Seasonal effects on stock markets

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Abstract[1]

We revisit factors associated with seasonality of stock markets. We find that interest rates and their seasonal components exhibit a strong relationship with returns and that association is more pronounced in countries, where interest rate seasonality is generally small. Additionally, using difference-in-difference estimation, we add to the growing evidence of increased synchronicity among countries belonging to the European Monetary Union. While we find strong evidence for stock market relationship with economic factors, our sample exhibits little indication that changing risk preferences throughout the year affect seasonality in stock returns.

1. Introduction

Stock market movements have been examined extensively over the past decades. The seasonal phenomena attributed to particularly large returns in the winter months have been credited to tax-loss selling (January effect), weather effects, and seasonally changing risk preferences (seasonal affective disorder or SAD) in the United States and internationally[2]. At the same time, a separate stream of research has thoroughly documented the capital market relationship with real economic activity and interest rates.[3] This activity varies significantly across the year and business cycle and the stock markets reflect that seasonal variation.

This study aims to disentangle the seasonal effect of weather and risk preferences from economic factors influencing returns across countries. Such factors include short-term interest rates, monetary base, industrial production, inflation, and foreign exchange rates. We use a panel of 34 countries between 1973 and 2015 to test the relationship between the stock returns, macroeconomic factors, and other effects. First, we test whether our data yields similar results to those in Kamstra et al (2003, 2012). We follow Kamstra et al. (2012) and use a panel approach to allow for contemporaneous correlation of residuals and increase the power of our tests. We replicate Kamstra et al. (2003) and find a positive and significant relationship between stock returns and the SAD effect, confirming the hypothesis that investors move away from risky investments as SAD increases in the fall and go back to riskier allocations in winter, when SAD occurrence decreases.

Next, in addition to weather and SAD, we test whether stock market returns are associated with macroeconomic variables previously shown to affect asset prices such as interest rates, monetary base, industrial production, consumer price index and foreign exchange rates. We additionally control for high-cash demand around the Holiday season with a December dummy and for business cycle with a recession dummy, since seasonality behaves differently during recessions and expansions. While we confirm the negative stock return relationship with the change in interest rates and monetary base, we do not find a significant effect of SAD when regressed with macroeconomic controls. We further split key macroeconomic variables into their seasonal and seasonally-adjusted components and find a negative and significant relationship between the stock returns and seasonally-adjusted changes in interest rates and

[1] *The author would like to thank Gary Richardson, John Wald, and seminar participants at the University of Texas at San Antonio for helpful comments on earlier versions of this paper.*

[2] *See Agrawal and Tandon (1994), Himschleifer and Shumway (2003), Cooper, McConnell and Ovtchinnikov (2006), McTier et al. (2013) for discussion on weather effects, tax-loss selling and others, on the stock markets.*

[3] *See Clark (1986), Fama and Schwert(1977), Fama (1981), Geske and Roll (1983), Solnik (1983), James et al (1985) for discussion on negative interest rate relationship with equity returns and macroeconomic dynamics.*

the monetary base. Additionally, we find a highly significant and positive relationship between the stock returns and the seasonal component of interest rates.

What is more, we check whether seasonal effects of key variables increase with the degree of seasonal smoothing of interest rates. We find that stock returns in countries that smooth interest rates more are more sensitive to interest rate changes. Finally, we compare the interest rate effect between countries that joined the European Monetary Union (hereafter EMU) and countries that did not, but are located at a similar latitude. We find that countries that joined the Euro zone exhibit higher stock market sensitivity to interest rate changes than the control countries. Given that the European Central Bank pursues a policy of very stable interest rates (Cesares, 2006), this result is consistent with our prior findings that the interest rate effect on the stock market increases as the seasonal variation in interest rates decreases.

The remainder of this paper is organized as follows: Section 2 gives background on SAD and macroeconomic activity literature. Section 3 provides hypothesis. Section 4 discusses data and methods used. Section 5 presents empirical results. Section 6 concludes.

2. Seasonal affective disorder and macroeconomic activity

In a series of articles Kamstra et al (2003, 2011, 2012) model differences in seasonal variation of daylight across countries. They hypothesize that the number of hours of daylight influences human sentiment and risk tolerance, which affect trading patterns and thus stock returns. Seasonal Affective Disorder (hereafter SAD) is clinically defined as a form of major depressive disorder. Kamstra et al (2003) note the SAD-induced seasonal pattern, where depressed investors get away from risky allocations in the fall and go back to more risky alternatives in the winter, when days become longer and SAD occurrence declines. This behavior leads to lower returns in the fall and higher returns in the winter across all, but one of the nine countries they considered. The authors conclude that SAD contributes to seasonality of stock returns and the effect is more pronounced the higher the latitude of the countries considered.

Interestingly, the seasonal pattern of money demand and interest rates is quite similar to that of the SAD incidence. Short-term interest rates are very seasonal due to production factors and an increased demand for money in the second half of the year (Chatterjee, 1993). Harvest at the end of the summer, increased manufacturing activity picking up midyear and peaking around September and the holiday shopping season in the last quarter of the year all contribute to the gradual increase in interest rates up until January-February when SAD also peaks. The seasonal variation is most pronounced at short maturities such as Treasury bills and money market instruments (Diller, 1970).

In the United States the Federal Reserve Bank has adjusted the supply of money in order to reduce seasonality in interest rates since its inception in 1914. After the suspension of the World War II interest rate peg, the Federal Reserve temporarily ceased its smoothing efforts between 1950s and 1960s. During that time, seasonal swings as large as 20% of the mean level of interest rates could be observed (Diller 1970). This pattern became less pronounced after the Federal Reserve resumed interest-rate-smoothing by adjusting the supply of bank reserves, money and credit via open market operations and today we observe seasonal swings not larger than 1%. Central banks internationally use different policy tools to smooth short-term interest rates or do not smooth at all. For example, since its inception the European Central Bank has pursued a cautious policy of very stable interest rates much less volatile than the U.S. interest rates (Cesares, 2006.) The resulting variation in seasonal prices may propel flow of funds between countries and further balance interest rate seasonal and foreign exchange rates (Truman, 1986.)

3 Hypotheses

The relationship between short-term interest rates and stock market returns is well-documented[4]. Fama (1981) and Geske and Roll (1983) discuss linkages between stock returns, interest rates, monetary policy, and real activity. They argue that stock returns respond to changes in money supply, which respond to changes in real activity. An increase in expected real activity leads to an increase in money balances, and thus an increase in stock market returns. Additionally, Geske and Roll (1983) hypothesize

[4] See Body (1976), Jaffe and Mandelker (1976) and Fama and Schwert (1977) discussing the negative relationship of interest rates in the post-1953 period.

that the increases in money supply growth caused by real activity, leads to a drop in interest rates, and this causes the negative relationship between interest rates and stock market returns. Numerous studies confirmed these results, including James at al. (1985) for the U.S. and Solnik (1983) internationally. Therefore, the documented effects of the SAD disorder on stock markets in prior papers may be simply picking up seasonal economic activity.

Hypothesis 1: Real economic activity is seasonal and thus short-term credit and stock markets will exhibit seasonal variation unrelated to SAD.

Along with testing SAD and weather variables as in Kamstra et al (2003) we test the relationship between macroeconomic variables as in Fama (1981) and Geske and Roll (1983). We expect positive relationship between increases in industrial production and negative relationship between changes in monetary base and interest rates and weaker relationship between SAD and stock market returns.

What is more, when examining the pattern of US interest rate seasonality, September-October is when the seasonal component steadily grows and peaks in December-January. In addition to controlling for real activity, we control for spending around the Holiday season, which tends to be particularly high in December. Since seasonality behaves differently during expansions and recessions (Jaditz, 1994) we further control for recessions in our tests.

In the United States the Federal Reserve smooths short-term interest rates by controlling growth in monetary base. While some central banks around the world engage in similar smoothing operations, others do not. In today's global economy, the resulting variations in seasonal interest rate smoothing drive flows of short-term funds between nations. Therefore, exchange rates might absorb some of the seasonal variation in interest rates and money supply through flow of funds across countries, and we control for the relationship between the stock markets and interest rates.

Additionally, Barro and Rush (1980) conjecture that only unanticipated changes have real effects. In countries that smooth interest rates more, seasonal interest rate variation will be less anticipated, and thus might result in stronger stock market reaction.

Hypothesis II: Seasonal component effect will be more pronounced in countries that smooth more.

Countries in the European Monetary Union share currency and are subject to the same monetary policy shocks. Peersman (2004) and Lehwald (2013) provide evidence for increased business cycle and output synchronization between countries in the EMU. Additionally, the Euro Area economy might be more sensitive to interest rate changes than other countries, such as the United States, since many Euro Area countries have large amount of short-term debt, higher exports as percent of GDP and higher percentage of adjustable rate mortgages (Cesares, 2006.) We would therefore expect stock markets in the EMU countries to be more sensitive to interest rate changes due to the macroeconomic environment rather than changing risk preferences and weather effects. If we control for weather and length-of-day by comparing countries at the same latitude, the only change variable between them is monetary policy. We would not expect much difference in SAD effect before and after countries joined the Euro Area, but we would expect a difference in how interest rates affect stock markets. Creation of the Euro Area in 1999 is an opportunity to compare influence of monetary policy actions before and after the event.

Hypothesis III: Countries that joined European Monetary Union will have more pronounced effect of seasonal interest rate variation than countries located at a similar latitude, but outside of the EMU unrelated to SAD.

4 Data and methods

A. Data

Our sample encompasses 34 countries from 1973 to 2015. We obtain daily price returns data for the main stock indices in each of the countries considered from Thomson Reuters Datastream. Temperature, precipitation and cloudiness data are from the National Oceanic and Atmospheric Administration (NOAA, formerly the National Climatic Data Center) weather service. We use TEMP, PRCP and SKC variables from the NOAA, respectively. Temperature is measured in Celsius degrees, precipitation is in millimeters and cloudiness in percentage of sky cover. We gather hourly data from weather stations within a quarter degree latitude from the country's main stock exchange. Stations include airports, central parks and weather observatories. Following Hirshleifer and Shumway (2003) and Kelly and Meschke (2010) we average hourly weather data between 6 am and 4 pm. Since production varies with agricultural output, we gather annual agricultural value-added data from the World Bank. Agricultural value added is defined as value added in local currency as percentage of a country's GDP.

We obtain macroeconomic data from the International Monetary Fund. Short-term interest rates, monetary base, industrial production, consumer price index and foreign exchange rates are calculated as monthly percentage changes. Since interest rates exhibit seasonality predominantly at short maturities, such as 30-day T-bill and money market rates (Diller, 1970), we use money market rate, wherever T-bill rates are not available. Foreign exchange rate is defined as foreign currency per 1 U.S. dollar.

Seasonality acts differently in expansions and recessions (Jaditz, 1994); therefore we add a recession dummy to our regressions. We use OECD-based monthly recession indicator that equals 1 from the Peak through the Trough and 0 otherwise. We obtain the recession dummy from the Federal Reserve Economic Data (FRED). We supplement the FRED variable with a calculated dummy based on monthly percentage changes in seasonally adjusted Gross Domestic Product. The GDP is from the International Monetary Fund. We follow Kamstra et al. (2003) and calculate SAD variable as

$$SAD_{i,t} = \begin{cases} N_{i,t} - 12, & in\ the\ fall\ or\ winter \\ 0 & otherwise \end{cases} \quad (1)$$

where $N_{i,t}$ represents number of night hours, which are calculated as

$$N_{i,t} = \begin{cases} 24 - 7.72 * arcos\left[-tan\left(\frac{2\pi * latitude}{360}\right)\tan(\lambda_t)\right] & in\ Northern\ hemisphere \\ 7.72 * arcos\left[-tan\left(\frac{2\pi * latitude}{360}\right)\tan(\lambda_t)\right] & in\ Southern\ hemisphere \end{cases} \quad (2)$$

where arcos and tan are arc cosine and tangent functions, respectively. Gamma λ_t is calculated as

$$\lambda_t = 0.4102 * sin\left[\left(\frac{2\pi}{365}\right)(julian_t - 80.25)\right] \quad (3)$$

$Julian_t$ represents the number of consecutive days in the year, ranging from 1 to 365 (366 in leap year). $Julian_t$ equals 1 on January 1st, 32 on February 1st, and so on.

We also include dummies as in Kamstra et al. (2003). Monday dummy that equals 1 when the trading day follows a weekend, and 0 otherwise, and Fall dummy that equals 1 in the fall and 0 otherwise[5]. Tax dummy equals 1 for a given country on the last trading day and the first 5 trading days of the tax year[6].

B. Methods

In order to examine the effect of seasonality of economic variables we split interest rates, monetary base, industrial production, consumer price index and foreign exchange into seasonal and seasonally adjusted components. We use X11/X13 seasonal adjustment methods developed by Fredrick R. Macaulay of the U.S. National Bureau of Economic Analysis and adapted to R software by Christoph Sax. The X11/X13 seasonal package uses iterative ratio-to-moving-average approach to estimate time series components by approximating trend, seasonal, irregular and seasonally adjusted components. We calculate seasonality by subtracting seasonally adjusted variable from the non-seasonally-adjusted one.

We first replicate Kamstra et al. (2003) model using panel data in order to ensure replicability of the original results on data spanning extended number of years and countries. We regress returns on SAD, temperature, precipitation, cloudiness, fall dummy, Monday dummy, tax dummy and two lags of returns (to control for residual autocorrelation).

$$r_{it} = \alpha + \beta_1 SAD_{it} + \beta_2 Temp_{it} + \beta_3 Prcp_{it} + \beta_4 CLD_{it} + \beta_5 D\_Fall_{it} + \beta_6 D\_Monday_{it} + \beta_7 D\_Tax_{it} + \beta_8 r_{it-1} + \beta_{9i} r_{it-2} + \varepsilon_{it} \quad (4)$$

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[5] *In Northern Hemisphere fall and winter are defined from September 21st to December 20th and December 21st to March 20th, respectively. In Southern Hemisphere fall and winter are defined from March 21st to June 20th and June 21st to September 20th, respectively.*

[6] *Fiscal year begins on March 1st in South Africa, April 1st in India, New Zealand, Sri Lanka, Hong Kong and Japan, April 6th in Ireland and United Kingdom, and January 1st in other countries in the sample.*

We build on the Kamstra et al. (2003) model and add additional controls and macroeconomic variables to it. We regress returns on short-term interest rates, monetary base, industrial production, consumer price index, foreign exchange, agricultural value added, recession dummy, December dummy, SAD, fall dummy, Monday dummy, tax dummy, and two returns lags.

$$r_{it} = \alpha + \beta_1 INT_{it} + \beta_2 MB_{it} + \beta_3 IP_{it} + \beta_4 CPI_{it} + \beta_5 FX_{it} + \beta_6 AGR_{it} + \beta_7 SAD_{it} + \beta_8 Temp_{it} + \beta_9 Prcp_{it} + \beta_{10} CLD_{it} + \beta_{11} D\_December_{it} + \beta_{12} D\_Recession_{it} + \beta_{13} D\_Fall_{it} + \beta_{14} D\_Monday_{it} + + \beta_{15} D\_Tax + \beta_{16} r_{it-1} + \beta_{17i} r_{it-2} + \varepsilon_{it} \quad (5)$$

Next, we test the effect of seasonality of macroeconomic components on the stock market by regressing returns on seasonal components of interest rates, monetary base, industrial production, consumer price index and foreign exchange, and their respective seasonally adjusted components, in additional to the previously used controls agricultural value added, recession dummy, December dummy, SAD, fall dummy, Monday dummy, tax dummy, and two returns lags.

$$r_{it} = \alpha + \beta sINT_{it} + \beta s\_adjINT_{it} + \beta sMB_{it} + \beta s\_adjMB_{it} + \beta sIP_{it} + \beta s\_adjIP_{it} + \beta sCPI_{it} + + \beta s\_adjCPI_{it} + \beta FX_{it} + \beta AGR_{it} + \beta SAD_{it} + \beta Temp_{it} + \beta Prcp_{it} + \beta CLD_{it} + \beta D\_December_{it} + \beta D\_Recession_{it} + \beta D\_Fall_{it} + \beta D\_Monday_{it} + \beta D\_Tax_{it} + \beta r_{it-1} + \beta_i r_{it-2} + \varepsilon_{it} \quad (6)$$

Since interest rates are highly seasonal and central banks smooth those interest rates to a varying degree, we test whether the seasonal effect of key variables differs with the degree of interest rate smoothing. We calculate 12-month autocorrelation of interest rate seasonal component by country and interact it with seasonal components of interest rates, monetary base, industrial production, consumer price index, foreign exchange along with their respective seasonally-adjusted components and SAD as follows:

$$r_{Seasonal}\ \beta sINT_{it} + \beta sINT_{it}\, seasonal\_int\_autocorrelation_i + \beta s\_adjINT_{it} + + \beta s\_adjINT_{it} seasonal\_int\_autocorrelation_i + \beta sMB_{it} seasonal\_int\_autocorrelation_i + + \beta sMB_{it} + \beta s\_adjMB_{it} * seasonal\_int\_autocorrelation_i + \beta s\_adjMB_{it} + \beta sIP_{it} * seasonal\_int\_autocorrelation_i + \beta sIP_{it} + \beta s\_adjIP_{it} * seasonal\_int\_autocorrelation_i + \beta s\_adjIP_{it} + \beta sCPI_{it} * seasonal\_int\_autocorrelation_i + \beta sCPI_{it} + \beta s\_adjCPI_{it} * seasonal\_int\_autocorrelation_i + \beta s\_adjCPI_{it} + \beta FX_{it} * seasonal\_int\_autocorrelation_i + + \beta FX_{it} + \beta AGR_{it} + \beta SAD_{it} * seasonal\_int\_autocorrelation_i + \beta SAD_{it} + \beta Temp_{it} + \beta Prcp_{it} + + \beta CLD_{it} + \beta D\_December_{it} + \beta D\_Recession_{it} + \beta D\_Fall_{it} + \beta D\_Monday_{it} + \beta D\_Tax_{it} + \beta r_{it-1} + \beta_i r_{t-2} + \varepsilon_{it} \quad (7)$$

Finally, we use a difference-in-difference tests to check whether the interest-rate effect is different between countries that joined the European Monetary Union and those that did not. We expand equation (6) and add a triple interaction of interest rate, dummy that equals 1 for countries that joined the Euro Area, 0 otherwise (EA_treated), and dummy that equals 1 beginning the year a country joined the Euro Area, and 0 before they joined or if they did not join the EA at all (EA). The full equation is as follows:

$$r_{it} = \alpha + \beta * INT_{it} * EA\_time_t * EA\_treated_i + \beta EA\_time_t * INT_{it} + \beta EA\_treated_i * INT_{it} + + \beta EA\_time_t * EA\_treated_i + \beta MB_{it} + \beta IP_{it} + \beta CPI_{it} + CSt_{it} + \beta FX_{it} + \beta AGR_{it} + \beta SAD_{it} + \beta Temp_{it} + \beta Prcp_{it} + \beta CLD_{it} + \beta D\_Recession_{it} + \beta D\_Fall_{it} + \beta D\_Monday_{it} + \beta D\_Tax_{it} + + \beta r_{it-1} + \beta_i r_{it-2} + \varepsilon_{it} \quad (8)$$

Equation decomposed into seasonal and seasonally adjusted components:

$$r_{it} = \alpha + \beta * sINT_{it} * EA\_time_t * EA\_treated_i + \beta EA\_time_t * sINT_{it} + \beta EA\_treated_i * sINT_{it} + + \beta * s\_adjINT_{it} * EA\_time_t * EA\_treated_i + \beta EA\_time_t * s\_adjINT_{it} + + \beta EA\_treated_i * s\_adjINT_{it} + \beta EA\_time_i * EA\_treated_i + \beta s\_adjINT_{it} + \beta sMB_{it} + + \beta s\_adjMB_{it} + \beta sIP_{it} + \beta s\_adjIP_{it} + \beta sCPI_{it} + \beta s\_adjCPI_{it} + sCSt_{it} + s\_adjCS_{it} + \beta FX_{it} + + \beta AGR_{it} + \beta SAD_{it} + \beta Temp_{it} + \beta Prcp_{it} + \beta CLD_{it} + \beta D\_Recession_{it} + \beta D\_Fall_{it} + + \beta D\_Monday_{it} + \beta D\_Tax_{it} + \beta r_{it-1} + \beta_i r_{it-2} + \varepsilon_{it} \quad (9)$$

Based on prior literature we expect to find negative coefficients on interest rates, monetary base, foreign exchange rate, cloud, precipitation, recession, Monday and fall dummies. We expect to find positive coefficients on industrial production, agricultural value added, consumer price index, SAD, temperature and December and tax dummies. Since the European Monetary Union markets tend to be more sensitive to interest rate changes, we expect a positive coefficient on the difference-in-difference estimation.

5. Results

Table I presents summary statistics of main variables in question. The average daily return equals 0.026% with a standard deviation of 1.235%. On average, the monthly percentage change in interest rates is quite small, less than 1 basis point, but when seasonally adjusted, interest rates are downward sloping at -0.008%. The big difference between seasonally adjusted and unadjusted interested rates is confirmed by the 12-month autocorrelation of seasonal component of interest rates. At average correlation coefficient of 0.83 we can say that interest rates across countries are quite seasonal.

Table II presents correlation coefficients between key variables. Stock returns are highly correlated with interest rates, particularly the seasonal component of interest rates, consumer price index, agricultural value added and December, Monday and tax dummies. SAD, on the other hand, is fairly highly correlated with agricultural value added, industrial production, temperature, and fall, December and tax dummies. Interestingly, SAD is quite highly correlated with agricultural value added at -0.16. However, the average agricultural value added as percentage of GDP is only 3% per year, which casts doubt on the agricultural influence on real output and its effect on the economy and the stock market.

While SAD correlations with stock returns and interest rates are rather modest, at 0.0052 and -0.0045, respectively, monthly figures of mean SAD, stock market returns, and interest rates averages and variations give a more in-depth view of seasonal patterns throughout the year. Figure 1 presents mean SAD changes throughout the year. We can see that SAD occurrence peaks around December-January each year, bottoms out in April and starts increasing in September. Figure 2 presents a comparable pattern in average stock market returns throughout the year, which is consistent with Kamstra et al. (2003).

Table I. Summary Statistics

Variable	Mean	St Dev.	Min	Max
R	0.026%	1.235%	-7.593%	7.955%
INT	0.000%	6.359%	-155.470%	381.470%
sINT	0.008%	1.340%	-61.367%	52.730%
s_adjINT	-0.008%	6.042%	-153.384%	365.716%
Seas.Autocorr.	0.8275	0.1666	0.1094	0.9730
MB	1.998%	10.231%	-63.470%	274.009%
sMB	-0.004%	6.281%	-96.809%	65.901%
s_adjMB	2.001%	7.868%	-55.744%	208.108%
IP	0.553%	9.373%	-63.786%	150.227%
sIP	-0.030%	8.746%	-56.438%	115.726%
s_adjIP	0.583%	3.551%	-27.343%	34.502%
CPI	0.293%	0.939%	-32.156%	38.380%
sCPI	0.002%	0.335%	-2.841%	2.631%
s_adjCPI	0.291%	0.867%	-31.875%	39.214%
FX	0.081%	2.872%	-23.574%	115.212%
sFX	0.002%	0.862%	-5.291%	6.383%
s_adjFX	0.078%	2.711%	-18.415%	111.741%
Agr. v.a.	2.990%	3.403%	0.035%	29.390%
SAD	1.106	1.538	-2.123	6.519
Dummy Fall	0.248	0.432	0.000	1.000
Dummy December	0.087	0.282	0.000	1.000
Recession	0.405	0.491	0.000	1.000

Dummy Monday	0.199	0.399	0.000	1.000
Dummy Tax	0.019	0.137	0.000	1.000
TEMP	11.202	10.561	-29.306	37.407
PRCP	2.893	7.290	0.000	399.000
CLD	2.135	9.742	0.000	66.400
Observations	203,973			

Table II. Correlations

		1	2	3	4	5	6	7	8	9	10	11	12
	R	**1.0000**											
	SAD	**0.0052**	**1.0000**										
	Agr_va	**0.0107**	**-0.1595**	**1.0000**									
	CPI	**0.0104**	**-0.0695**	**0.2536**	**1.0000**								
	FX	**0.0037**	**-0.0088**	**0.0664**	**0.2114**	**1.0000**							
	INT	**0.0095**	**-0.0045**	**0.0072**	**0.5326**	**0.1853**	**1.0000**						
	MB	**0.0047**	**-0.0171**	**0.1982**	**0.0140**	**0.0639**	**0.0732**	**1.0000**					
	IP	**-0.0028**	**-0.0968**	**0.0060**	**0.0110**	**0.0081**	**-0.0027**	**0.0120**	**1.0000**				
	s.CPI	0.0015	**-0.0578**	0.0010	**0.4284**	0.0011	**0.0031**	**-0.0055**	**0.0172**	**1.0000**			
0	s.adj CPI	**0.0108**	**-0.0509**	**0.2792**	**0.9130**	**0.2341**	**0.5886**	**0.0179**	**0.0045**	**0.0225**	**1.0000**		
1	s.FX	**-0.0024**	**0.0239**	-0.0002	**-0.0105**	**0.2853**	**0.0139**	**0.0048**	**0.0388**	**-0.0224**	-0.0014	**1.0000**	
2	s.adj FX	**0.0046**	**-0.0154**	**0.0688**	**0.2231**	**0.9580**	**0.1909**	**0.0652**	**-0.0048**	**0.0076**	**0.2441**	-0.0017	**1.0000**
3	s.MB	0.0019	**0.0270**	-0.0005	**-0.0227**	**0.0032**	**0.0320**	**0.4015**	**0.0204**	**-0.0356**	**-0.0089**	**0.0148**	-0.0010
4	s.adj MB	**0.0044**	**-0.0308**	**0.2152**	**0.0240**	**0.0674**	**0.0719**	**0.9210**	**0.0028**	**0.0079**	**0.0229**	-0.0007	**0.0705**
5	s.IP	**-0.0045**	**-0.1072**	0.0021	**0.0102**	**0.0062**	-0.0009	**0.0228**	**0.8940**	**0.0209**	0.0021	**0.0434**	**-0.0083**
6	s.adj IP	**0.0027**	-0.0012	**0.0079**	**0.0037**	**0.0038**	**-0.0054**	**-0.0191**	**0.4414**	**-0.0037**	**0.0057**	-0.0002	**0.0040**
7	s.INT	**0.0131**	**-0.0046**	**0.0073**	**0.2048**	**0.1680**	**0.9645**	**0.0827**	-0.0010	**-0.0221**	**0.2363**	**0.0472**	**0.1623**
8	s.adj INT	**0.0083**	**-0.0044**	**0.0070**	**0.5240**	**0.1750**	**0.9974**	**0.0695**	**-0.0027**	**0.0040**	**0.5785**	**0.0099**	**0.1812**
9	Dummy Fall	**-0.0035**	**0.3211**	**0.0025**	**-0.0237**	**-0.0122**	-0.0004	**0.0265**	**0.0267**	**-0.0489**	**-0.0040**	**-0.0632**	**0.0059**
0	Dummy December	**0.0111**	**0.4140**	0.0008	**-0.0423**	**-0.0115**	**-0.0025**	**0.0679**	**-0.0991**	**-0.0937**	**-0.0045**	**-0.0195**	**-0.0063**
1	Dummy Monday	**-0.0174**	-0.0001	0.0000	0.0004	0.0002	-0.0002	0.0006	-0.0014	0.0005	0.0002	-0.0009	0.0005

2	Dummy Tax	**0.0119**	**0.1313**	**-0.0001**	**-0.0029**	**-0.0001**	**-0.0012**	**0.0104**	**-0.0373**	**-0.0060**	**-0.0006**	**-0.0039**	**0.0011**
3	TEMP	**-0.0027**	**-0.4798**	**0.3768**	**0.0198**	**0.0133**	**0.0554**	**0.1429**	**0.0200**	**-0.0670**	**0.0498**	**-0.0361**	**0.0254**
4	PRCP	**-0.0058**	**-0.0409**	**0.0241**	**-0.0153**	-0.0013	**-0.0161**	**0.0076**	**-0.0037**	**0.0058**	**-0.0197**	**0.0006**	**-0.0016**
5	CLD	-0.0002	**0.0264**	**-0.0790**	0.0021	**-0.0163**	**0.0165**	**-0.0528**	**-0.0129**	**-0.0022**	**0.0032**	**0.0005**	**-0.0173**

Correlation coefficients reported in bold are significant at the 5% level.

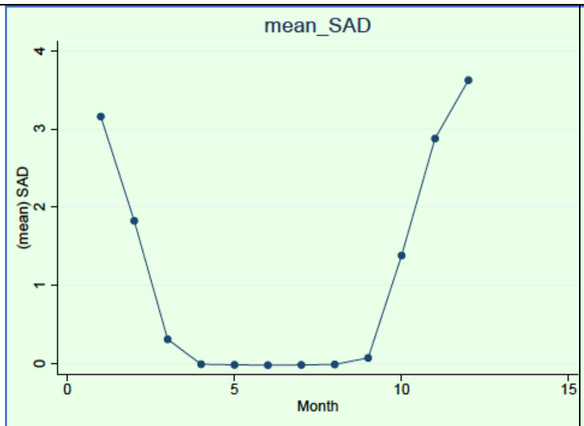

Figure 1. Mean SAD from January to December

Figure 2. Mean stock returns from January to December

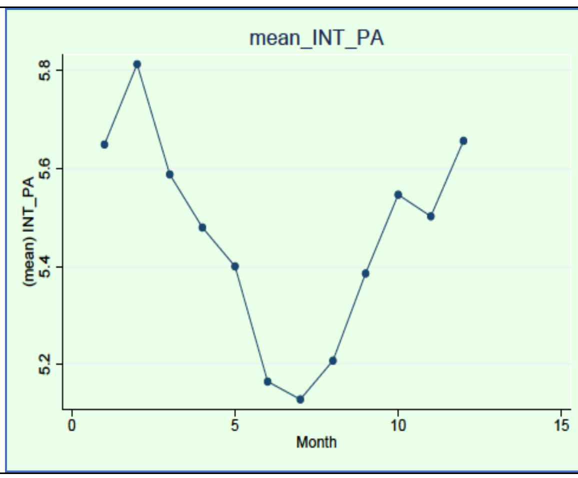

Figure 3. Mean interest rates from January to December

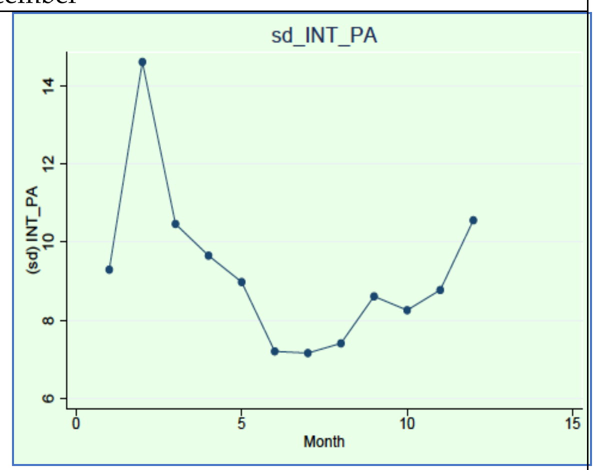

Figure 4. Variation in interest rates from January to December

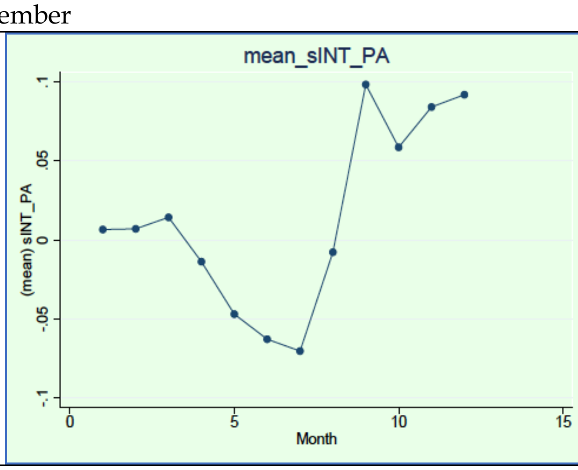

Figure 5. Mean interest rate seasonality from January to December

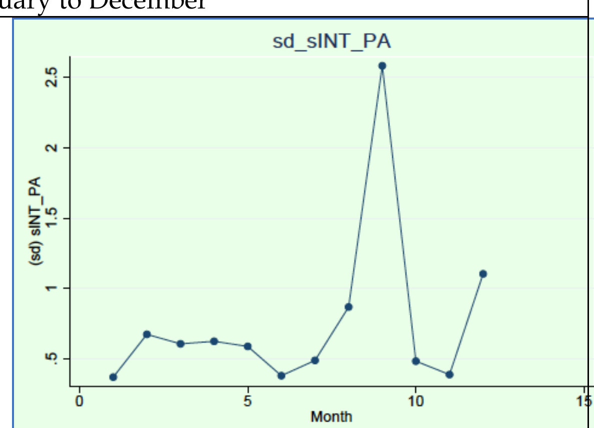

Figure 6. Variation in interest rate seasonality from January to December

Furthermore, Table III presents summary of interest rates, their seasonal component, length of night and latitude by country. According to Kamstra et al. (2003, 2012) SAD and its effect increases with latitude and thus leads to stock market seasonality. If number of daylight hours has effect on stock market, we should also expect a higher seasonal variation in interest rates at higher latitudes. However, Table III does not show a consistent pattern of increase or decrease in interest rates by country and latitude. The seasonal variation in interest rates equals 0.19% in Finland at 60.2°N, but only 0.03% in Sweden at 59.3N°. Similarly, seasonal variation in interest rates is at 0.31% in Canada at 43.6°N, but at 5.42% in Romania at 44.4°N. Figures 3-6 show a more consistent pattern of monthly changes due to changes in seasons of production, rather than changes due to varying sun exposure.

Table III. Summary by Country

Country	Sample Size	Latitude	Night Hours Min	Max	Interest seasonality Mean	St. Dev	Seasonal Autocorr.
Finland*	6,181	60.17N	5.2	18.5	0.00%	0.19%	0.92
Norway	3,396	59.91N	5.3	18.4	0.00%	0.13%	0.86
Estonia*	3,005	59.44N	5.5	18.3	0.00%	0.08%	0.84
Sweden	4,678	59.32N	5.5	18.2	0.00%	0.03%	0.97
Latvia*	1,207	56.95N	6.2	17.5	-0.04%	0.41%	0.57
Russia	4,743	55.76N	6.5	17.2	0.01%	6.36%	0.11
Poland	4,556	53.23N	7.1	16.7	0.04%	0.59%	0.46
Netherlands*	17,734	52.37N	7.2	16.5	0.00%	0.27%	0.69
United Kingdom	20,255	51.50N	7.4	16.3	0.00%	0.09%	0.91
Belgium*	3,511	50.85N	7.5	16.2	0.00%	0.05%	0.98
Czech Republic	5,627	50.08N	7.7	16.1	0.00%	0.09%	0.84
Germany*	9,914	50N	7.7	16.1	0.00%	0.05%	0.90
Luxembourg	3,647	49.82N	7.7	16.0	0.00%	0.04%	0.81
France*	21,928	48.86N	7.9	15.9	0.00%	0.12%	0.96
Austria*	5,491	48.20N	8.0	15.8	0.00%	0.15%	0.88
Slovakia*	5,371	48.15N	8.0	15.8	-0.02%	0.44%	0.62
Hungary	1,996	47.5N	8.1	15.7	0.02%	0.12%	0.92
Slovenia	2,274	46.06N	8.3	15.5	0.00%	0.05%	0.81
Croatia	4,920	45.82N	8.3	15.5	0.00%	0.44%	0.55
Romania	4,743	44.43N	8.5	15.3	0.02%	1.68%	0.76
Canada	2,034	43.64N	10.0	15.2	-0.02%	0.04%	0.89
Bulgaria	3,447	42.73N	8.7	15.1	0.01%	0.16%	0.95
Turkey	1,013	41.01N	8.9	14.9	0.80%	3.90%	0.57
United States	17,648	40.42N	8.9	14.8	0.01%	0.03%	0.84
Portugal*	4,405	38.72N	9.1	14.6	0.00%	0.09%	0.97
Japan	21,195	36N	9.4	14.4	0.00%	0.03%	0.96
Malta	2,033	35.9N	9.4	14.3	0.00%	0.04%	0.81
Cyprus	521	35.19N	9.5	14.3	0.00%	0.07%	0.81
Chile	1,558	33.45S	9.9	14.4	0.00%	0.04%	0.89
Mexico	6,168	19.43N	10.7	13.1	-0.03%	1.05%	0.80
India	2,525	19.08N	10.7	13.0	0.10%	1.71%	0.82
Indonesia	554	6.13S	11.8	12.5	0.04%	0.50%	0.67
Colombia	2,161	4.71N	11.6	12.2	0.00%	0.04%	0.78
Singapore	3,534	1.35N	11.8	12.0	0.00%	0.12%	0.91
EMU					0.00%	0.04%	0.81
Total	203,973		5.2	18.5	0.01%	1.34%	0.80

Table IV presents OLS panel regressions with daily returns on countries' main indexes as dependent variable. Column 1 presents a replication of Kamstra et al. (2003) model, where we regress daily returns against two lagged returns, SAD, Monday, tax and fall dummies, temperature in Celsius degrees, precipitation in milliliters per day, and percent cloudiness. Column 2 presents results of extended analysis, where in addition to regressing daily returns on lagged returns, SAD, Monday, tax and fall dummies, and weather controls, we include interest rates, monetary base, industrial production, consumer price index, foreign exchange and December and recession dummies as independent variables. Column 3 provides an analysis based on macroeconomic variables split into their seasonal and seasonally-adjusted components.

Results in Column 1 are comparable to those in Kamstra et al. (2003, 2012). We observe a positive and statistically significant SAD coefficient, which is consistent with a notion that risk-averse investors move away from risky investments in the fall, leading to lower than average returns before winter equinox. Subsequently, when SAD occurrence is on a downward path, the investors return to more risky allocations, which leads to higher than average returns in winter. Other results are as expected as well, we observe negative returns on first weekday and on a rainy day, while returns around end of fiscal year are higher. Column 2 contains macroeconomic independent variables and additional controls and paints a different picture. While we see very similar results for all controls used by Kamstra et al., we do not observe a statistically significant relationship between SAD and stock returns. Interestingly, changes in interest rates, monetary base and foreign exchange rates are negatively related to returns and highly significant. While industrial production does not seem to have a direct relationship with the stock market, the negative relationship between the market and interest rates and monetary base is consistent with Fama (1981) and Geske and Roll (1983). While 1% increase in short-term interest rates is associated with a 0.37% decrease in stock returns, a 1% increase in monetary base is associated with a 0.06% decrease in returns internationally.

Table IV. Stock Market Sensitivity

	(1)	(2)	(3)
INT		-0.372*	
		(0.062)	
sINT			5.342***
			(0.000)
s_adjINT			-0.803***
			(0.001)
MB		-0.060*	
		(0.082)	
sMB			-0.021
			(0.681)
s_adjMB			-0.084*
			(0.092)
IP		-0.011	
		(0.727)	
sIP			-0.027
			(0.404)
s_adjIP			0.090
			(0.301)
CPI		0.965	
		(0.104)	
sCPI			2.447*
			(0.056)
s_adjCPI			0.715
			(0.241)
FX		-0.832**	
		(0.029)	
sFX			-0.345
			(0.565)
s_adjFX			-0.872**
			(0.015)
Dummy December		4.154***	4.189***
		(0.001)	(0.000)
Recession		-6.098***	-6.028***
		(0.000)	(0.000)
Agr.v.a.		0.302*	0.320*
		(0.087)	(0.098)
SAD	0.728**	0.165	0.151
	(0.017)	(0.756)	(0.778)
Dummy Monday	-5.271***	-4.517***	-4.517***

	(0.000)	(0.000)	(0.000)
Dummy Tax	7.110***	5.095*	5.140**
	(0.000)	(0.051)	(0.047)

Table IV. Continued

	(1)	(2)	(3)
TEMP	0.004	-0.114**	-0.108**
	(0.906)	(0.028)	(0.030)
PRCP	-0.008***	-0.004	-0.004
	(0.005)	(0.218)	(0.199)
CLD	0.006	-0.034*	-0.031*
	(0.688)	(0.088)	(0.095)
Dummy Fall	-1.604***	-2.520**	-2.274**
	(0.006)	(0.026)	(0.042)
L.R	0.085***	0.059***	0.059***
	(0.000)	(0.000)	(0.000)
L2.R	0.002	-0.000	-0.000
	(0.614)	(0.969)	(0.951)
Cons.	0.037***	0.063***	0.061***
	(0.000)	(0.000)	(0.000)
N	448282	203973	203973
adj. R-sq	0.008	0.005	0.005

p-values in parentheses, * p<0.10 ** p<0.05. Coefficients multiplied by 100 for brevity.
*as in Kamstra et al. (2003)

What is more, a 1% increase in value of local currency against the U.S. Dollar is associated with 0.83% decrease in stock market performance, which confirms Truman's (1986) theory of variation in prices contributing to international flow of funds. Annual agricultural value added as percent of GDP is positively and significantly related to stock market returns, which is expected, as agricultural production contributes to changes in real economic activity. December dummy is positive and highly significant, confirming that returns are higher during the high cash demand time during December Holiday spending. As expected, stock returns are lower in recessionary periods.

The third regression in Table IV presents additional detail, where macroeconomic variables from Column 2 are further split into seasonal and seasonally adjusted components. While 1% change in seasonally-adjusted interest rates is associated with a 0.8% decrease in stock market returns, 1% change in seasonal component of interest rates has a much stronger effect on returns and is associated with a 5.3% increase in stock market returns. At the same time, we continue to observe an insignificant SAD coefficient, which confirms the hypothesis that seasonal short-term credit markets and stock markets exhibit seasonality unrelated to SAD. We repeat Kamstra et al. (2003) robustness check and exclude days with 0 returns in all three models and find virtually the same results.

Moreover, Barro and Rush (1980) conjecture that only unanticipated changes in economy have real effects. In countries where interest rate seasonality is low, seasonal changes would be unexpected and thus have a stronger effect. In line with this thought, we expand our analysis and examine whether the magnitude of seasonal effect of key variables increases with the degree of seasonal smoothing of interest rates. Table V presents OLS panel regression results with similar specifications to those in Columns 2-3 of Table IV. We regress daily stock market returns on weather, tax, Monday, fall, December and recession controls. Additionally, we interact SAD and macroeconomic variables with 12-month autocorrelation of interest rate seasonality by country. Column 1 presents interactions with seasonally-unadjusted interest rates, monetary base, industrial production, consumer price index, foreign exchange rate, agricultural value added and SAD. Column 2 differs from Column 1 in that 12-month autocorrelation of interest rate seasonality is interacted with interest rates, monetary base, industrial production, consumer price index and foreign exchange rate split into seasonal and seasonally-adjusted components, as well as with SAD and agricultural value added.

We observe that the negative stock market relationship with interest rates is larger in countries where interest rates exhibit large seasonal swings. In countries, where 12-month autocorrelation of interest rate seasonality is close to 1, a 1% interest rate increase is associated with a 2.6% drop in stock market returns. At the same time, in countries where seasonal interest

Table V. Stock Market Returns and Seasonal Autocorrelations

	(1)	(2)
Seas.Autocorr.	0.177**	0.177**
	(0.011)	(0.011)
INT	2.465***	
	(0.000)	
INT#Seas.Autocorr.	-5.089***	
	(0.000)	
sINT		7.231***
		(0.000)
sINT#Seas.Autocorr.		-5.639
		(0.133)
s_adjINT		0.151
		(0.898)
s_adjINT#Seas.Autocorr.		-1.564
		(0.469)
MB	0.119	
	(0.521)	
MB#Seas.Autocorr.	-0.225	
	(0.341)	
sMB		0.095
		(0.579)
sMB#Seas.Autocorr.		-0.120
		(0.634)
s_adjMB		0.178
		(0.638)
s_adjMB#Seas.Autocorr.		-0.340
		(0.469)
IP	0.247	
	(0.560)	
IP#Seas.Autocorr.	-0.302	
	(0.519)	
sIP		0.197
		(0.634)
sIP#Seas.Autocorr.		-0.279
		(0.547)
s_adjIP		0.401
		(0.685)
s_adjIP#Seas.Autocorr.		-0.284
		(0.805)
CPI	5.881**	
	(0.034)	
CPI#Seas.Autocorr.	-6.011*	
	(0.063)	
sCPI		9.178*
		(0.067)

Table V. Continued

	(1)	(2)
sCPI#Seas.Autocorr.		-9.642*
		(0.083)
s_adjCPI		4.919*
		(0.070)
s_adjCPI#Seas.Autocorr.		-4.916

		(0.120)
FX	-3.637***	
	(0.001)	
FX#Seas.Autocorr.	3.575***	
	(0.003)	
sFX		-4.619*
		(0.067)
sFX#Seas.Autocorr.		5.323*
		(0.056)
s_adjFX		-3.357***
		(0.001)
s_adjFX#Seas.Autocorr.		3.185***
		(0.005)
SAD	1.404	1.247
	(0.157)	(0.276)
SAD#Seas.Autocorr.	-1.254	-1.174
	(0.372)	(0.456)
agr_va	3.407***	3.564***
	(0.003)	(0.003)
agr_va#Seas.Autocorr.	-3.805***	-3.992***
	(0.007)	(0.006)
Dummy Monday	-0.044***	-0.044***
	(0.000)	(0.000)
Dummy Tax	0.068***	0.069***
	(0.009)	(0.007)
Dummy Fall	-0.021*	-0.018
	(0.061)	(0.110)
TEMP	-0.104**	-0.104**
	(0.013)	(0.015)
PRCP	-0.039	-0.038
	(0.290)	(0.295)
CLD	-0.022*	-0.022*
	(0.057)	(0.064)
L.R	0.061***	0.060***
	(0.000)	(0.000)
L2.R	0.001	0.001
	(0.775)	(0.810)
N	204164	204164
adj. R-sq	0.005	0.005

rate smoothing is more aggressive, and autocorrelation approaches 0.1, a 1% increase in interest rates is associated with almost 2% increase in stock market return.

Column 2 presents more detail on the relationship between stock market returns and interest rate seasonality. While the effect of seasonally-adjusted interest rates does not differ whether countries observe high or low seasonality, the seasonal changes in interest rates have a strong effect. We confirm that stock markets are more sensitive to seasonal interest rate changes and the magnitude of that relationship differs with the degree of seasonality in countries examined. We can see that a 1% seasonal interest rate increase in countries exhibiting high seasonal swings (autocorrelation approaches 1) is associated with a 1.59% increase in stock market return. On the other hand, countries where interest rates do not exhibit much variation from month to month, a 1% increase in such variation is associated with a 6.67% increase in stock market return. In other words, the surprise factor more than triples the magnitude of seasonal stock market reaction, in countries where interest rate seasonal are not highly variable.

Furthermore, the creation of European Monetary Union (EMU) gives an opportunity to compare the effect of interest rate seasonality before and after the event. We compare the stock market relationship between countries that joined the EMU and countries that did not, but are located at a similar latitude. Table VI presents results of a difference-in-difference estimation between countries that joined the EMU and controls. The EMU countries include Austria, Belgium, Estonia, France, Germany and Portugal, control countries include Czech Republic, Hungary, Japan, Norway, Poland, and the United Kingdom for a total of 52,058 observations. Column 1 presents results of stock market regression with difference-in-difference estimation with a triple interaction of interest rates, dummy EA_treated that equals 1 for a country that is a EMU member and 0 otherwise, and dummy EA_time that equals 1 beginning the year countries joined the Euro Zone and 0 otherwise. Column 2 presents estimation with triple interactions of interest rates split into the seasonal component and seasonally-adjusted component. Each model contains macroeconomic variables, SAD and controls used in prior tables.

Results in Column 1 show an increased effect of interest rates on the stock market in EMU countries after joining the Union. Column 2 shows results similar to those in Column 1. The effect of seasonally-adjusted interest rates is larger in the EMU countries, but there appears to be no difference in the effect of seasonal component between countries in the Union and those outside. Results in Table VI confirm the hypothesis of a more pronounced interest rate effect in EMU countries and are consistent with findings in Table V, countries with lower seasonality are more sensitive to seasonal interest rate changes. The European Central Bank leads a cautious monetary policy with very stable interest rates (Cesares, 2006), which is confirmed in Table III. The autocorrelation of interest rate seasonal component is lower than that of control countries. The interrelations between EMU member countries, higher amounts of short-term debt and adjustable rate mortgages make their economies more sensitive to changes in interest rates, which is confirmed by our study.

Table VI. Difference in Difference in European Monetary Union

	(1)	(2)
EA_treated#EA_time#INT	38.615*	
	(0.070)	
EA_treated#EA_time#sINT		-171.303
		(0.303)
EA_treated#EA_time#s_adjINT		58.683***
		(0.003)
EA_treated#INT	-23.697	
	(0.154)	
EA_time#INT	2.032	
	(0.883)	
EA_treated#sINT		20.139
		(0.439)
EA_time#sINT		-52.940
		(0.364)
EA_treated#s_adjINT		-22.817*
		(0.058)
EA_time#s_adjINT		11.293*
		(0.093)
EA_treated	0.019	0.017
	(0.347)	(0.368)
EA_time	0.004	0.004
	(0.819)	(0.798)
EA_treated#EA_time	-0.031	-0.030
	(0.220)	(0.236)
INT	3.840	
	(0.709)	
sINT		31.541***
		(0.000)
s_adjINT		-4.295
		(0.341)
agr_va	-0.067	-0.009

	(1)	(2)
	(0.893)	(0.986)
SAD	0.097	0.190
	(0.870)	(0.756)
CPI	0.450	
	(0.346)	
MB	-0.266**	
	(0.024)	
IP	-0.094*	
	(0.067)	
FX	-0.629	
	(0.113)	

Table VI. Continued

	(1)	(2)
sCPI		4.117**
		(0.015)
s_adjCPI		-0.232
		(0.765)
sMB		0.015
		(0.836)
s_adjMB		-0.515***
		(0.008)
sIP		-0.113**
		(0.022)
s_adjIP		0.086
		(0.441)
sFX		-1.146
		(0.134)
s_adjFX		-0.489
		(0.158)
Dummy Fall	-0.037**	-0.035**
	(0.019)	(0.027)
Dummy December	0.051**	0.039**
	(0.032)	(0.044)
Dummy Monday	-0.026	-0.026
	(0.280)	(0.273)
Dummy Tax	0.073*	0.064
	(0.076)	(0.115)
TEMP	-0.273***	-0.250***
	(0.001)	(0.005)
PRCP	-0.070	-0.071
	(0.337)	(0.325)
CLD	-8.635***	-8.593***
	(0.000)	(0.000)
L.R	0.055**	0.055**
	(0.023)	(0.023)
L2.R	-0.012***	-0.012***
	(0.008)	(0.006)
Cons	0.113***	0.111***
	(0.000)	(0.001)
N	54772	54772
adj. R-sq	0.004	0.005

p-values in parentheses, * p<0.10 ** p<0.05

Coefficients multiplied by 100 for brevity

6. Conclusion

We study the effect of seasonal movements in short-term interest rates, monetary base, industrial production, consumer price index and foreign exchange rates along with weather and risk preferences on stock market returns. We examine 34 countries between 1973 and 2015 and find that interest rates and their seasonal components exhibit a strong relationship with returns. That association is more pronounced in countries, where seasonal variation in interest rates is smaller. This is further confirmed with difference-in-difference estimation comparing countries that joined the European Monetary Union and those that did not. Interest rates have an increased effect on the stock market in EMU countries, when compared to countries outside the Union, but at a similar latitude. While we find strong evidence for stock market relationship with economic factors, our sample exhibits little indication of the changing risk preferences throughout the year.

APPENDIX

Table VII. Variable definitions

INT	percentage difference of short-term interest rates
sINT	seasonal component of percentage difference of interest rates
s_adjINT	seasonally adjusted percentage difference in interest rates
MB	monetary base, monthly percentage change
sMB	seasonal component of monetary base
s_adjMB	seasonally adjusted monetary base
IP	industrial production, monthly percentage change
sIP	seasonal component of industrial production
s_adjIP	seasonally adjusted industrial production
CPI	consumer price index, monthly percentage change
sCPI	seasonal component of CPI
s_adjCPI	seasonally adjusted CPI
FX	national currency per USD, monthly percentage change
sFX	seasonal component of FX
s_adjFX	seasonally adjusted FX
SAD	SAD variable from Kamstra et al. (2003) SAD = night_hours-12 in fall or winter, 0 otherwise
Agr. v.a.	agricultural value added as percent of GDP
TEMP	Average daily temperature (C) from 6 am to 4 pm
PRCP	Daily precipitation in millimeters
CLD	Daily cloud cover in percent
Dummy Monday	1 on Monday, 0 o.w.
Dummy Tax	1 7 days before and 1 day after end of fiscal year
Dummy December	December dummy to proxy for increased cash demand around holidays
Recession	1 if recession, 0 o.w. from FRED, IMF and CIA Factbook
Dummy Fall	1 if fall, 0 o.w.
EA_time	1 after countries enter Euro zone, 0 before

EA_treated	1 for countries in the EA, 0 outside

s_adj- seasonally adjusted variable; s- seasonal component only

seasonal component calculated as difference between unadjusted and seasonally adjusted variable

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