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Historical evolution of monthly anomalies in international stock markets☆

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ABSTRACT

This paper is a comprehensive investigation of the evolution of various monthly anomalies (January effect, December effect, and the Mark Twain effect) in the US stock market for its entire history. This is done using various statistical techniques (average analysis, Student's *t*-test, ANOVA, the Mann–Whitney test) and a trading simulation approach). To confirm our results we extended the analysis to the UK, Japan, Canada, France, Switzerland, Germany and Italy stock markets. The results indicate that the January effect was most prevalent in the US and that the December effect and the Mark Twain effect were never prevalent in the US. This result was confirmed in other markets as well. The January effect was most prevalent in the middle of the 20th century but has since disappeared. Furthermore, the January effect provided exploitable profit opportunities. Our results are consistent and add to the existing literature through the use of a complete history of the US market. Overall, the US stock market is consistent with the Adaptive Market Hypothesis.

1. Introduction

The Efficient Market Hypothesis (EMH) predicts that stock prices reflect all available information about the value of a firm, and therefore there is no possibility of economic profits (see Fama, 1965, 1970). However, Rossi (2015) observes that after years of investigation in all its forms (weak, semi-strong, and strong forms) and considerable controversy, in recent years scholars have been continuing to find evidence contradicting the EMH (for example see Klock, 2014; Perez, 2018). This is, however, not a recent realisation as others have shown that the predictions of the EMH are not absolute (see Grossman and Stiglitz, 1980; Shiller, 2000, 2003; Akerlof and Shiller, 2009). Furthermore, Rossi and Gunardi (2018) contend that the calendar anomalies literature continues to be fragmented and therefore the study of calendar anomalies remains relevant.

To this end, Plastun et al. (2019) and Urquhart and McGroarty (2016), amongst others, focused on the evolution of calendar anomalies using data that spans over a century. For example, used data from 1900 to 2018 in the US stock market and found that the 'golden age' of calendar anomalies was in the middle of the 20th century. However, since the 1980s all calendar anomalies

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disappeared, which is consistent with the EMH. Whilst, Urquhart and McGroarty (2016) demonstrated that stock market return predictability varies over time and is related to the stock market conditions, thereby Adaptive Market Hypothesis (AMH) in the S&P500, FTSE100, NIKKEI225 and the EURO STOXX 50. That is, the analogous behaviour of stock market returns varies over time is not omnipresent as suggested by the EMH. In support, Urquhart and Hudson (2013) explored the persistence of returns in the US, UK and Japanese stock markets and found evidence in favour of the AMH. Although questions around the evolution of the January effect specifically are not new, Perez (2018), Gupta (2017) and Patel (2016) continue to investigate the evolution of the January effect in advanced and emerging markets. Others such as Ahmed and Boutheina (2017) and Gupta (2017) focused on the evolution of other monthly anomalies such as the December effect and the Mark Twain effect. A comprehensive analysis of the AMH with calendar effects was performed by Xiong et al. (2018). They found that calendar effects in the Chinese stock market vary from over time.

This paper seeks to add to the existing monthly anomalies literature by using data from which covers the entire US stock market history and to confirm the US results by comparing with similar markets. This has not previously been done in the literature. Furthermore, it seeks to expand on the limited literature on the December effect and the Mark Twain effect in the US, whilst confirming the voluminous January effect literature. To achieve this we employ various statistical techniques (average analysis, Student's *t*-test, ANOVA, the Mann–Whitney test) and a trading simulation approach. The trading simulation approach is unique to the literature in that it provides practical implications for the anomaly, that is, whether there was a possibility of exploitable profits from an anomaly. The layout of the paper is as follows. Section 2 describes the data and outlines the empirical methodology. Section 3 presents the US empirical results, and Section 4 offers some concluding remarks.

2. Literature review

According to Thaler (1987) the first attempts to test the EMH examined short term correlations in stock prices, and when no evidence of serial correlation was found initially it was thought that stock prices followed a random walk. However, the work of Rozeff and Kinney (1976) found seasonal patterns in the New York Stock exchange over the period 1904–1974. In particular, this referred to January returns being on average 3.5%, compared to 0.5% in the other months. This is the most prominent of the monthly anomalies, that is, the January effect.

After Rozeff and Kinney (1976), others such as Gultekin and Gultekin (1983) found the January effect in 16 countries, Ho (1990) who found the January effect in six out of eight emerging Asian Pacific markets, and Lakonishok and Smidt (1988) who confirmed the January effect in the US followed. This continued initial wave of the confirmation of the January effect shifted focus in the literature towards an explanation for the January effect and to a certain extent the other forms of monthly anomalies such as the Mark Twain effect and the December effect.

Roll (1983) and Keim (1983), amongst others, attributed the existence of the January effect to the size effect (or the small-firm effect), including those that underperformed in the past (De Bondt and Thaler, 1985). Essentially the contention is that small firms in the processing of seeking to improve profitability, sell stocks at a capital loss in other to avoid taxation, otherwise known as tax loss selling hypothesis (Wachtel, 1942), and buy back these stocks in January, thereby increasing returns in that month. This is, however, not limited to small firms. In addition, the tax loss selling hypothesis is not limited to December tax years only. As shown by Agrawal and Tandon (1994) in most countries tax loss selling was confirmed with a December tax year, however, in the UK it was confirmed with a March tax year. Choudhry (2001) found strong evidence of the January effect prior to the first world war in the UK, US, and Germany despite the lack of tax treatment of capital gains in these countries during that period. This contradicted the tax loss selling hypothesis.

Various studies have cited the size effect as the main reason for the January effect. Lakonishok and Smidt (1988) confirmed the results of Roll (1983) in the US. Whilst Bhabra et al. (1999) studied the impact of the 1986 Tax Reform Act in the US on the tax loss selling and confirmed that tax loss selling shifted to November as a result. More recently, Moller and Zilca (2008) and Gu (2003) found similar results.

Other explanations have been advanced for the existence of the January effect. Haugen and Lakonishok (1988) advanced the window dressing hypothesis which states that investors sell certain stocks at the end of the year in order to present more acceptable portfolio performance in year-end reports. Stoll and Whaley (1983) found that transaction costs in small firms and Chang and Pinegar (1990) found that seasonality in the risk premier explained the January effect. Lastly, Kohers and Kohli (1992) found that the January effect was linked to the business cycle. Lastly, Blume and Stambaugh (1983) attributed the January effect to statistical bias.

The evolution of the January effect, and in general the various monthly anomalies, was investigated across the world. According to Lo (2004) the AMH is based on the evolutionary approach to economic interactions where the competition, natural selection, and psychology, amongst others, determine the efficiency of financial markets. That is, market efficiency is not omnipresent or adapts over time. This is in contrast to the neoclassical EMH explanation of the market efficiency. A reading of the literature suggests that the January effect is more consistent with the AMH. For example, Xiong et al. (2018) analysed the evolution of four calendar anomalies (including the January effect) in the Chinese stock market and found evidence in favour of the AMH.

That is, post the initial wave of the confirmation of the January effect more evidence from recent studies is mixed. Suggesting that the January effect has since disappeared in advanced markets (see Marquering et al., 2006; Perez, 2018). For example, Floros (2008) found no evidence of the January effect in the Greek stock market, Rossi and Gunardi (2018) found no evidence of the January effect in advanced markets between 2001 and 2010, and Giovanis (2009) found no evidence of the January effect in 36 out of 55 stock markets. Marrett and Worthington (2011) found higher returns in April instead of January. Mills et al. (2000) found higher monthly returns in January and February in the Greek stock market.

However, others continue to find evidence of the January effect to varying degrees. Patel (2016) found evidence in the US and

other markets using data from 1997 to 2014. Similarly, Haug and Hirschey (2006) found that the January effect was still prevalent in US equities, even in equally weighted small-cap stock returns. Jacobsen et al. (2005) also confirmed the January effect in the US. However, in addition, Jacobsen et al. (2005) studied the interaction of the January effect with the Halloween effect and found that unlike the January effect the Halloween effect was a market-wide phenomenon.

In emerging markets, for example, in the Indian stock market Gupta (2017) studied the January effect using 15 years' worth of data and found no anomalous evidence. In the Tunisian stock market Ahmed and Boutheina (2017) also did not find evidence of the January effect but confirmed the month of the effect in August and April. Balaban et al. (1995) found evidence of the January effect in the Turkish stock market. Alagidede and Panagiotidis (2006) found evidence of an anomaly in April instead of January in Ghana. However, Zhang and Li (2006) in China found evidence of the January effect in the Chinese stock market.

Equally relevant for this study, the Mark Twain effect and December effect received less attention in the literature compared to the January effect. This is as these effects are less prominent than the January effect. Referring to higher than average returns in October as compared to other months, both Ahmed and Boutheina (2017), Balaban et al. (1995), and Floros (2008) did not find evidence of the Mark Twain effect in the Tunisian, Istanbul and Greek stock markets, respectively. Furthermore, Rossi and Gunardi (2018) did not find any significant evidence of the Mark Twain effect and December effect in Germany, France, Italy and Spain. However, Norvaisiene et al. (2015) found evidence of the Mark Twain effect in Estonia. Agrawal and Tandon (1994) found evidence of the December effect in an international study which excluded the US. Parikh (2009) and Gupta (2017) confirmed the December effect in the Indian stock market. No literature confirming Mark Twain effect or the December effect in the US was found suggesting that these have since disappeared (Marquering et al., 2006) or may have never existed.

3. Data and methodology

We use monthly data from the US, UK, Canadian, French, Germany, Italy, and Japanese stock markets. This data was sourced from the Global Financial Database.[2] The sample periods are summarised in Table 1 below. In order to explore the evolution of the various monthly anomalies (January effect, Mark Twain effect, December effect) we split overall period into a number of sub-periods. The length of each sub-period is 25 years. This explains why some data sets are do not end with 2018, but with 2017 or 2015. This allows for sufficient data sets for analysis with statistically significant results and at the same time to see the dynamics of the evolution.

The following hypotheses are tested in this research:

- H_1: the various monthly anomalies are not a market myth or legend.
- H_2: the various monthly anomalies evolve over time.
- H_3: the various monthly anomalies can be exploited to get abnormal profits from trading in the stock markets.

To confirm or reject these hypotheses we use average analysis, parametric tests (Student's t-tests and ANOVA analysis), non-parametrical test (Mann–Whitney test), and the trading simulation approach. The average analysis provides preliminary evidence of differences in returns between the months of the year. Furthermore, both the parametric and non-parametric tests are carried out given evidence of fat tails and kurtosis in stock market return data. To this end, the null hypothesis (H_0) in each case is that the data belong to the same population and a rejection of this null suggesting the presence of an anomaly. The Student's t-tests are carried out under the same null hypothesis.

The tests are carried out at the 95% confidence level, and the degrees of freedom are N ($N = N_1 + N_2$). Returns are computed as follows:

$$R_t = \left(\frac{\text{Close}_t}{\text{Close}_{t-1}} - 1 \right) \times 100 \tag{1}$$

where R_t is the return on the tth day in percentage, Close_t is the close price on the tth day, and Close_{t-1} is the open price on the $t-1$th day.

When an anomaly is detected we examine whether it gives rise to exploitable profit opportunities by means of a trading simulation approach. Specifically, we use an algorithm based on the various monthly anomalies to replicate the behaviour of a trader who opens positions in the stock market and holds them for a certain period of time (for example, for the January effect the algorithm is: buy on the start of January and close this position at the end of January).

We use the following procedure to simulate the trading process. First we compute the percentage result of the deal (%Result):

$$\%\text{Result} = \frac{100 \times P_{\text{open}}}{P_{\text{close}}} \tag{2}$$

where P_{open} is the opening price, and P_{close} is the closing price.

The sum of results from each deal is the total financial result of trading. A strategy resulting positive total profits is defined as indicating an exploitable market anomaly. To ensure that the results we obtain are statistically different from the random trading we carry out t-tests on the results. Given that the sample size of the trading simulation results is less than a 100, the t-test is utilised instead of the z-test.

[2] The data is available for download at https://www.globalfinancialdata.com.

Table 1
Data.

Country	Stock market	Sample period
US	S&P 500 Index	1791–2015
UK	FTSE All Share Index	1693–2017
Canada	S&P/TSX 300 Composite Index	1915–2014
France	CAC All Tradable Index	1898–2018
Germany	CDAX Composite Index	1870–2018
Italy	Banca Commerciale Italiana Index	1905–2018
Japan	Nikkei 225	1914–2013
Switzerland	Switzerland Composite Stock Price Index	1916-2015

Table 2
Overall results for the various monthly anomalies.

Effect	Method	1791–1815	1816–1840	1841–1865	1866–1890	1891–1915	1916–1940	1941–1965	1966–1990	1991–2015
January effect	Average analysis	−	−	−	+	+	+	+	+	+
	ANOVA	−	−	−	−	+	+	+	−	−
	Student's *t*-test	−	−	−	−	+	+	+	−	−
	Mann–Whitney test	−	−	−	−	+	+	+	−	−
	Overall	0	0	0	1	4	4	4	1	1
Mark Twain effect	Average analysis	−	+	+	+	+	+	−	−	+
	ANOVA	−	−	−	−	−	−	−	−	−
	Student's *t*-test	−	−	−	−	−	−	−	−	−
	Mann–Whitney test	−	−	−	−	−	−	−	−	−
	Overall	0	1	1	1	1	1	0	0	1
December effect	Average analysis	+	−	+	−	−	−	+	+	+
	ANOVA	−	−	−	−	−	−	−	−	−
	Student's *t*-test	−	−	−	−	−	−	−	−	−
	Mann–Whitney test	−	−	−	−	−	−	−	−	−
	Overall	1	0	1	0	0	0	1	1	1

Note: + means that the anomaly is present, and − means that it is not present. The overall column simply counts the number of + with a higher number indicating stronger evidence of the anomaly.

Table 3
Trading simulation results of the January effect.

Period	Number of trades, units	Number of successful trades, units	Number of successful trades, %	Profit, %	Profit % per year	*t*-test	Result
1866–1890	25	14	56.0	18.65	1.9	1.4	Failed
1891–1915	25	18	72.0	39.74	4.0	3.23	Passed
1916–1940	25	15	60.0	42.56	4.3	3.17	Passed
1941–1965	25	20	80.0	45.25	4.5	3.45	Passed
1966–1990	25	17	68.0	42.72	4.3	2.45	Passed
1991–2015	25	15	60.0	25.85	2.6	1.88	Passed

A *t*-test compares the means from two samples to test whether these means originate from the same population. In our case, the first is the average profit/loss factor of one trade applying the trading strategy, and the second is equal to zero because random trading (without transaction costs) should generate zero profit.

Therefore, the null hypothesis (H_0) is that the means are equal in both samples and the alternative (H_1) indicates that they are not. The *t*-tests are conducted at a 5% level of significance. Failure to reject H_0 implies that there are no advantages from exploiting the trading strategy being considered, whilst a rejection suggests that the adopted strategy can generate abnormal profits.

4. Results

Appendix A contains the US results. Appendix B contains supplementary results on the Canadian, French, German, Italian, Japanese, Swiss, and UK stock markets. In particular, the Canadian results are shown in both full and aggregated forms.[3] In order to fit all available results into one paper, for other countries aggregated results are used. The full results include an average analysis (Table 12 and Figure 3), detailed statements of the ANOVA analysis (Table 13), Mann–Whitney (Table 14) and *t*-tests (Table 15).

[3] Please note that full results of all stock markets are available on request.

Table 4
Overall results of the January effect.

Period	Average analysis	ANOVA	Student's *t*-test	Mann–Whitney test	Overall
Canadian stock market					
1915–1939	+	+	+	+	4
1940–1964	+	+	+	+	4
1965–1989	+	–	–	–	1
1990–2014	–	–	–	–	0
French stock market					
1898–1922	+	–	–	–	1
1923–1947	+	–	–	–	1
1948–1972	+	+	+	+	4
1973–1997	+	–	–	+	2
1998–2018	+	–	–	–	1
German stock market					
1870–1894	–	–	–	–	0
1895–1919	+	+	+	–	3
1920–1944	+	+	+	+	4
1945–1969	+	–	+	–	2
1970–1994	+	–	–	–	1
1994–2018	+	–	–	–	1
Italian stock market					
1905–1929	+	–	–	–	1
1930–1954	+	–	–	–	1
1955–1979	+	+	+	–	3
1980–2004	+	+	+	–	3
2005–2018	+	–	–	–	1
Japanese stock market					
1914–1938	+	+	+	+	4
1939–1963	+	+	+	+	4
1964–1988	+	+	+	+	4
1989–2013	–	–	–	–	0
Swiss stock market					
1916–1940	–	–	–	–	0
1941–1965	+	+	+	+	4
1966–1990	+	+	+	–	3
1991–2015	+	–	–	–	1
UK stock market					
1693–1717	–	–	–	–	0
1718–1742	–	–	–	–	0
1743–1767	–	–	–	–	0
1768–1792	–	–	–	–	0
1793–1817	–	–	–	–	0
1818–1842	+	–	–	–	1
1843–1867	+	+	+	-	3
1868–1892	+	+	+	+	4
1893–1917	+	+	+	+	4
1918–1942	+	+	+	+	4
1943–1967	+	–	–	–	1
1968–1992	+	–	–	+	2
1993–2017	–	–	–	–	0

Note: + means the that anomaly is present, and − means that it is not present. The Overall column simply counts the number of + with a higher number indicating stronger evidence of the anomaly.

In terms of the January effect, the average analysis reveals that since 1866 returns in the stock market were higher than average in January (see Table 2). However, for the Mark Twain effect, the average analysis reveals that between 1816 and 1940 returns in October were higher than average. This trend has since reversed in the rest of the sample. Lastly, the average analysis revealed evidence of the December effect in the US between 1941 and 2015.

The January effect average analysis results to a large extent are supported by statistical tests (ANOVA, *t*-test, and Mann–Whitney test) which were all significant between 1891 and 1965. However, in recent times statistical tests have Not confirmed the January effect. Statistical tests for both the Mark Twain effect and the December effect fail to confirm anomalies in returns. Given the confirmation of the January effect, we conduct a trading simulation to determine if this anomaly generated exploitable profits. As can be seen in Table 3, a trading strategy based on the January effect generated abnormal profits in the US stock market for over 100

Table 5
Overall results of the Mark–Twain effect.

Period	Average analysis	ANOVA	Student's *t*-test	Mann–Whitney test	Overall
Canadian stock market					
1915–1939	+	–	–	–	1
1940–1964	–	–	–	–	0
1965–1989	+	–	–	–	1
1990–2014	–	–	–	–	0
French stock market					
1898–1922	–	–	–	–	0
1923–1947	–	–	–	–	0
1948–1972	+	–	–	+	2
1973–1997	+	–	–	–	1
1998–2018	–	–	–	–	0
German stock market					
1870–1894	+	–	–	–	1
1895–1919	+	–	–	–	1
1920–1944	+	–	–	+	2
1945–1969	–	–	–	–	0
1970–1994	+	–	–	–	1
1994–2018	–	–	–	–	0
Italian stock market					
1905–1929	+	–	–	+	2
1930–1954	–	–	–	–	0
1955–1979	+	–	–	–	1
1980–2004	–	–	–	–	0
2005–2018	–	–	–	–	0
Japanese stock market					
1914–1938	+	–	–	–	1
1939–1963	+	–	–	–	1
1964–1988	+	–	–	–	1
1989–2013	+	–	–	–	1
Swiss stock market					
1916–1940	+	–	–	+	2
1941–1965	+	+	+	–	3
1966–1990	–	–	–	–	0
1991–2015	–	–	–	–	0
UK stock market					
1693–1717	+	–	–	+	2
1718–1742	+	–	–	+	2
1743–1767	+	+	+	+	4
1768–1792	+	+	+	+	4
1793–1817	–	–	–	–	0
1818–1842	+	–	–	–	1
1843–1867	+	–	–	–	1
1868–1892	–	–	–	–	0
1893–1917	+	–	–	–	1
1918–1942	–	–	–	–	0
1943–1967	–	–	–	–	0
1968–1992	+	–	–	–	1
1993–2017	–	–	–	+	1

Note: + means the that anomaly is present, and − means that it is not present. The Overall column simply counts the number of + with a higher number indicating stronger evidence of the anomaly.

years (between 1891 and 2015).

Overall, our analysis reveals that the January effect remains prevalent in the US stock market. However, the Mark Twain effect and December effect were never prevalent in the US. These results are confirmed the average analysis, statistical tests, and the trading simulation. The results of the January effect are, therefore, inconsistent with the EMH.

4.1. Robustness

The results of the US stock market are collaborated by the results of the Canadian, French, German, Italian, Japanese, Swiss, and UK stock markets. That is, in all these stock markets the January effect was prevalent but has since disappeared, and the Mark Twain

Table 6
Overall results of the December effect.

Period	Average analysis	ANOVA	Student's *t*-test	Mann–Whitney test	Overall
Canadian stock market					
1915–1939	–	–	–	–	0
1940–1964	–	–	–	–	0
1965–1989	+	+	+	+	4
1990–2014	+	+	+	+	4
French stock market					
1898–1922	–	–	–	–	0
1923–1947	+	–	–	–	1
1948–1972	+	–	–	–	1
1973–1997	+	–	–	–	1
1998–2018	+	–	–	–	1
German stock market					
1870–1894	+	–	–	–	1
1895–1919	–	–	–	–	0
1920–1944	+	–	–	–	1
1945–1969	+	–	–	–	1
1970–1994	+	–	–	–	1
1994–2018	+	–	–	+	2
Italian stock market					
1905–1929	+	–	–	–	1
1930–1954	+	–	–	–	1
1955–1979	–	–	–	–	0
1980–2004	+	–	–	–	1
2005–2018	+	–	–	–	1
Japanese stock market					
1914–1938	–	–	–	–	0
1939–1963	+	–	–	–	1
1964–1988	+	–	–	–	1
1989–2013	+	–	–	–	1
Swiss stock market					
1916–1940	+	–	–	–	1
1941–1965	+	–	–	–	1
1966–1990	+	+	+	+	4
1991–2015	+	–	–	–	1
UK stock market					
1693–1717	+	–	–	–	1
1718–1742	+	+	+	–	3
1743–1767	+	–	–	–	1
1768–1792	+	–	–	+	2
1793–1817	+	–	–	–	1
1818–1842	+	+	+	+	4
1843–1867	+	–	–	–	1
1868–1892	+	–	–	–	1
1893–1917	+	–	–	–	1
1918–1942	–	–	–	–	0
1943–1967	+	–	–	–	1
1968–1992	+	–	–	–	1
1993–2017	+	+	+	+	4

Note: + means the that anomaly is present, and - means that it is not present. The Overall column simply counts the number of + with a higher number indicating stronger evidence of the anomaly

and December effects were never prevalent with some exceptions. Specifically, the Mark Twain effect was prevalent in the UK between 1768 and 1792, and the December effect was prevalent in Canada between 1965 and 2014, and in the UK between 1993 and 2017. Lastly, the trading simulation approach results are also congruent with the US results, revealing that the January effect in the main generated exploitable profits. In recent years, however, this trend has begun to reverse in almost all these markets (see Tables 4, 5, 6, and 7).

Summarising all previous results in Fig. 1 we conclude that the January effect appeared at the beginning of the 20th century and was most prevalent in the 1940s until the 1960s. However, the January effect has since disappeared with January returns in many cases are not positive, and when they are positive they do not differ statistically from the average returns in other months. Furthermore, it is now impossible to generate profits from trading based on this anomaly (at least with stable results which will differ from random).

Table 7
Trading simulation results of the January effect.

Period	Number of trades, units	Number of successful trades, units	Number of successful trades, %	Profit, %	Profit % per year	*t*-test	Result
Canadian stock market							
1965–1989	25	20	80.0	53.48	5.3	2.88	Passed
1990–2014	25	21	84.0	51.46	5.1	3.92	Passed
French stock market							
1898–1922	25	15	62.5	36.82	3.7	2.08	Passed
1923–1947	25	16	64.0	82.07	8.2	2.08	Passed
1948–1972	25	16	64.0	74.01	7.4	3.12	Passed
1973–1997	25	18	72.0	71.23	7.1	2.32	Passed
1998–2018	21	13	61.9	4.97	0.5	0.20	Failed
German stock market							
1870–1894	25	10	40.0	−13.05	−1.3	−0.82	Failed
1895–1919	25	15	60.0	28.47	2.8	2.70	Passed
1920–1944	25	21	84.0	104.69	10.5	3.23	Passed
1945–1969	25	17	68.0	50.84	5.1	2.91	Passed
1970–1994	25	18	72.0	35.32	3.5	1.53	Failed
1994–2018	24	16	66.7	10.63	1.1	0.36	Failed
Italian stock market							
1905–1929	24	13	54.2	33.27	3.3	0.88	Failed
1930–1954	24	15	62.5	36.82	3.7	2.08	Passed
1955–1979	25	16	64.0	57.15	5.7	2.16	Passed
1980–2004	25	18	72.0	119.23	11.9	3.42	Passed
2005–2018	14	10	71.4	8.19	0.8	0.33	Failed
Japanese stock market							
1914–1938	24	19	79.2	89.23	8.9	3.79	Passed
1939–1963	25	18	72.0	167.14	16.7	2.48	Passed
1964–1988	25	21	84.0	85.43	8.5	6.05	Passed
1989–2013	25	14	56.0	−1.37	−0.1	−0.05	Failed
Swiss stock market							
1916–1940	24	13	54.2	−16.30	−1.6	−0.48	Failed
1941–1965	25	21	84.0	62.29	6.2	4.65	Passed
1966–1990	25	17	68.0	62.24	6.2	2.51	Passed
1991–2015	25	16	64.0	29.73	3.0	1.28	Failed
UK stock market							
1818–1842	25	15	60.0	56.55	5.7	1.05	Failed
1843–1867	25	16	64.0	32.04	3.2	2.63	Passed
1868–1892	25	19	76.0	34.39	3.4	3.36	Passed
1893–1917	25	18	72.0	30.11	3.0	4.80	Passed
1918–1942	25	20	80.0	23.74	2.4	3.50	Passed
1943–1967	25	17	68.0	21.07	2.1	1.39	Failed
1968–1992	25	20	80.0	105.34	10.5	2.27	Passed

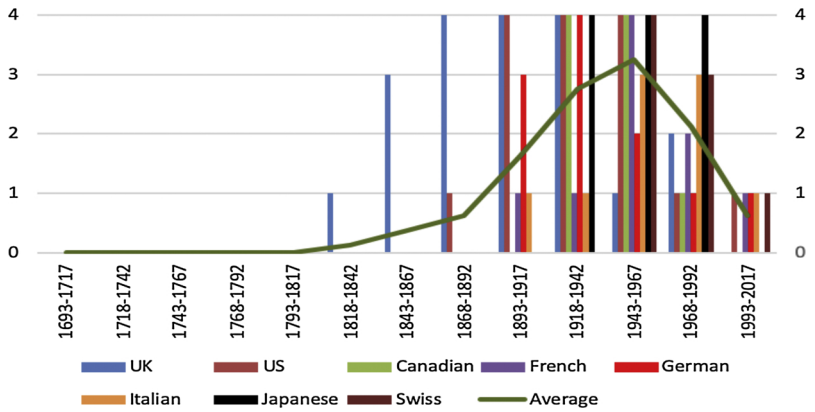

Fig. 1. Evolution of the January effect. Note: The scale is from 0 to 4, where 0 is total absence of anomaly and 4 is the most convincing presence of anomaly.

5. Conclusion

This paper examined various monthly anomalies (January effect, December effect, and the Mark Twain effect) in the US over the entire history of the market using various methods (average analysis, the Student's *t*-test and ANOVA, Kruskal–Wallis and Mann–Whitney tests, and the trading simulation approach). This paper sought to investigate how these calendar anomalies evolved over time, to test whether stock markets were inefficient in the past and present, and could these inefficiencies be exploited for profit.

The results show that the January effect was the most prevalent of the three anomalies. That in fact, the December effect and the Mark Twain effect were never prevalent in the US. Furthermore, the January effect was most prevalent in the middle of the 20th century but has since disappeared. The January effect indeed created opportunities for market participants to profit. Combined with similar results from comparable stock markets this confirms that the January effect existed in these markets and is not just a market legend. Therefore, this market behaviour is more consistent with the AMH in that the US market has evolved from being inefficient to efficient.

Our results are consistent with the existing literature. The fact that a complete history of the various markets was used adds weight to the work of Marquering et al. (2006), Perez (2018) and Rossi and Gunardi (2018), amongst others, who in the main highlighted the disappearance of anomalies over time. Or in other words, that markets evolve to become more efficient. Furthermore, our results confirm the prominence of the January effect which has been a recurring theme in the literature (see Patel, 2016; Haugen and Lakonishok, 1988; Jacobsen et al., 2005, amongst others). Although this study did not directly test for the reasons behind the prominence of the January effect, there is no reason to doubt the key explanations in the literature (such as tax loss selling (Wachtel, 1942) and window dressing (Haugen and Lakonishok, 1988)) given the congruency of our results to the literature.

However, given that recent evidence of the December effect was Canada and the Mark Twain effect in the UK, market efficiency from a practical perspective remains interesting. That is, opportunities to exploit these anomalies still exist. This is on interest to practitioners who can exploit these opportunities, but also to academics who can challenge the conventional wisdom that less efficient markets are only found in emerging countries.

Appendix A. History of month of the year effect in the US stock market

Table 8, Fig. 2, Table 9, Table 10, Table 11

Table 8
Average returns.

Month	1791–1815	1816–1840	1841–1865	1866–1890	1891–1915	1916–1940	1941–1965	1966–1990	1991–2015
January	−0.44	−0.06	−1.47	0.75	1.59	1.70	1.81	1.71	1.03
February	−0.39	0.18	2.04	0.32	−0.18	0.18	0.07	0.60	0.72
March	0.17	0.10	1.45	−0.21	−0.31	−0.06	0.54	0.70	0.41
April	0.16	0.18	−0.45	−0.12	1.17	−1.26	1.05	1.06	1.29
May	0.02	0.18	1.31	0.13	−1.09	−0.48	0.80	0.09	1.13
June	0.41	0.83	0.36	−0.26	−0.35	−0.59	0.40	0.69	0.01
July	−0.29	−1.23	−1.06	0.56	−0.72	2.76	1.70	−0.28	0.24
August	0.19	0.72	0.33	0.65	1.43	2.05	0.36	0.01	−0.23
September	0.19	0.72	0.33	0.65	1.43	2.05	0.36	0.01	−0.23
October	0.19	−0.24	−0.65	−0.44	−0.25	−2.05	0.48	0.01	−0.19
November	−0.16	−0.88	0.01	−0.14	0.83	−0.81	0.67	−0.06	1.82
December	0.24	−0.05	0.73	0.00	−0.17	−1.64	1.18	0.74	1.29

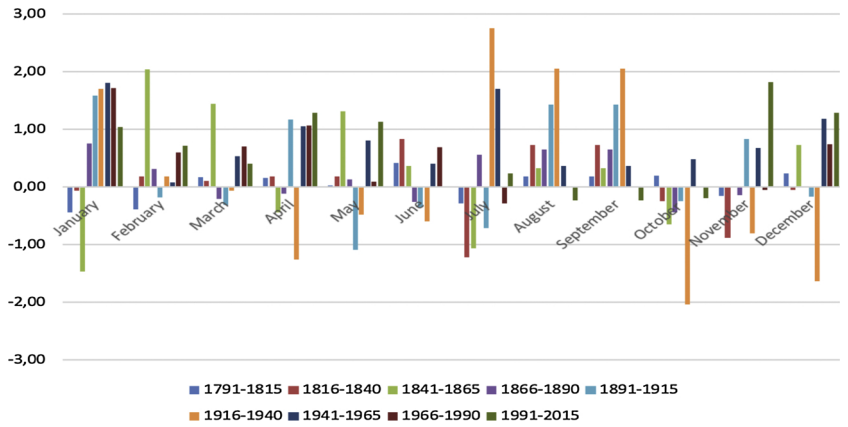

Fig. 2. Average returns.

Table 9
ANOVA test of the month of the year effect.

Month	1791–1815	1816–1840	1841–1865	1866–1890	1891–1915	1916–1940	1941–1965	1966–1990	1991–2015
January	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Confirmed	Confirmed	Not confirmed	Not confirmed
February	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
March	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
April	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
May	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
June	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
July	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed
August	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
September	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
October	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
November	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
December	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed

Table 10
t-Test of the month of the year effect.

Month	1791–1815	1816–1840	1841–1865	1866–1890	1891–1915	1916–1940	1941–1965	1966–1990	1991–2015
January	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Confirmed	Confirmed	Not confirmed	Not confirmed
February	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
March	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
April	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
May	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
June	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
July	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed
August	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
September	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
October	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
November	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
December	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed

Table 11
Mann–Whitney test of the month of the year effect.

Month	1791–1815	1816–1840	1841–1865	1866–1890	1891–1915	1916–1940	1941–1965	1966–1990	1991–2015
January	Not confirmed	Not confirmed	Confirmed	Not confirmed	Confirmed	Confirmed	Confirmed	Not confirmed	Not confirmed
February	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
March	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
April	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
May	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
June	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
July	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed
August	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
September	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
October	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed
November	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Confirmed
December	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed	Not confirmed

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ribaf.2019.101127.

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