



# Weather and SAD related mood effects on the financial market<sup>☆</sup>



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## ABSTRACT

We investigate the relationship between weather or seasonal affective disorder and the financial market, using a wide variety of financial market data as well as several weather variables and a seasonal affective disorder proxy. We distinguish between a model with a direct effect of the weather and seasonal affective disorder on the financial market and one with an indirect effect via a latent variable mood. Whereas only the latter model is justified by psychological literature, the former model is often used as an approximation. One major innovation of this paper is a consistent econometric implementation of the indirect effects model. We demonstrate that the approximation by direct effects yields inconsistent estimates. Our study supports some weather related, but no seasonal affective disorder related effects on the financial market. We show that, instead of focusing on single market segments, an analysis of various financial market segments is required. We also show that the analysis of individual stock returns or bond spreads reveals additional information, compared to the analysis of aggregate stock or bond indexes.

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## 1. Introduction

There are different streams of literature that investigate the impact of mood on the financial market. This includes the branches of literature that analyze if asset prices are related to *seasonal affective disorder*<sup>2</sup> (see, e.g., Kamstra et al., 2003), the daylight savings

anomaly (see Kamstra, Kramer, & Levi, 2000), results of sports events (see, e.g., Ashton, Gerrard, & Hudson, 2003; Edmans, Garcia, & Norli, 2007), the movie program (see Lepori, 2010) or the weather (see, e.g., Hirshleifer & Shumway, 2003; Saunders, 1993). As primarily weather and seasonal affective disorder data are available on a daily basis and show sufficient variation, this paper focuses on weather and seasonal affective disorder related mood effects.

The relation between the financial market and seasonal affective disorder has been analyzed by Kamstra et al. (2003), Garrett, Kamstra, and Kramer (2005), Kamstra (2005) and Kamstra, Kramer, and Levi (2009). The correlation between the weather and the financial market (e.g. stock market returns) has also been the subject of empirical studies. Saunders (1993) found that the returns on the New York Stock Exchange were negatively related to cloud cover in New York City. The higher stock returns on sunny days were supposed to have resulted from the positive mood, induced by good weather, of floor traders and brokers. Some papers extended the literature by using additional weather variables: Krämer and Runde (1997) included cloud cover, humidity and barometric pressure. Keef and Roush (2003, 2005, 2007) investigated the influence of wind, temperature, rain, humidity, sunshine and cloud cover.

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<sup>2</sup> As described by Kamstra, Kramer, and Levi (2003), seasonal affective disorder is a severe depressive disorder that affects many people during the seasons of fewer hours of daylight, i.e. when the days are shorter. Seasonal affective disorder symptoms include sadness, difficulty to concentrate, social withdrawal, profound and chronic fatigue, loss of energy, lethargy, sleep disturbance, and carbohydrate or

sugar craving. Medical evidence suggests that seasonal affective disorder is caused by serotonin dysregulation in the brain and abnormalities in the prefrontal and parietal cortex areas because of the reduced volume of daylight.

Dowling and Lucey (2005) evaluated weather effects using cloud cover, rain, humidity and geomagnetic storms. Goetzmann and Zhu (2005) included cloud cover, rain and snow, and Theissen (2007) used cloud cover, sunshine, rain and temperature. Other papers extended the analysis to market segments other than the stock market. For instance, Keef and Roush (2005) integrated fixed income securities into the analysis, also investigating government bonds and bank bills. Kaplanski and Levy (2009) and Symeonidis, Daskalakis, and Markellos (2010) analyzed the relationship between weather variables, seasonal affective disorder and the stock market volatility (including the VIX index).

In this article, in contrast to the existing empirical literature we differentiate between a direct functional chain, where weather and seasonal affective disorder have a direct impact on the financial market variables, and an *indirect functional chain*, where weather and seasonal affective disorder influence mood which in turn influences the financial market variables. We show that depending on the assumption on the functional chain, different econometric approaches are appropriate. These two econometric approaches provide different statistical significance for the individual weather variables. The literature, presented and discussed in Section 2, strongly supports the indirect functional chain. We show that an approximation of the indirect functional chain by a direct functional chain, as often used in the empirical Behavioral Finance literature, results in inconsistent parameter estimates.

Whereas many existing papers on weather or seasonal affective disorder effects focus on *one* financial market segment (e.g. stock index returns), this article investigates weather and seasonal affective disorder related mood effects on a *variety of financial market segments*, namely the risk-free interest rates, two US corporate bond indexes, yield spreads of individual US corporate bonds, the S&P 500 returns, individual stock returns and the VIX volatility index. We observe some weather and no seasonal affective disorder effects. We also find that specified weather variables have a different effect on the various financial market segments. Our estimates support the claim that the different financial market segments are related to each other. We show that a careful interpretation of weather and seasonal affective disorder effects in one market segment requires the knowledge of the impact of weather and seasonal affective disorder on all the regressors (i.e. also on the other financial market segments). Thus, it is not sufficient to analyze weather or seasonal affective disorder effects for one market segment alone, as often done in the empirical Behavioral Finance literature, but one needs a comprehensive model including all market segments. Moreover, we show that a disaggregated analysis on a bond level or stock level reveals additional findings.

The paper is structured as follows: Section 2 presents findings from the psychological and experimental literature on the transmission channel between weather/seasonal affective disorder and the financial market. In Section 3 we describe the data used in our study. In Section 4 we model the impact of weather and seasonal affective disorder on financial market variables by both a direct functional chain and an indirect functional chain. Section 5 outlines the methodology used, describes our results and provides alternative interpretations. Finally, Section 6 concludes.

## 2. Mood – the transmission channel

### 2.1. Transmission channels between weather and the financial market

In spite of a large stream of empirical Behavioral Finance literature that analyzes if the weather has an impact on the financial market, the underlying transmission channel between the weather and the financial market is still subject to exploration. The existing

literature offers several potential transmission channels between the weather and the individual's decision-making process and consequently the financial market (see, e.g., Arkes, Herren, & Isen, 1988; Au, Chan, Wang, & Vertinsky, 2003; Bassi, Colacito, & Fulghieri, 2013; Howarth & Hoffman, 1984; Johnson & Tversky, 1983; Wright & Bower, 1992).

One transmission channel is that the weather has an impact on the mood or another intrapersonal variable, which in turn may generate individual cognitive biases (misestimation of probabilities and therefore of expected values or risk, see, e.g., Johnson & Tversky, 1983; Wright & Bower, 1992). Another transmission mechanism is that the weather influences mood or another intrapersonal variable, which in turn has an impact on the individuals' risk attitudes (risk aversion). Concerning the impact of mood on the risk aversion, there are two alternative hypotheses in the psychological literature: The *affect infusion model* (see, e.g., Forgas, 1995; Forgas & Bower, 1987) postulates that an improvement in the mood reduces risk aversion. The *mood maintenance hypothesis* (see Isen & Patrick, 1983 or Isen & Geva, 1987) argues that an improvement in the mood increases risk aversion (in order to maintain the positive mood the level of risk taken is reduced). To provide examples of these behavioral transmission channels, "good weather" could improve the mood which in turn could result in an overestimation of the expectations, an underestimation of risk (both represent cognitive biases) or an increase (according to the mood maintenance hypothesis) or a decrease (in line with the affect infusion model) of the risk aversion. Another (non-behavioral) transmission channel between the weather and the financial markets is the "opportunity cost of trading" effect detected by Schmittmann, Pirschel, Meyer, and Hackethal (2014): Good weather creates higher opportunity cost of trading for retail investors and therefore reduces the liquidity on the market which may have an impact on the market prices.

Even though some empirical Behavioral Finance papers claim that the link between the weather and the financial market works via mood and risk aversion (e.g. Cao & Wei, 2005; Goetzmann & Zhu, 2005), this argument often lacks a detailed analysis. Bassi et al. (2013) recently investigated the transmission channel between weather and decision-making under risk in a comprehensive experimental study and show that the weather influences the individual's decision-making through the risk aversion channel. They also find evidence that this effect is mediated by the mood in a causal mechanism, such that altogether the weather affects the agents' mood and the mood affects the agents' risk attitudes. The results of Bassi et al. (2013) also imply that it is the affect infusion model and not the mood maintenance hypothesis that drives the impact of mood on the risk aversion. Thus, "good weather" improves the mood and thereby reduces the risk aversion which in turn stimulates risk-taking.

### 2.2. The transmission channel between seasonal affective disorder and the financial market

Kamstra et al. (2003) describe in detail the link between seasonal affective disorder and the financial market: Seasonal affective disorder induces depression. According to psychological literature (e.g. Eisenberg, Baron, & Seligman, 1998) depression increases the risk aversion. This is in line with the affect infusion model mentioned above. This higher risk aversion in turn should influence the financial market variables (e.g. reduce the prices of risky assets and increase the prices of low-risk assets).

### 2.3. Mood

As both Bassi et al. (2013) and some psychological literature (see, e.g., Howarth & Hoffman, 1984) emphasize the role of mood

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