWE, Global Ex USA, Europe, and Pacific (26%) exhibit evidence of the DR. The mean daily (median, min, max) return between the DR and non-DR days across all countries and GA is 0.04% (0.06%, -0.05%, 0.11%).

5.3 The SCR and DR: Sub Periods (Year by Year) Analysis

5.3.1 The SCR

In this section, I will present for each factor its average proportion of years by country/region. I will then compare it to the proportion of statistically significant positive years to see how much it reduces.

For the MKT factor, it shows on average 75.60% (median, min, and max, respectively: 76.92%, 61.5%, and 88.46%) of positive SCR years with the following top 5: NZL (88.46%), Pacific (84.61%), DNK (84.61%), GBR (84.61%), and Global Ex USA (80.76%). Worst 5: ISR (61.53%), IRL (65.38%), North America (69.23%), USA (69.23%), and JPN (69.23%).

Proportion of Positive SCR Years		Proportion of Significant (corrected) Positive SCR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
NZL	88.46	Global Ex USA	23.08
Pacific	84.62	NOR	19.23
DNK	84.62	GRC	19.23
GBR	84.62	DNK	15.38
Global Ex USA	80.77	AUS	11.54
Global	80.77	GBR	11.54
AUS	80.77	Global	11.54
NOR	76.92	PRT	11.54
Europe	76.92	ISR	11.54
BEL	76.92	Pacific	11.54
GRC	76.92	CHE	11.54
CAN	76.92	JPN	7.69
SWE	76.92	Europe	7.69
AUT	76.92	CAN	7.69
CHE	76.92	SGP	7.69
FIN	73.08	FRA	7.69
SGP	73.08	AUT	7.69
PRT	73.08	ESP	7.69
ESP	73.08	NZL	7.69
NLD	73.08	ITA	3.85
ITA	73.08	NLD	3.85
HKG	73.08	DEU	3.85
DEU	73.08	IRL	3.85
FRA	73.08	SWE	3.85
JPN	69.23	HKG	3.85
USA	69.23	BEL	3.85
North America	69.23	FIN	0.00
IRL	65.38	USA	0.00
ISR	61.54	North America	0.00

Table 32: Proportion of SCR Years by Country/Region for MKT Factor

For the SMB factor, it shows on average 71.88% (median, min, and max, respectively: 69.23%, 42.31%, and 96.15%) of positive SCR years with the following top 5: CAN (96.15%), FIN (84.61%), Global (84.61%), SWE (84.61%), and NLD (84.61%). Worst 5: IRL (42.31%), PRT (53.84%), ISR (61.53%), DNK (61.53%), and GBR (61.53%).

Proportion of Positive SCR Years		Proportion of (corrected) Significant Positive SCR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
CAN	96.15	CAN	30.77
FIN	84.62	Global Ex USA	23.08
Global	84.62	FRA	19.23
SWE	84.62	NOR	19.23
NLD	84.62	ITA	15.38
FRA	84.62	Europe	15.38
AUS	80.77	FIN	15.38
Global Ex USA	80.77	AUS	11.54
Pacific	80.77	North America	11.54
North America	73.08	Global	11.54
JPN	73.08	USA	11.54
Europe	73.08	SWE	11.54
NOR	73.08	SGP	11.54
SGP	73.08	ISR	11.54
USA	69.23	GRC	11.54
GRC	69.23	ESP	11.54
HKG	69.23	Pacific	11.54
AUT	69.23	AUT	7.69
BEL	69.23	IRL	7.69
CHE	69.23	JPN	7.69
DEU	69.23	NLD	7.69
NZL	65.38	HKG	7.69
ITA	65.38	GBR	7.69
ESP	61.54	DEU	7.69
GBR	61.54	CHE	7.69
DNK	61.54	PRT	3.85
ISR	61.54	DNK	3.85
PRT	53.85	BEL	3.85
IRL	42.31	NZL	0.00

Table 33: Proportion of SCR Years by Country/Region for SMB Factor

For the HML FF factor, it shows on average 59.81% (median, min, and max, respectively: 57.69%, 42.31%, and 80.77%) of positive SCR years with the following top 5: USA (80.76%), North America (76.92%), ISR (73.07%), Global (73.07%), and NLD (73.07%). Worst 5: AUT (42.31%), CHE (42.31%), SWE (46.15%), DNK (50.00%), and BEL (50.00%).

Proportion of Positive SCR Years		Proportion of (corrected) Significant Positive SCR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
USA	80.77	North America	15.38
North America	76.92	ISR	11.54
ISR	73.08	HKG	11.54
Global	73.08	USA	11.54
NLD	73.08	Global	7.69
HKG	73.08	Global Ex USA	3.85
GRC	65.38	NOR	3.85
Global Ex USA	65.38	NLD	3.85
JPN	65.38	ITA	3.85
PRT	61.54	Pacific	3.85
IRL	61.54	FRA	3.85
Pacific	61.54	CAN	3.85
GBR	61.54	CHE	3.85
CAN	61.54	ESP	3.85
ITA	57.69	GBR	0.00
FIN	57.69	SGP	0.00
DEU	57.69	BEL	0.00
SGP	57.69	Europe	0.00
FRA	53.85	DEU	0.00
Europe	53.85	SWE	0.00
AUS	53.85	NZL	0.00
NZL	53.85	PRT	0.00
ESP	53.85	GRC	0.00
NOR	50.00	DNK	0.00
BEL	50.00	JPN	0.00
DNK	50.00	FIN	0.00
SWE	46.15	AUT	0.00
CHE	42.31	IRL	0.00
AUT	42.31	AUS	0.00

Table 34: Proportion of SCR Years by Country/Region for HML FF Factor

For the HML Devil factor, CAN, HKG, NLD, NOR, USA, Global, and North America exhibit SCR (24%). The mean daily (median, min, max) return between the SCR and non-SCR days across all countries and GA is 0.08% (0.07%, -0.05%, 0.20%).

Proportion of Positive SCR Years		Proportion of (corrected) Significant Positive SCR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
North America	88.46	Global Ex USA	15.38
USA	88.46	CAN	11.54
Global	73.08	NOR	11.54
CAN	73.08	IRL	11.54
HKG	73.08	HKG	11.54
NOR	69.23	AUS	7.69
PRT	69.23	GRC	7.69
FIN	65.38	Global	7.69
DNK	65.38	SWE	7.69
DEU	65.38	Pacific	7.69
NLD	61.54	FIN	7.69
Global Ex USA	61.54	ESP	7.69
GBR	61.54	ISR	3.85
IRL	61.54	DEU	3.85
SGP	57.69	North America	3.85
Europe	57.69	ITA	3.85
ISR	57.69	Europe	3.85
Pacific	57.69	NLD	3.85
GRC	57.69	USA	3.85
ITA	53.85	BEL	0.00
FRA	53.85	CHE	0.00
CHE	53.85	GBR	0.00
BEL	53.85	SGP	0.00
ESP	50.00	PRT	0.00
AUT	46.15	FRA	0.00
SWE	46.15	DNK	0.00
NZL	42.31	JPN	0.00
AUS	42.31	AUT	0.00
JPN	34.62	NZL	0.00

Table 35: Proportion of SCR Years by Country/Region for HML Devil Factor

For the UMD factor, it shows on average 40.98% (median, min, and max, respectively: 42.31%, 23.07%, and 61.53%) of positive SCR years with the following top 5: JPN (61.53%), Pacific (57.69%), ESP (57.69%), GRC (57.69%), and SGP (53.84%). Worst 5: NOR (23.07%), BEL (23.07%), North America (26.92%), USA (26.92%), and Global (30.76%).

Proportion of Positive SCR Years		Proportion of (corrected) Significant Positive SCR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
JPN	61.54	Global Ex USA	15.38
Pacific	57.69	Pacific	11.54
ESP	57.69	ESP	7.69
GRC	57.69	FRA	7.69
SGP	53.85	AUS	7.69
PRT	50.00	PRT	3.85
NLD	50.00	CHE	3.85
ISR	50.00	FIN	3.85
CHE	50.00	North America	3.85
GBR	46.15	GBR	3.85
HKG	46.15	GRC	3.85
SWE	46.15	BEL	3.85
FIN	42.31	JPN	3.85
Europe	42.31	SGP	3.85
AUS	42.31	NZL	3.85
ITA	38.46	DEU	0.00
AUT	38.46	Europe	0.00
DNK	38.46	Global	0.00
Global Ex USA	34.62	USA	0.00
DEU	30.77	SWE	0.00
FRA	30.77	NLD	0.00
NZL	30.77	NOR	0.00
CAN	30.77	DNK	0.00
IRL	30.77	ITA	0.00
Global	30.77	AUT	0.00
USA	26.92	IRL	0.00
North America	26.92	HKG	0.00
BEL	23.08	CAN	0.00
NOR	23.08	ISR	0.00

Table 36: Proportion of SCR Years by Country/Region for UMD Factor

5.3.2 The DR

On the basis of the SCR analysis above, here are the results for the DR.

For the MKT factor:

Proportion of Positive DR Years		Proportion of (corrected) Significant Positive DR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
BEL	80.77	ISR	11.54
AUT	80.77	Europe	11.54
DNK	80.77	AUT	11.54
PRT	80.77	BEL	7.69
GBR	76.92	PRT	7.69
NLD	73.08	ESP	7.69
SGP	73.08	NZL	7.69
Europe	73.08	NOR	7.69
FIN	73.08	NLD	7.69
Global Ex USA	73.08	ITA	7.69
NZL	69.23	IRL	3.85
ITA	69.23	Global Ex USA	3.85
AUS	69.23	Global	3.85
NOR	69.23	AUS	3.85
DEU	69.23	FRA	3.85
CHE	69.23	FIN	3.85
CAN	69.23	DNK	3.85
FRA	69.23	DEU	3.85
ISR	65.38	CAN	3.85
IRL	65.38	HKG	0.00
HKG	65.38	GRC	0.00
GRC	65.38	JPN	0.00
ESP	65.38	GBR	0.00
SWE	61.54	SGP	0.00
USA	61.54	SWE	0.00
North America	61.54	USA	0.00
Global	57.69	CHE	0.00
Pacific	57.69	North America	0.00
JPN	53.85	Pacific	0.00

Table 37: Proportion (%) of Positive DR Years by Country/Region for MKT factor

For the SMB factor:

Proportion of Positive DR Years		Proportion of (corrected) Significant Positive DR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
CAN	80.77	Global	11.54
SWE	73.08	ISR	7.69
FRA	69.23	North America	7.69
Global	69.23	CAN	7.69
NLD	69.23	SWE	7.69
NOR	65.38	ESP	7.69
SGP	65.38	USA	7.69
DNK	61.54	NOR	7.69
FIN	61.54	AUT	3.85
GBR	61.54	HKG	3.85
IRL	61.54	FRA	3.85
Europe	61.54	FIN	3.85
CHE	61.54	Global Ex USA	3.85
Global Ex USA	57.69	DEU	3.85
NZL	57.69	NZL	3.85
North America	57.69	Europe	0.00
ITA	57.69	SGP	0.00
JPN	57.69	PRT	0.00
USA	57.69	AUS	0.00
Pacific	53.85	NLD	0.00
ESP	53.85	JPN	0.00
BEL	53.85	ITA	0.00
HKG	53.85	IRL	0.00
DEU	50.00	GRC	0.00
AUS	42.31	GBR	0.00
AUT	42.31	DNK	0.00
GRC	42.31	CHE	0.00
ISR	42.31	BEL	0.00
PRT	30.77	Pacific	0.00

Table 38: Proportion (%) of Positive DR Years by Country/Region for SMB factor

For the HML FF factor:

Proportion of Positive DR Years		Proportion of (corrected) Significant Positive DR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
AUS	76.92	USA	19.23
USA	76.92	North America	15.38
HKG	73.08	Global Ex USA	15.38
North America	73.08	Global	15.38
JPN	73.08	HKG	7.69
Pacific	73.08	NOR	7.69
Global	69.23	JPN	7.69
NLD	65.38	Europe	7.69
Global Ex USA	65.38	GRC	7.69
CAN	65.38	Pacific	3.85
AUT	61.54	NLD	3.85
GBR	61.54	AUT	3.85
NZL	57.69	GBR	3.85
CHE	57.69	ESP	3.85
ISR	57.69	DEU	3.85
IRL	57.69	CAN	3.85
ITA	53.85	BEL	3.85
ESP	53.85	PRT	0.00
NOR	53.85	SWE	0.00
DEU	53.85	SGP	0.00
PRT	53.85	AUS	0.00
SGP	53.85	NZL	0.00
SWE	53.85	ITA	0.00
GRC	53.85	IRL	0.00
FRA	50.00	FRA	0.00
Europe	50.00	FIN	0.00
BEL	50.00	DNK	0.00
DNK	50.00	DEU	0.00
FIN	42.31	CAN	0.00

Table 39: Proportion (%) of Positive DR Years by Country/Region for HML FF factor

For the HML Devil factor:

Proportion of Positive DR Years		Proportion of (corrected) Significant Positive DR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
Pacific	76.92	North America	15.38
HKG	73.08	Global	15.38
North America	73.08	USA	15.38
Global	73.08	CAN	7.69
USA	73.08	Europe	7.69
NOR	73.08	Global Ex USA	7.69
Global Ex USA	65.38	GBR	7.69
NLD	65.38	HKG	7.69
Europe	61.54	AUS	3.85
AUS	61.54	ITA	3.85
FRA	61.54	SWE	3.85
ISR	57.69	PRT	3.85
IRL	57.69	NOR	3.85
AUT	57.69	NLD	3.85
CAN	57.69	JPN	3.85
DEU	53.85	Pacific	3.85
JPN	53.85	AUT	3.85
ESP	53.85	GRC	3.85
GRC	53.85	FIN	3.85
PRT	53.85	ESP	3.85
SGP	53.85	DEU	3.85
BEL	50.00	IRL	0.00
NZL	50.00	NZL	0.00
SWE	50.00	FRA	0.00
DNK	46.15	SGP	0.00
CHE	46.15	DNK	0.00
GBR	46.15	CHE	0.00
FIN	42.31	BEL	0.00
ITA	42.31	ISR	0.00

Table 40: Proportion (%) of Positive DR Years by Country/Region for HML Devil factor

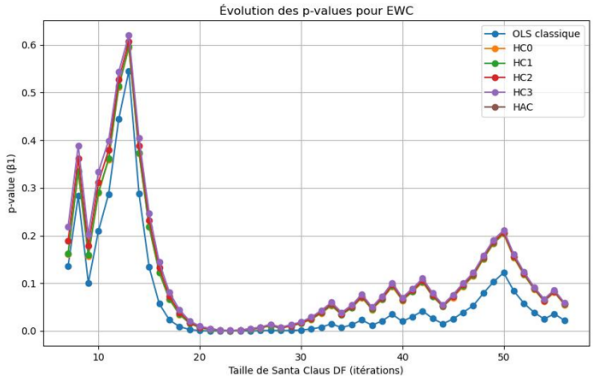
For the UMD factor:

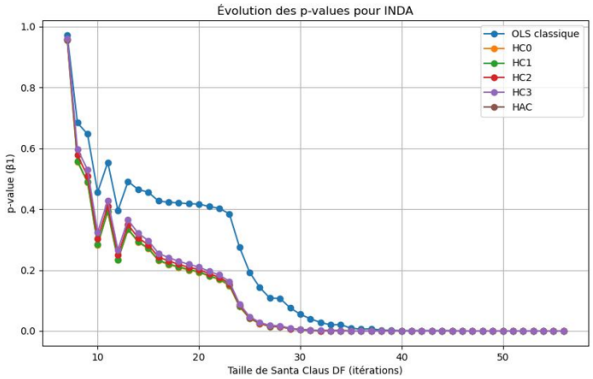
Proportion of Positive DR Years		Proportion of (corrected) Significant Positive DR Years	
Country/Region	**Proportion (%)**	**Country/Region**	**Proportion (%)**
GRC	73.08	Global Ex USA	19.23
Pacific	69.23	JPN	11.54
SWE	69.23	ESP	11.54
JPN	69.23	Europe	11.54
GBR	65.38	Pacific	7.69
IRL	61.54	Global	7.69
Europe	61.54	NLD	7.69
Global Ex USA	61.54	CAN	7.69
DNK	61.54	DNK	7.69
Global	57.69	FRA	7.69
USA	57.69	AUT	7.69
PRT	57.69	GRC	3.85
ISR	57.69	ITA	3.85
HKG	57.69	GBR	3.85
FRA	57.69	DEU	3.85
CHE	57.69	CHE	3.85
ITA	53.85	PRT	3.85
NLD	53.85	SGP	0.00
NZL	53.85	North America	0.00
SGP	53.85	USA	0.00
ESP	53.85	SWE	0.00
DEU	53.85	AUS	0.00
CAN	53.85	NZL	0.00
North America	53.85	ITA	0.00
AUS	53.85	IRL	0.00
FIN	50.00	FRA	0.00
BEL	50.00	FIN	0.00
AUT	42.31	DNK	0.00
NOR	38.46	CHE	0.00

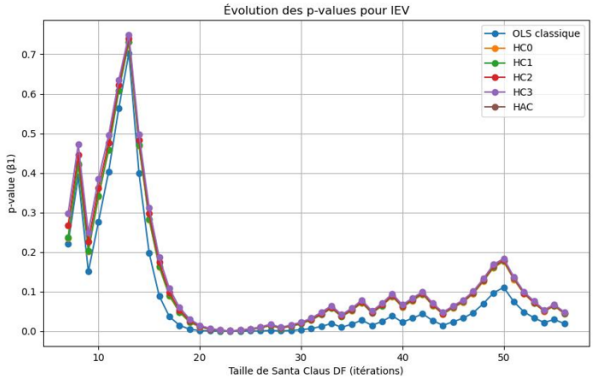
Table 41: Proportion (%) of Positive DR Years by Country/Region for UMD factor

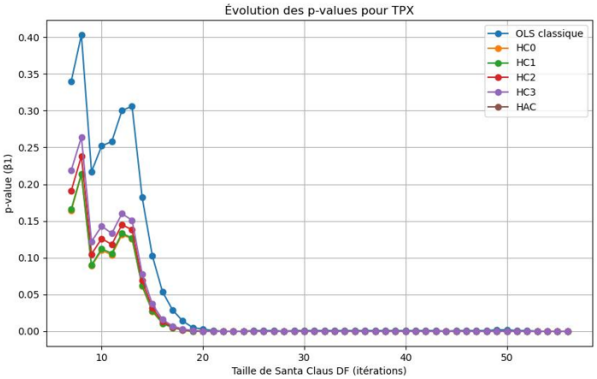
5.4 Statistical Significance and Sample Size

From the tables above (especially the ones in the summary), we can notice a huge decrease (12 times on average for the SCR and 14.5 for the DR) between the proportion of positive years and the proportion of significant positive years even though the mean returns of SCR days is much higher than the mean returns of non-SCR days. Despite the fact that we corrected the p-values to account for heteroskedasticity and autocorrelation, the proportions do not really improve. Trying to investigate that, we looked at the p-values for some indices where we bootsrapped the number of SCR days. Thanks to the below chart, we can see that the size of the sample size plays a huge role for the significance. Further study (lack of time for this project) could be a comparison between the proportion of significant years and the significant - corrected with boostrapped - years, to see how much it improve. The main challenge is not to disturb the distribution of the SCR returns. One may think of bootsraping (random selection of SCR returns with remise) or generating SCR returns based on their distribution characteristics.


Évolution des p-values pour EWC
OLS classique
HC0
HC1
HC2
HC3
HAC
p-value (β1)
Taille de Santa Claus DF (itérations)


Évolution des p-values pour INDA
OLS classique
HC0
HC1
HC2
HC3
HAC
p-value (β1)
Taille de Santa Claus DF (itérations)


Évolution des p-values pour IEV
OLS classique
HC0
HC1
HC2
HC3
HAC
p-value (β1)
Taille de Santa Claus DF (itérations)


Évolution des p-values pour TPX
OLS classique
HC0
HC1
HC2
HC3
HAC
p-value (β1)
Taille de Santa Claus DF (itérations)