International Journal of Business & Applied Sciences
Vol. 10 No. 1, pp. 7-13 (2021)
ISSN: 2165-8072 (Online); 2471-8858 (Print)

International Time Series Momentum

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Moskowitz, Ooi, and Pedersen (2012, JFE) document the anomaly of times series momentum. The objective of this study is to investigate if the anomaly is robust. By analyzing an entirely independent sample covering continental Europe, this research finds that not only time series momentum exists in the region, but also their correlations are very low, only half of those of contemporaneous market movements. Thus, time series momentum is more instrumental for diversification than markets are. Further, this type of momentum exhibits a compelling seasonality of higher returns in January than in the remainder of the year.

Keywords: Time Series Momentum; International Markets; Seasonality

Introduction

At the center of debate in the finance literature is whether the market is efficient. The traditional view maintains that information is factored into prices and no more predictability should be consistently observed. As more and more researchers document various abnormalities, a new area of behavioral finance emerges and the debate starts. Decades later, there is still no consensus on if the market is efficient. One of the most long-lasting anomalies is cross section momentum published in the seminal work of Jegadeesh and Titman (1993): rank stocks based on past performance over intermediate horizons, 3 to 12 months, past winner stocks continue to outperform past loser stocks in the next 3 to 12 months. over intermediate horizons. Numerous researchers have since examined the phenomenon from various angles; a discussion of them is in the subsequent Literature Review section.

An even longer and central topic is time series momentum. As early as 1838, Grant documents economist David Ricardo's attention to trend: "cut short your losses… let your profits run." Some later researchers, such as Fama (1965) and Conrad and Kaul (1998), argue that although past returns could predict future returns, it is not economically meaningful. Recently, Moskowitz, Ooi, and Pederse (2012) discover that, across major asset classes such as equity, currency, commodity, and bond, a security's own past returns can predict its future performance. Trading strategies based on this predictability generates significant profits. They dub this phenomenon "time series momentum" and find that it fits well with the three leading behavioral theories proposed by Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Hong and Stein (1999).

Such findings are very important in the context of the debate on market efficiency. Are the findings results of data mining or true confrontations to market efficiency? This is an important question to our understanding of financial markets and constitutes the rational for this study. Moskowitz, Ooi, and Pedersen state that "for the evaluation of time series momentum strategies, we rely on the sample starting in 1985 (p.236)." Thus, to see if data mining is the driving force and how robust the phenomenon is, this paper investigates it using an independent sample from thirteen continental European countries for the period of 1869-1984.

Literature Review

The conventional belief is that market is efficient, yet there has been mounting evidence showing otherwise. One of the most long-standing anomalies in the finance literature is cross section momentum, i.e., a simple strategy of buying past winners and selling past losers over intermediate investment horizon generates one percent per month. Since Jegadeesh and Titman (1993) disseminate their findings, numerous researchers have been examining cross section momentum.

Risk-based explanation has been examined. Fama and French (1996) conclude that their three-factor model can explain all existing anomalies except momentum. Grundy and Martin (2001) argue that the conditional version of the three-factor model enlarges momentum profits. In contrast, Conrad and Kaul (1998) attribute momentum to expected returns. Chordia and Shivakumar (2002) propose that macroeconomic risk fully account for momentum; Griffin, Ji, and Martin (2003) find otherwise and momentum reversal in the long run is consistent with behavioral models. Liu and Zhang (2008) claim that momentum is driven by industrial production. Barroso and Santa-Clara (2015) find that the risk of momentum is predictable, managing the risk almost doubles the Sharpe ratio of the strategy, and such risk management deepens the momentum anomaly. Daniel and Moskowitz (2016) state that a dynamic momentum strategy nearly doubles the alpha and Sharpe ratio of a static momentum strategy, a robust result not explained by other factors.

Out-of-sample evidence for cross section momentum has accumulated. Rowenhorst (1998) finds momentum in European countries and Rowenhorst (1999) further documents the presence of momentum in emerging markets. Chan, Hameed, and Tong (2000) and Griffin, Ji, and Martin (2003) uncover momentum in Americas, Asia, Africa, and Europe. Jegadeesh and Titman (2001) provide support for momentum continuation after their previous 1993 study. Goetzmann and Huang (2018) find the existence and performance of momentum in imperial Russia is consistent with behavioral explanations.

Cross section momentum is recently found to be present in other types of financial markets. Okunev and White (2003) present evidence for its presence in currency markets. Erb and Harvey (2006) uncover momentum in commodity futures. Asness, Moskowitz, and Pedersen (2013) show bond momentum and they further consolidate the evidence on momentum in currency, commodity, bond, and equity markets.

Various data sources are used in the literature. Researchers focusing on the United States mostly rely on the data available at the Center for Research in Security Prices, which start as early as 1926 for monthly data (see Jegadeesh and Titman (1993, 2001), etc.). Studies examining international countries mainly use Datastream International, Pacific-Basin Capital Markets, etc.; such data begin in the 1970s (see Chan, Hameed, and Tong (2000), Griffin, Ji, Martin (2003), etc.). Some researchers investigate momentum using market indexes from different markets (see, e.g., Chan, Hameed, and Tong (2000), Bhojraj and Swaminathan (2006)) and they focus on cross section momentum.

Another closely related area is time series momentum. Hurst, Ooi, and Pedersen (2017) look at 137 years of data and find strong and persistent performance of time series momentum. Goyal and

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Jegadeesh (2018) examines both cross section and time series momentum. They show that the outperformance of time series momentum relies on a time varying market factor. Gao, et al. (2018) discover that US ETFs' first half-hour performance predicts their last half-hour performance. Huang, et al. (2020) perform asset-by-asset regressions and find little evidence for time series momentum. Gupta and Kelly (2019) construct factor portfolios and find significant profits using time series momentum trading. Ham, et al. (2019) discover that time series momentum is stronger in China's futures markets than cross section momentum or mere long strategies.

Method

This study examines a sample constructed from the Global Financial Data Inc. To be consistent with the convention of momentum literature, month-end closing values are used to calculate momentum returns as early as possible for the thirteen countries from 1869 to 1984. The reason to end in 1984 is because Moskowitz, Ooi, and Pedersen (2012) examine time series momentum from 1985 onward and an independent sample is desirable for an independent investigation.

Table 1 shows summary statistics of the data. Reported are start month in the first column, average monthly return in the second column, and volatility measured in standard deviation in the third column. As can be seen, there is much variation in monthly returns: from the smallest of 0.10% in Greece to the largest of 1.88% in Sweden. The majority of countries are above 1%. Volatility demonstrates even more variation. The lowest volatility goes to Austria with 2.40% and the highest, Sweden again, 33.93%. The other country that has double-digit standard deviation is Germany with 12.42%. All the other eleven countries have volatility below 10%.

Table 1
Summary Statistics

Country	Start	Return	Volatility
Austria	196912	0.41	2.40
Belgium	195012	0.80	3.46
Denmark	196912	1.23	4.78
Finland	196112	1.34	3.60
France	189501	1.04	5.93
Germany	186912	1.00	12.42
Greece	197612	0.10	3.23
Italy	192412	1.24	8.13
Netherlands	195012	1.05	4.51
Norway	196912	1.31	7.75
Spain	194004	1.00	4.41
Sweden	191812	1.88	33.93
Switzerland	196602	0.55	4.47

Data is from the Global Financial Data Inc. Returns are from close to close month-end values of market indexes from 1869 to 1984. Reported below are for each country the data start date, average monthly returns in percentage, and volatility (standard deviation).

The benefit of the data is the following: common databases in the literature start much later, e.g., data in the Center for Research in Security Prices begin in the 1920s; Datastream International starts in the 1970s, so does Pacific-Basin Capital Markets. Moreover, the Global Financial Data Inc. constructs data systematically and the consistency is indispensable for a long sample period.

After returns data is in place, time series momentum portfolios are constructed using the method depicted in Figure 1. At the beginning of January 1901 in a particular country, its market's performance is measured over the past six months, from June 1900 to November 1900, by compounding market returns during that period. The one-month gap between the end of the ranking period and the start of the holding period is to avoid microstructure influence, as argued in the momentum literature. If the performance is positive, take a long position in the market. Otherwise, short the market. Such positions last for one month, January 1901, and are liquidated at the end of the month. Momentum profit is measured as the return in January 1901. This procedure is repeated every month. Ranking periods of three, nine, and twelve months are also examined to be thorough and for comparison purpose.

Results

Profitability of time series momentum

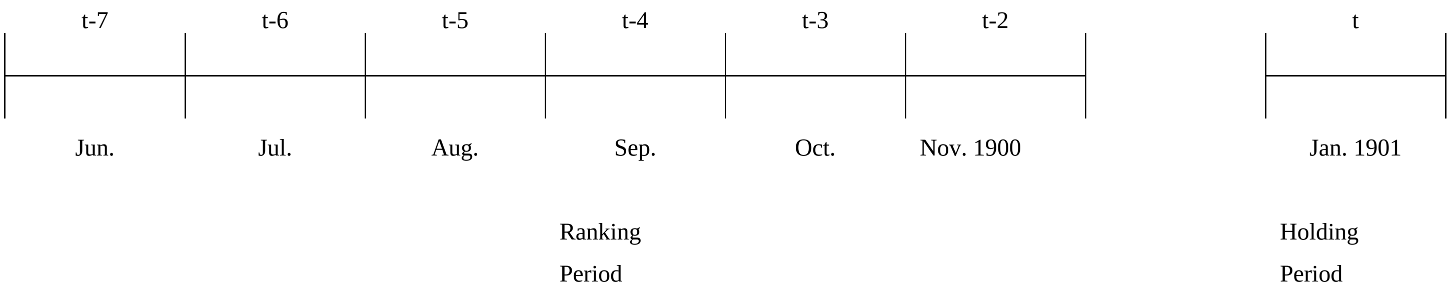
Table 2 contains average monthly returns and associated *t*-statistics from time series momentum strategy. Panels A to D are for three-, six-, nine-, and twelve-month ranking, respectively. It can be seen that, for various formation periods, momentum earns positive returns. For example, for the typical six-month ranking, momentum profit is 0.48% per month with a *t*-statistic of 2.59 in France. Notice that the profit increases from 0.40% for three-month ranking to 0.69% for twelve-month ranking. The existence of time series momentum profitability in this sample period adds to previous research and proves that time series momentum is not specific to the particular sample of Moskowitz, Ooi, and Pedersen (2012).

As the patterns are qualitatively similar for three-, six-, nine-, and twelve-month ranking months, the results hereafter focus on the typical six-month ranking in order to conserve space.

Correlations of time series momentum

Table 3 reports the correlations of time series momentum returns from the typical six-month ranking period. Among all pair-wise

Figure 1: Forming Portfolios for Time Series Momentum Strategies



This figure illustrates the formation of time series momentum portfolios. For the six-month ranking, at the beginning of every month *t*, measure market returns over the previous six months: *t*-7, *t*-6, ... , *t*-2. If the return is positive, buy the market index. Otherwise, sell short. Hold such positions for one month, *t*, and liquidate at the end of the month. Time series momentum return is the return from month *t*. The strategies are also similarly constructed for ranking periods of three, nine, and twelve months.

Table 2: Time Series Momentum Profits

Country	Begin	MOM	t
Panel A: Three-month ranking period			
Austria	197005	0.40	(2.16)
Belgium	195105	0.25	(1.43)
Denmark	197005	1.29	(3.55)
Finland	196205	0.94	(4.16)
France	189506	0.40	(2.17)
Germany	187005	0.80	(2.35)
Greece	197705	-0.43	(-1.34)
Italy	192505	-0.37	(-1.21)
Netherlands	195105	0.37	(1.59)
Norway	197005	0.22	(0.37)
Spain	194009	0.75	(3.90)
Sweden	191905	-0.71	(-0.58)
Switzerland	196607	-0.22	(-0.74)
Panel B: Six-month ranking period			
Austria	197008	0.36	(1.96)
Belgium	195108	0.34	(1.95)
Denmark	197008	1.25	(3.38)
Finland	196208	1.02	(4.51)

France	189509	0.48	(2.59)
Germany	187008	0.52	(1.53)
Greece	197708	-0.13	(-0.39)
Italy	192508	0.37	(1.21)
Netherlands	195108	0.35	(1.53)
Norway	197008	1.22	(2.04)
Spain	194012	0.90	(4.69)
Sweden	191908	-0.59	(-0.48)
Switzerland	196610	-0.05	(-0.15)
Panel C: Nine-month ranking period			
Austria	197011	0.52	(2.81)
Belgium	195111	0.48	(2.71)
Denmark	197011	1.23	(3.29)
Finland	196211	1.06	(4.65)
France	189512	0.44	(2.38)
Germany	187011	0.57	(1.65)
Greece	197711	-0.46	(-1.33)
Italy	192511	0.84	(2.74)
Netherlands	195111	0.41	(1.78)
Norway	197011	1.30	(2.15)
Spain	194103	0.99	(5.17)
Sweden	191911	-0.35	(-0.29)
Switzerland	196701	0.59	(1.92)
Panel D: Twelve-month ranking period			
Austria	197201	1.47	(1.92)
Belgium	195301	1.82	(2.17)
Denmark	197201	2.22	(1.43)
Finland	196401	2.91	(2.28)
France	189701	0.69	(0.92)
Germany	187201	2.49	(3.08)
Greece	197901	-0.05	(-0.03)
Italy	192701	1.85	(1.61)
Netherlands	195301	0.73	(0.63)
Norway	197201	0.47	(0.16)
Spain	194201	2.58	(3.80)
Sweden	192101	2.16	(2.80)
Switzerland	196801	-1.71	(-0.99)

Time series momentum strategy is implemented for the six-month ranking period. At the beginning of each month *t*, compound market returns over the previous six months: *t*-7, … , *t*-2. If the compounded return is positive, buy the market index; otherwise, sell. The position is held for one month, *t*, and liquidated at the end of the month. Time series momentum profit is measured as the return in month *t*. Similar strategies are formed for three-, nine-, and twelve-month ranking periods.

correlations, the lowest is -0.20, between Greece and Finland, and the highest is 0.41, between Switzerland and Netherlands. For each country, the average of the correlations between the country and all the other countries is calculated and shown at the bottom of the Table: it ranges from -0.03 for Spain to 0.19 for Belgium. The mean of such averages across all the countries is 0.07. The positive correlations are consistent with the globalization phenomenon.

To calibrate the importance of such correlations, they are being compared to market correlations over the same time period and the findings are in Panel B. Markets exhibit a wider dispersion in correlations: the pair-wise correlations range from the smallest of -0.22 between Greece and Spain to 0.61 between Switzerland and Netherlands. For each country, the average correlation with all the other countries range from 0.02 for Greece to 0.32 for Sweden. The average correlation across all the countries is 0.19, which more than doubles the momentum correlation of 0.07.

To the extent that market correlations reflect common sources of systematic risk, the much lower correlation among time series momentum suggests that, if anything, time series momentum is not driven by global risk and analyses can focus on local risk instead.

Table 3: Correlations
Panel A: Time Series Momentum Correlations

Country	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Italy	Netherlands	Norway	Spain	Sweden
Austria												
Belgium	0.21											
Denmark	0.13	0.16										
Finland	0.25	0.16	0.09									
France	0.02	0.28	-0.02	0.00								
Germany	0.16	0.19	-0.02	-0.07	0.05							
Greece	-0.06	0.12	0.03	-0.20	-0.02	0.02						
Italy	-0.01	0.13	0.12	0.01	-0.01	0.02	0.04					
Netherlands	0.17	0.32	0.22	0.14	0.29	0.30	0.04	0.20				
Norway	0.14	0.34	-0.09	0.13	0.19	-0.03	-0.01	0.14	0.08			
Spain	0.09	0.10	0.08	0.05	-0.02	0.03	0.01	0.11	-0.05	0.02		
Sweden	0.08	-0.04	0.17	0.06	0.01	0.00	0.03	-0.01	-0.02	0.14	0.01	
Switzerland	0.17	0.32	0.08	0.08	0.28	0.28	0.13	0.09	0.41	0.07	-0.08	0.03
Average	0.11	0.19	0.07	0.02	0.10	0.09	0.04	0.11	0.11	0.08	-0.03	0.03
Avg. of avg.	0.07											

Panel B: Market Correlations

Country	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Italy	Netherlands	Norway	Spain	Sweden
Austria												
Belgium	0.27											
Denmark	0.18	0.26										
Finland	0.26	0.33	0.21									
France	0.20	0.51	0.15	0.26								
Germany	0.26	0.41	0.17	0.20	0.04							
Greece	0.01	0.13	0.01	-0.11	0.08	0.02						
Italy	0.01	0.27	0.27	0.09	0.20	0.14	0.20					
Netherlands	0.28	0.47	0.36	0.21	0.41	0.44	0.07	0.26				
Norway	0.18	0.48	0.23	0.19	0.43	0.18	0.00	0.21	0.37			
Spain	0.15	0.12	0.12	0.24	0.12	0.09	-0.22	0.08	0.13	0.06		
Sweden	0.06	-0.04	0.25	-0.05	0.01	-0.01	-0.03	0.02	-0.02	0.19	0.01	
Switzerland	0.20	0.52	0.22	0.17	0.44	0.54	0.08	0.24	0.61	0.31	0.13	0.32
Average	0.17	0.31	0.20	0.13	0.22	0.20	0.02	0.16	0.28	0.19	0.07	0.32
Avg. of avg.	0.19											

At the beginning of each month *t*, compound market returns over the previous six months: *t*-7, …, *t*-2. If the compounded return is positive, buy the market index; otherwise, sell. The position is held for one month, *t*, and liquidated at the end of the month. Time series momentum profit is measured as the return in month *t*. Reported below in Panel A are the correlations of monthly momentum profits; Panel B is for market correlations over the same time period.

Table 4 displays the seasonality of time series momentum in January and non-January months. As evident from the results, for the typical six-month ranking period, time series momentum earns positive returns in January for all thirteen countries except two: a near zero return of -0.04% for Greece and -1.55% for Switzerland. Notably, among the remaining eleven countries, January returns are higher than those from non-January months, which is true for nine of the eleven countries with the exceptions of Netherlands and Norway. For instance, January return is 1.02% in Austria, much higher than non-January return of 0.31%.

Such interesting findings are different from those of cross section momentum studies, where the predominant result is negative returns in January and positive in non-January months (see Jegadeesh and Titman (1993, 2001), Griffin, Ji, and Martin (2003), etc.). The differences could be related to the fundamental reasons for the January anomaly, e.g., Tinic and West (1984), Starks, Yong, Zheng (2006). There is yet no consensus and remains to be seen.

Table 4: Seasonal Patterns of Time Series Momentum

Country	Begin	MOM	T	Jan	t	Non Jan	t
Austria	197008	0.36	(1.96)	1.02	(1.33)	0.31	(1.60)
Belgium	195108	0.34	(1.95)	0.40	(0.45)	0.34	(1.93)
Denmark	197008	1.25	(3.38)	2.40	(1.70)	1.15	(3.00)
Finland	196208	1.02	(4.51)	2.20	(1.72)	0.92	(4.18)
France	189509	0.48	(2.59)	0.81	(1.08)	0.45	(2.36)
Germany	187008	0.52	(1.53)	1.58	(1.95)	0.43	(1.17)
Greece	197708	-0.13	(-0.39)	-0.04	(-0.03)	-0.14	(-0.40)
Italy	192508	0.37	(1.21)	1.40	(1.22)	0.28	(0.88)
Netherlands	195108	0.35	(1.53)	0.07	(0.06)	0.38	(1.64)
Norway	197008	1.22	(2.04)	0.04	(0.02)	1.32	(2.18)
Spain	194012	0.90	(4.69)	3.00	(4.67)	0.71	(3.57)
Sweden	191908	-0.59	(-0.48)	1.42	(1.77)	-0.77	(-0.58)
Switzerland	196610	-0.05	(-0.15)	-1.55	(-0.95)	0.09	(0.30)

At the beginning of each month *t*, compound market returns over the previous six months: *t*-7, …, *t*-2. If the compounded return is positive, buy the market index; otherwise, sell. The position is held for one month, *t*, and liquidated at the end of the month. Time series momentum profit is measured as the return in month *t*. Reported are the monthly momentum profits in percentage across all months, in January alone, and from February to December. *T*-statistics are in parentheses.

Discussion and Implication

The theoretical and practical implications of the findings are significant. On the theoretical side, it has been widely debated on how efficient the market is. The traditional paradigm and the relatively new area of behavioral finance maintain different views. This paper's finding on the international existence of time series momentum does not support market efficiency.

On the practical side, the profitability of time series momentum portfolios indicates that trading strategies could be deployed to earn reasonable returns. The higher positive returns in January than in non-January months could be further incorporated to make the strategies more profitable. Moreover, as these portfolios exhibit lower correlations than contemporaneous markets do, they are more helpful for portfolio diversification than merely using the overall markets.

Limitations of this research include that, as the data covers a relatively early period when not many variables are available, empirical models cannot be tested in the data. This aspect could be on the agenda for future research.

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