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Globally dangerous diseases: Bad news for Main Street, good news for Wall Street?

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Michael Donadelli - Renatas Kizys - Max Riedel

Globally Dangerous Diseases: Bad News for Main Street, Good News for Wall Street?

SAFE Working Paper No. 158

SAFE | Sustainable Architecture for Finance in Europe

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Non-Technical Summary

Mood and anxiety in the stock market – coined as investor sentiment – are documented in asset pricing literature to have a significant impact on returns. The variety of mood variables studied in the past ranges from weather conditions and international sporting events to negative newspaper articles on aviation disasters and wars. Also, interpersonal communication, leading to ‘social mood’, was observed to translate into emotions such as optimism, pessimism, happiness, or anxiety. A general finding is that fear leads to negative asset returns while positive emotions increase investors' willingness to take risks.

Differently from the existing works, this study examines whether investor mood, driven by World Health Organization (WHO) alerts and media news on globally dangerous diseases, is priced in pharmaceutical companies' stocks in the United States. We focus on four major diseases that were regarded as a Public Health Emergency of International Concern (PHEIC) by the WHO. These include the outbreak of severe acute respiratory syndrome (SARS) in 2003, Influenza A (H1N1) in 2009, and Polio and Ebola in 2014. Specifically, our main contribution consists of employing a novel mood variable (disease-related news or DRN), based on WHO alerts and media news on a globally dangerous disease, to examine the effect of investor sentiment on pharmaceutical stock prices.

We concentrate on irrational investors who buy and sell pharmaceutical companies' stocks guided by beliefs as opposed to rational expectations. We argue that rational trading should not occur because of two reasons. First, in the wake of DRNs, uncertainty surrounding distant cash flows of vaccine developers may be too high. Second, resources available for smaller pharmaceutical companies may be too limited to engage in large-scale R&D. As a result, pharmaceutical stock prices should not respond to DRNs.

To address our research questions, we construct four daily pharmaceutical investment portfolios covering the years 2003 to 2014. The empirical strategy draws upon two commonly used - event-study and regression-based - methodologies to evaluate the investor sentiment effect on stock prices of pharmaceutical firms following a DRN.

Our findings show that DRNs have a positive and significant sentiment effect among investors (on Wall Street). The effect is stronger (weaker) for small (large) companies that are less (more) likely to engage in the development of new vaccines in the wake of DRNs. A potential negative mood (on Main Street) - induced by disease-related fear - does not alter the positive sentiment effect. These results give rise to profitable trading strategies leading to sizable outperformances over the market portfolio. Importantly, returns on DRN-based trading strategies are economically and statistically greater than returns on randomly drawn strategies.

Overall, our study shows that optimism and pessimism - induced by DRNs - can significantly influence portfolio investment decisions in the pharmaceutical industry. Our findings are of importance and practical usefulness for institutional and individual investors, portfolio managers, financial analysts and pharmaceutical firms alike.

Globally Dangerous Diseases: Bad News for Main Street, Good News for Wall Street?

Michael DONADELLI, Renatas KIZYS and Max RIEDEL *

Abstract

This paper examines whether investor mood, driven by World Health Organization (WHO) alerts and media news on globally dangerous diseases, is priced in pharmaceutical companies' stocks in the United States. We concentrate on irrational investors who buy and sell pharmaceutical companies' stocks guided by beliefs as opposed to rational expectations. We argue that disease-related news (DRNs) should not trigger rational trading. We find that DRNs have a positive and significant sentiment effect among investors (on Wall Street). The effect is stronger (weaker) for small (large) companies, who are less (more) likely to engage in the development of new vaccines in the wake of DRNs. A potential negative mood (on Main Street) – induced by disease-related fear – does not alter the positive sentiment effect. Our findings give rise to profitable trading strategies leading to significantly positive performances. Overall, this unparalleled research shows that large events of devastating nature to the economy can be considered as good news to some groups of interest, such as stock market traders.

Keywords: WHO alerts, investor sentiment, pharmaceutical industry, trading strategies

JEL Codes: G11, G14, I11

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1 Introduction

A relatively large number of studies shows that sentiment may drive agents' investment decisions (see, among others, [De Long et al., 1990](#); [Cen and Liyan-Yang, 2013](#); [Kaplanski and Levy, 2015](#)). In this respect, the behavioral finance literature provides solid evidence supporting the existence of a significant relation between stock returns and investor sentiment.¹ Investor sentiment is typically defined as a belief about future cash flows and investment risks that is not justified by the facts at hand (see [Baker and Wurgler \(2007\)](#), pp. 129). Certain events may create either a positive or a negative sentiment that strongly affects investors' investment decisions and, thus, the corresponding stock market prices.

Early studies observe, for example, that sunshine, which is well known to be a driver of peoples' mood, tends to comove positively with daily stock returns (see [Saunders, 1993](#); [Hirshleifer and Shumway, 2003](#)). [Yuan et al. \(2006\)](#) find that lunar phases may affect stock market returns. More recent studies find that international sporting games – and in particular soccer games – heavily affect investors' sentiment, and in turn, stock market returns (see [Edmans et al., 2007](#); [Kaplanski and Levy, 2010a](#)). [Kaplanski and Levy \(2010b\)](#) show that major aviation disasters tend to generate a negative sentiment within two days after the event. [Horváth and Huizinga \(2015\)](#) examine the impact of the announcement on the creation of the European Financial Stability Facility on bank share prices.

Key in this research is the possibility – hitherto unaccounted for by existing literature – that large events of devastating nature to the economy and society can be regarded as good news to some groups of interest, such as stock market investors. Differently from the existing works, we rely on globally dangerous diseases (i.e., SARS, Influenza A(H1N1), Polio, Ebola), which are perceived by the general public (Main Street) as large negative developments, but can generate sector-specific positive investor sentiment (Wall Street). Specifically, our main contribution consists of employing a novel mood variable (hereinafter disease-related news or DRNs), based on World Health Organization's alerts and media news related to globally dangerous diseases, to examine the effect of investor sentiment on

¹See, among others, [Saunders \(1993\)](#); [Hirshleifer and Shumway \(2003\)](#); [Kamstra et al. \(2003\)](#); [Loughran and Schultz \(2004\)](#); [Cao and Wei \(2005\)](#); [Baker and Wurgler \(2006\)](#); [Edmans et al. \(2007\)](#); [Kaplanski and Levy \(2010a,b\)](#); [Curatola et al. \(2016\)](#)

pharmaceutical stock prices. Our principal hypothesis here is that fear of globally dangerous diseases will be negatively associated with investor pessimism, whereas DRNs will positively affect investment in pharmaceutical stocks. This hypothesis builds on the argument that – while globally dangerous diseases spread fear and generate negative sentiment – investors unrealistically anticipate an increase in cash flows of pharmaceutical companies due to selling new medicines aimed at fighting the new pandemic disease.

Thus, investor sentiment about the performance of pharmaceutical companies may be one key element that drives financial investment decisions. This notwithstanding, there is a dearth of research into pharmaceutical companies’ stock market performance (see [Himmelman and Schiereck, 2012](#); [Theodossiou and Theodossiou, 2014](#)).

To the best of our knowledge, the relation between pharmaceutical stock returns and investor sentiment – driven by DRNs – has not been investigated in the literature, with the exception of [Huberman and Regev \(2001\)](#). [Huberman and Regev \(2001\)](#) use a case study to investigate the effect of investor enthusiasm to a major breakthrough in cancer research. Interestingly, the stock price of *EntreMed*, a bio-pharmaceutical company, responded stronger to the breakthrough five months later, when it was reported in the popular press, than when it was originally announced in *Nature*. Nevertheless, their research neither (i) generalizes to the whole pharmaceutical industry, nor (ii) studies investor sentiment effects on stock prices and returns, nor (iii) designs global disease-news-induced trading strategies.

The main contribution of this study is to evaluate the balance between two contrasting effects of outbreaks of globally dangerous diseases. On the one hand, we recognize the possibility that pandemic diseases spread fear among the general public and stock market investors, which triggers a negative (fear-induced) sentiment in pharmaceutical stock prices. On the other hand, an outbreak of a pandemic disease is expected to have a positive sector-specific sentiment effect on pharmaceutical stock prices. Methodologically, accounting for the two competing (negative and positive) effects manifests in a unique framework that alleviates the possibility of spurious correlations. In more detail, this study addresses the following questions, hitherto unedited in the context of pharmaceutical stock market. First, does investors’ fear gauge, which is provoked by DRNs, lead to a decrease in pharmaceutical stock market returns? Second, does an outbreak of a globally dangerous disease trigger a

positive sector-specific investor sentiment effect on pharmaceutical stock prices? Third, does investor sentiment (optimism or pessimism) about future performance of pharmaceutical companies persist over time? Fourth, do stock prices of large pharmaceutical stocks respond to DRNs differently than stock prices of small pharmaceutical stocks?

To address these issues, we use stock prices of 102 pharmaceutical firms listed in the United States to construct four different investment portfolios. In addition, as robustness check, we consider the S&P500 Information Technology stock index. Our empirical strategy draws upon two commonly used – event-study and regression-based – methodologies to evaluate the investor sentiment effect on stock prices of pharmaceutical firms following a DRN.

We identify a significantly positive and persistent investor sentiment – following DRNs – in stock returns of pharmaceutical companies. This may be generated by positive beliefs about R&D investments in the aftermath of disease outbreaks. Notice also that the persistence of investor sentiment may be reflected in information salience (Palomino et al., 2009). Furthermore, we construct a fear gauge index by employing the stock market volatility index VIX as a proxy for investor fear. The index always exerts a negative and significant effect on returns of pharmaceutical companies’ stocks. We find that sentiment tends to exert a stronger effect on small firms than on large firms. This finding is along the lines of Qiu and Welch (2004) who observe that, under certain conditions, small firm returns become a proxy for investor sentiment (see also Edmans et al., 2007; Baker and Wurgler, 2006). Importantly, our results are supported by a battery of robustness checks.

Overall, our findings give rise to profitable trading strategies where an investor takes a long-position in a portfolio of pharmaceutical stocks and a short one in the stock market volatility index (i.e., VIX). We stress that these strategies lead to a significant positive performance.

The remainder of this study is organized as follows. In Section 2, we provide the background and motivation to the study. In Section 3, we describe our mood variable DRN and report descriptive statistics. In Section 4, we outline the methodology and formulate our main hypotheses. In Section 5, we discuss the estimation results. In Section 6, we design hypothetical trading strategies. Finally, in Section 7, we provide some concluding remarks

and we also shed light on the practical usefulness of our results.

2 Motivation and Background

2.1 Investor Sentiment and Media Coverage: The Case of Pandemic Diseases

Mood and anxiety in the stock market – coined as investor sentiment – are documented in asset pricing literature to have a significant impact on stock market returns.² Mehra and Sah (2002) relate in a theoretical framework the effect of feelings on investors’ decision making in financial markets. Nofsinger (2005) finds that interpersonal communication, leading to “social mood”, translates into emotions such as optimism, pessimism, happiness, or anxiety. A general finding is that fear leads to negative asset returns while positive emotions increase investors’ willingness to take risks.

In this study, we hypothesize that increased media coverage of globally dangerous diseases has a positive and relatively persistent effect on pharmaceutical companies. Despite the overall negative sentiment in the population due to fear of being infected, public and political demand for containing a global epidemic disease can lead to additional income channels for pharmaceutical companies. Typical reactions to an infectious illness include higher R&D investment (partially subsidized by the government), vaccine mass orders, or general increase in demand for preventive measures (e.g., medicine, disinfection agents, surgical masks). We focus on four major diseases that were regarded as a Public Health Emergency of International Concern (PHEIC) by the WHO. The outbreak of severe acute respiratory syndrome (SARS) in 2003, Influenza A(H1N1) in 2009, and Polio and Ebola in 2014 were all more or less intensively covered by media.

The role of mass media in communication of risks has been subject to intense debate. It is argued that low-probability, high-consequence events, such as health risks associated with outbreaks of rare diseases, are overemphasized in media-generated news waves. This

²In the literature, a variety of mood variables was considered. For instance, weather conditions (Saunders, 1993; Hirshleifer and Shumway, 2003), hours of daylight in fall and winter (Kamstra et al., 2003), international soccer results (Edmans et al., 2007; Kaplanski and Levy, 2010a; Curatola et al., 2016), or negative newspaper articles (Tetlock, 2007).

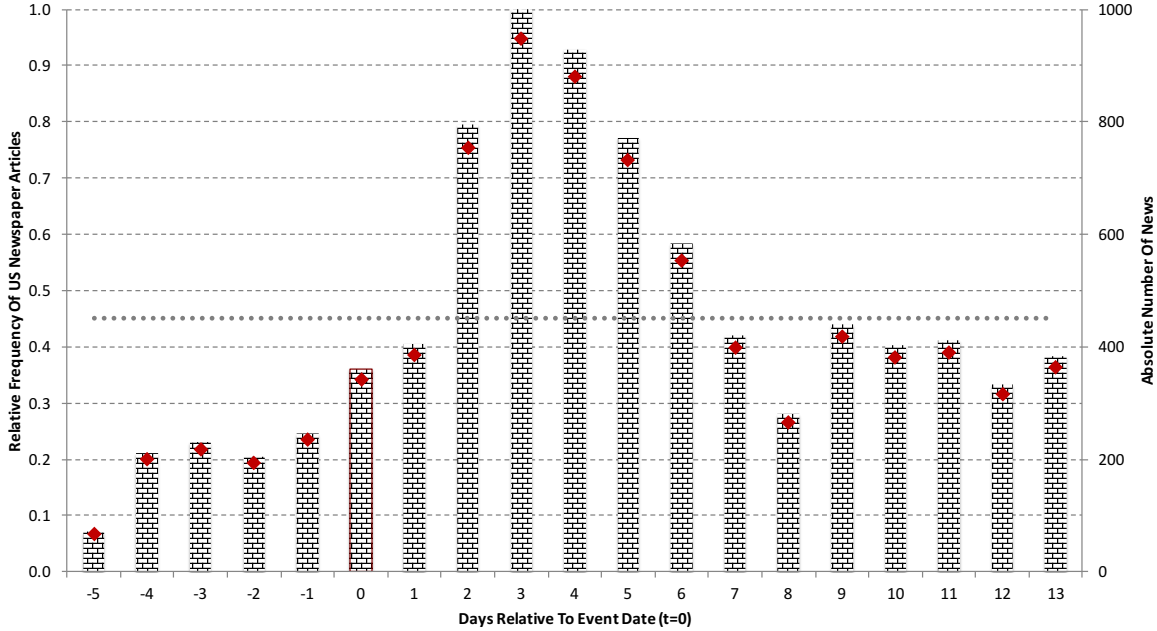
unbalanced reporting leads to a disjunction between actual and population’s perceived risk (see [Vasterman et al., 2005](#); [Mairal, 2011](#); [Young et al., 2013](#)).³ Public overreaction and panic can also lead to adverse economic effects. In particular, sectors such as tourism or retail sales fall due to individuals’ preventive measures, such as reduction in traveling to the affected geographical areas or avoidance of public places.⁴

In the spirit of [Kaplanski and Levy \(2010b\)](#), we search for media articles related to globally dangerous diseases in order to (i) gain better understanding of the scale and timing of the information salience of such diseases and (ii) to evaluate the importance of the information salience as a potential source of investor sentiment in the pharmaceutical industry. [Figure 1](#) illustrates the normalized number of media news informing the general public about the outbreak and acceleration for the aforementioned pandemic diseases. It is evident from [Figure 1](#) that the frequency of the relevant news notably increases on the announcement day ($t = 0$), that is, when the official WHO PHEIC statement is made. The news coverage intensifies and attains maximum on the third day after the official WHO PHEIC announcement. In addition, the absolute number of news remains above the average up to six days after the announcement. This is not surprising since PHEIC statements are followed by other official/institutional news, which will be used to build our event-day mood variable in the next section. Specifically, in two out of four cases an event (i.e., DRNs) was taking place on any of the seven days following a PHEIC announcement. These observations provide support for the existence of a relative strong relationship between official news and media coverage and therefore between DRNs and investor sentiment. Moreover, they suggest that such sentiment effect lasts for several days supporting the persistent sentiment hypothesis that will be formulated in [Section 4](#).

³For instance, a representative survey conducted by [Blendon et al. \(2004\)](#) indicates that 69% of respondents living in Ontario, 57% in Canada excluding Ontario and 32% in the United States were concerned about contracting SARS. Whereas, educative and informative communication to the public in Singapore resulted in a much lower overall anxiety level. [Quah and Hin-Peng \(2004\)](#) report that only 14% of respondents viewed SARS as a personal risk in May 2003.

⁴In case of SARS, [Hanna and Yiping \(2004\)](#) estimate the total cost at about 0.5% of GDP in China, while [Keogh-Brown and Smith \(2008\)](#) assess the global economic impact between USD 30 and 100bn. Using a general equilibrium model for the UK, [Smith et al. \(2009\)](#) estimate costs related to Influenza A(H1N1) between 0.5% and 1.0% of UK’s GDP. However, the total economic burden is difficult to quantify since both direct health care costs as well as indirect costs of work absenteeism and loss of productivity have to be taken into account.

Figure 1: MEDIA COVERAGE AROUND PHEIC ALERTS ON GLOBALLY DANGEROUS DISEASES



Notes: This figure depicts the normalized number of distinct, disease-related newspaper articles published in the United States around the event days. The event dates ($t = 0$) are considered to be the official PHEIC statements. The number of articles relies on all four disease announcements and is normalized relative to its peak value over the 19 days period. The dotted line represents the average relative value across the 19 days period. Red points illustrate the absolute number of disease-related newspaper articles. Data are obtained using the LexisNexis database for global news and business information.

2.2 The Pharmaceutical Industry

The pharmaceutical industry is at the heart of the US economy. Although public and private spending on pharmaceuticals in the US collectively contributed just over 2% (around USD 1,000) to the country’s GDP per capita in 2011 (OECD, 2013),⁵ this share was the largest among the OECD countries. In 2009, the overall US health care expenditure accounted for 18% of the country’s GDP, but it is estimated to contribute 37% in 2050.⁶ Furthermore, biopharmaceutical companies in the US account for the largest share of all US companies’ R&D expenditure, which represents nearly 20% of all domestic R&D (PhRMA, 2015).⁷ This is one of the fastest growing industries. Indeed, both revenues and R&D spending by the US biopharmaceutical industry tripled from 1996 to 2008 (Lazonick and Tulum, 2011). Fur-

⁵Source: OECD Health Statistics (2013).

⁶Source: The Statistics Portal (Statista), 2015 (available at www.statista.com/statistics/215163/us-health-expenditure-as-percentage-of-gdp-forecast).

⁷Source: The Pharmaceutical Research and Manufacturers of America (PhRMA) (available at www.phrma.org/economic-impact).

ther, [Offit \(2005\)](#) documents an increase in market concentration of vaccine producers in the US over past decades. Specifically, there are currently only four FDA-approved US-based publicly-traded vaccine producers and distributors.⁸ The reasons for companies undertaking or quitting vaccine production are multi-fold. On the one hand, research, development, testing, and manufacturing of vaccines are costly; on the other hand, the market for selling vaccines is smaller than the market for pharmaceutical drugs, to name just few reasons. However, high entry barriers for the development of a new vaccine bears potential for monopoly. Additionally, there is no manufacturing of generic vaccines, as vaccine production is substantially more complicated and technologically advanced than drug production. A generic drug is defined by the WHO as “a pharmaceutical product, usually intended to be interchangeable with an innovator product, that is manufactured without a licence from the innovator company and marketed after the expiry date of the patent or other exclusive rights”⁹. The result is an increase in vaccine shortages, especially for flu vaccines ([Hinman et al., 2006](#)). The emergence of a globally dangerous disease can thus be regarded as a potentially new market for vaccine producers along with subsidized R&D. Therefore, it is surprising that research focusing on the effects of investors’ sentiments on the stock prices of pharmaceutical companies has been underwhelming.

2.3 The US Stock Market and Investor Attention to Pharma-Stocks

This empirical study focuses on the US stock market. There are two main reasons to select the US stock market for this study: (1) it is one of the most closely followed markets in the world and, as such, very efficient with respect to new information inflow as well as one of the most liquid ones (see, among others, [Kaplanski and Levy, 2010a](#)); (2) the US stock market is one of the leading stock markets in the world and accounts for about 40% of the global market ([Hou et al., 2011](#)).¹⁰ Our study is further motivated by a growing role of pharmaceutical

⁸FDA’s “Complete List of Vaccines Licensed for Immunization and Distribution in the US” includes Emergent Biosolutions, Johnson & Johnson, Merck and Pfizer (available at www.fda.gov/BiologicsBloodVaccines/Vaccines/ApprovedProducts/ucm093833.htm).

⁹www.who.int/trade/glossary/story034/en/

¹⁰Notice that the average stocks traded (as % of GDP) in the US over the last decade is above 200% (Source: World Development Indicators).

companies' stocks within the industry of financial services in the US. Perceptive Life Sciences Offsh Fund LTD (USD 859M), Traxis Sivik Global Healthcare Offshore (USD 44M), and Visium Balanced Offshore Fund CL2 (USD 3,697M) are examples of the sector-specific equity funds investing exclusively in bio-pharmaceutical stocks.¹¹ There is also a large number of funds with significant exposures to stocks of (main) individual pharmaceutical companies. Indeed, Table 1 indicates that, as of second quarter of 2014, institutional investors hold significant positions in largest pharmaceutical firms' stocks, including Pfizer, Johnson & Johnson, Merck & Company, AstraZeneca, Amgen and Gilead Sciences Inc.

Table 1: INSTITUTIONAL INVESTORS' POSITIONS IN (MAIN) PHARMACEUTICAL STOCKS

Pharmaceutical Company	Fund (% of pharma stocks held)
Pfizer	Jana Partners (0.05%); Fairfax Financial Holdings (0.48%); Orbimed Advisors (1.42%); Eton Park Capital Management (1.53%); Boyar Asset Management (3.94%); York Capital Management Global Advisors (1.35%); Farallon Capital Management (0.43%); Muhlenkamp and Co (0.21%)
Johnson & Johnson	Berkshire Hathaway (0.03%); Fairfax Financial Holdings (0.61%); Perry Corp (0.99%); Orbimed Advisors (0.59%); Boyar Asset Management (2.14%);
Glaxo	Chou Associates Management (0.14%);
Merck & Company	Fairfax Financial Holdings (0.05%); Orbimed Advisors (1.72%); Healthcor Management (1.69%); Vertex One Asset Management (0.67%); Sarissa Capital (7.87%);
Abbott Laboratories	Southeastern Asset Management (27, 2.98%);
AstraZeneca	Chou Associates Management (0.28%); Third Point (0.91%), Corvex Management (1.09%); Duquesne Family Office (1.11%); Highfields Capital Management (0.76%); York Capital Management Global Advisors (1.20%)
Amgen	Third Point (0.65%); Orbimed Advisors (3.12%); Pennant Capital Management (0.50%); Highline Capital Management (7.06%); Sarissa Capital (1.81%);
Lilly Eli & Co	Highfields Capital Management (2.13%);
Bristol Myers Squibb Co	Orbimed Advisors (4.09%); Boyar Asset Management (2.12%); Muhlenkamp and Co (1.82%)
Gilead Sciences Inc.	Baker Bros. Advisors (0.26%); Palo Alto Investors (0.95%); Orbimed Advisors (3.34%); Pennant Capital Management (3.07%); Argonaut Capital Management (1.25%); Healthcor Management (2.69%); Parnassus Investments (2.44%); Muhlenkamp and Co (2.12%)
Vertex Pharmaceuticals Inc	Orbimed Advisors (0.59%); Healthcor Management (3.88%);
Novo Nordisk	Markel Corp (1.42%)
<i>Source: Form 13F (SEC) - Reports Filed by Institutional Investment Managers</i>	

3 Data

3.1 Official Announcements of Globally Dangerous Diseases

The data cover the entire history of global diseases that were considered as PHEICs by the WHO - a 12-year period, from March 2003 to December 2014. The global diseases period

¹¹Source: HSBC Hedge Weekly n. 28 - Investment Fund Performance Review, July 2014.

incorporates 146 DRNs, which we consider to be our event days.¹² We categorize the events according to several criteria: *WHO Statement*, *WHO Disease Outbreak News*, *Approval*, *Gvt. Order*, *Gvt. Order Cancel*, *Research Funding* and *Statement*. Events that are considered to be a *WHO Statement*¹³ or *WHO Disease Outbreak News*¹⁴ are obtained from the official website of WHO. All the other events are obtained through a rigorous online search.

WHO Statements is an official statement communicated to the public with regard to any new and substantial information related to a certain disease. For instance, on August 8th 2014 the “Statement on the 1st meeting of the IHR Emergency Committee on the 2014 Ebola outbreak in West Africa” informed on the current state of the Ebola disease outbreak. Additionally, the emergency committee stated that conditions for a PHEIC have been met and provided advice to address the Ebola outbreak in the affected countries. Typically, the mass media uses such *WHO Statements* to communicate the news to a greater public.

WHO Disease Outbreak News, on the other hand, are to some extent regular updates on the current situation and include, for instance, news about first cross-border transmissions of a disease. In case of the SARS outbreak in 2003, there were periods of daily updates, while news on the 2009 Influenza A(H1N1) outbreak were covered on a weekly basis. We recognize that all regularly spaced updates may be anticipated by stock market investors and may be priced in prior to the actual update. For this reason, our sample of announcements comprises only those updates that documented first-time cross-border transmissions. Such strategy helps ensure the independence of subsequent announcements, insofar as cross-border transmissions of pandemic diseases occur unpredictably. In case of SARS, we observe a rapid spread across countries within the first two months.¹⁵ In total, 29 countries were affected by the disease. In case of Influenza A(H1N1), the official list counts more than 214 countries and overseas territories or communities as of August 1st 2010. The disease spreads quickly and our list includes a sizable number of first cross-border transmission dates (around 50).

¹²Notice that WHO announcements and disease-based news released on week-end days are assumed to have an effect on Monday.

¹³<http://www.who.int/mediacentre/news/statements/en>

¹⁴<http://www.who.int/csr/don/en>

¹⁵Occasionally there were false alarms. Some countries were temporarily included and subsequently removed from the list of affected countries (if a SARS outbreak could not be confirmed in retrospect). We also included such false alarm dates in our analysis since the public is likely to take the information as a fact without questioning its reliability at the time the news is published.

For Polio, we abstain from identifying first outbreak dates as there are only ten event dates in total. Considering Ebola, we count ten cross-border transmissions in total. However, the disease was still not under control at the time this paper was written.

In addition to *WHO Statements* and *WHO Disease Outbreak News*, we include release dates of *official statements* provided by government ministries and agencies as well as individual publicly traded companies. Newly developed vaccines are subject to governmental approval and a positive feedback might have a substantial impact on the share price of the vaccine producing company as well as on its competitors/followers. We use official press release dates provided by the website of the US Department of Health and Human Services (HHS) and label them *Approval*. Please note that this category is only relevant for Influenza A(H1N1). For SARS and Ebola, vaccines are still in development while potent Polio vaccines have existed for decades. *Gvt. Order* and *Gvt. Order Cancel* refer to government purchases of vaccine and subsequent cancellations of orders. Again, these dates refer to the Influenza A(H1N1) outbreak only. In the case of the SARS outbreak, companies were granted research funding to develop a potent vaccine. We label the official dates of funding announcements *Research Funding*. The category *Statement* subsumes different, potentially influential, statements provided by government officials and companies referring to the current situation with regard to a disease. All DRNs are classified and summarized in Table [A.2](#).

3.2 Descriptive Statistics

The stock market data - end-of-trading-day prices and market values - are retrieved from Thomson Reuters Datastream. The cross section includes 102 pharmaceutical companies that are listed either on the New York Stock Exchange (NYSE) or NASDAQ. In addition, we retrieve the *S&P500 Information Technology* index. For non-US based companies, we use the data on American Depository Receipts (ADRs). This gives rise to a 12-year period with 3097 trading days, from January 2003 to November 2014. To test for the impact of DRNs on pharmaceutical stock returns, we employ the rates of return on a variety of portfolios comprising pharmaceutical stocks. Specifically, we construct four benchmark “phar-

maceutical portfolios”. The first is an equally-weighted portfolio (EW).¹⁶ The second is a value-weighted portfolio of all pharmaceutical stocks with time-varying market-value based weights (VW). The third portfolio is a constant-value-weighted portfolio accounting for the 10 largest pharmaceutical stocks (TOP). The fourth is a constant-value-weighted portfolio of 10 smallest pharmaceutical stocks (BOTTOM). The value-weighted portfolio emphasizes the role of large companies as opposed to small companies. The TOP portfolio illustrates a real-world situation where investors are constrained by cardinality constraints. The BOTTOM portfolio addresses our *Hypothesis 4* stated in the next section. Finally, the inclusion of S&P500 Information Technology – a standardized and tradable diversified portfolio of stocks – seeks to project our hypotheses on sectors other than the pharmaceutical. In doing so, we show that the DRN positive sentiment spreads to other sectors and confirm that the breadth of sentiment is not confined to the pharmaceutical industry only.

We then compute continuously-compounded day-to-day percentage returns on the aforementioned portfolios, R_{EW} , R_{VW} , R_{TOP} , R_{BOTTOM} and R_{SP500}^{IT} , respectively. The descriptive statistics are summarized in Table 2.

Over the sample period, the mean return on the value-weighted portfolio of pharmaceutical stocks with time-varying weights (VW), 0.0549%, was considerably greater than the mean of the remaining portfolios. The median follows a similar pattern with one notable exception, where the difference between the mean and the median (and hence the ensuing asymmetries in the probability density function) is largest for the EW portfolio. The range of variation between the maximum and the minimum returns is greatest for the S&P500 IT portfolio (11.46% and -9.67% , respectively) and lowest for the VW portfolio (10.17% and -6.52% , respectively). The BOTTOM portfolio has the highest idiosyncratic risk, as measured by the standard deviation (1.63%), whereas the TOP portfolio is the least risky to invest (1.03%). Moreover, portfolio returns are negatively skewed, with an exception of the VW portfolio. The negative skewness implies that large negative returns are more likely than large positive returns, whereas the converse is true for the positively skewed returns. Furthermore, returns on the five portfolios are leptokurtic, where the coefficient of excess

¹⁶The equally-weighted portfolio draws on the literature that studies the optimality of portfolios of naïve investors (De Miguel et al., 2009)

Table 2: DESCRIPTIVE STATISTICS

Statistic	<i>EW</i>	<i>VW</i>	<i>TOP</i>	<i>BOTTOM</i>	<i>SP500^{IT}</i>
Mean (%)	0.0077	0.0549	0.0159	-0.0125	0.0366
Median (%)	0.0405	0.0586	0.0209	0.0000	0.0559
Maximum (%)	10.5582	10.1711	10.3673	8.2638	11.4610
Minimum (%)	-7.1160	-6.5238	-7.7975	-11.2926	-9.6701
Std. Dev.(%)	1.2198	1.1391	1.0262	1.6259	1.3702
Skewness	-0.3194	0.0210	-0.1041	-0.1746	-0.0439
Excess Kurt.	4.5993	4.6354	9.0512	2.6647	9.3379
Jarque-Bera	2782.39	2772.99	10577.2	931.996	5184.43
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ljung-Box Q_5	29.581	8.2820	24.890	12.497	21.378
	(0.0000)	(0.1414)	(0.0001)	(0.0286)	(0.0007)
Ljung-Box Q_5^2	1069.197	667.071	1260.68	167.730	802.233
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	3097	3097	3097	3097	3097

Notes: This table summarizes the descriptive statistics (mean, median, maximum, minimum, standard deviation, skewness, excess kurtosis, the Jarque-Bera statistic, Ljung-Box test statistics for returns and returns squared) of continuously compounded day-to-day percentage returns on five investment portfolios. *EW* denotes returns on an equally-weighted portfolio of pharmaceutical stocks. *VW* denotes returns on a (time-varying) value-weighted portfolio of pharmaceutical stocks. *TOP* denotes returns on a constant-value-weighted portfolio of 10 largest pharmaceutical firms. *BOTTOM* denotes returns on a constant-value-weighted portfolio of 10 smallest pharmaceutical stocks. *SP500^{IT}* denotes returns on the S&P Information Technology stock index. Q_5 denotes the Ljung-Box test statistic for the fifth-order cumulative autocorrelation of stock returns, and Q_5^2 denotes the Ljung-Box test statistic for the fifth-order cumulative autocorrelation of returns squared. The p-values are provided in round parentheses. The table also provides the p-values for the significance tests of the Jarque-Bera and Ljung-Box statistics. We use daily data for the period 01/01/2003 – 11/13/2014 (a total of 3097 observations).

kurtosis is greater than zero. A high value of excess kurtosis contributes to the observed non-normality of returns for the five portfolios, as measured by the Jarque-Bera test statistic. The Ljung-Box test statistic provides evidence of serial correlation in (squared) returns. Therefore, our regression-based methodology in Section 4.3 is designed so as to account for heteroscedasticity.

4 Hypotheses and Methodology

4.1 Testable Hypotheses

This section outlines testable hypotheses for pharmaceutical stock returns around DRNs. DRNs may give rise to two conflicting sentiment effects, the DRNs positive effect and the fear effect. In this respect, [Kaplanski and Levy \(2012\)](#) document a “negative and significant war sentiment effect” during the Yom Kippur war in Israel, and a positive and significant “holiday sentiment effect”. Firstly, DRNs may lead to anxiety, bad mood and pessimism

among the general public and stock market investors, associated with a panic effect generated by overemphasized media coverage of pandemic diseases. In this scenario, anxiety and fear spread across different stock market sectors and may instigate a drop in the pharmaceutical stock prices. Our first hypothesis states that the investor’s fear gauge, provoked by DRNs, may lead to a decrease in the rate of return on pharmaceutical companies’ stocks.

Hypothesis 1. *DRNs may lead to bad mood among investors which negatively affects portfolio returns of pharmaceutical stocks.*

Secondly, globally dangerous diseases may be perceived by stock market investors as a profitable investment opportunity. Investors might unreasonably anticipate that a disease will trigger an increase in R&D expenditure by pharmaceutical companies. This development generates a positive sentiment and hence raises demand for pharmaceutical companies’ stocks. As a result, portfolio valuation increases. Thus, our second hypothesis predicts a positive relation between DRNs and returns on pharmaceutical stocks.

Hypothesis 2. *DRNs have a positive effect on portfolio returns of pharmaceutical stocks.*

Our third hypothesis underlies the assumption that investors initially underreact to an announcement of a globally dangerous disease but they overreact thereafter, wherein the degree of overreaction depends on the announcement’s relative salience as measured by media coverage (Palomino et al., 2009). The larger the information salience of an announcement the faster the contents are incorporated into the share prices (Klibanoff et al., 1998). Within the pharmaceutical industry, considerable media coverage can cause significant changes in stock prices through continuous overreporting, even though no genuinely new information becomes available to the market (Huberman and Regev, 2001). Thus, motivated by the existing literature and the observed inflow of information around PHEIC alerts (see Figure 1), we further hypothesize that, after the event, the positive sentiment of stock market investors remains at an elevated level.

Hypothesis 3. *DRNs have a persistent effect on portfolio returns of pharmaceutical stocks. Such persistence is consistent with an inflow of disease-related information in the stock market.*

Our fourth hypothesis builds on the notion that investor sentiment should affect stronger small stocks relative to large stocks (see, for instance, [Brown and Cliff, 2005](#)). Therefore, we expect that on and after the event day, investor sentiment will be potentially stronger for small pharmaceutical firms than for large firms. This hypothesis is supported by recent studies suggesting that stocks of small firms are mainly held by local investors who tend to be largely influenced by specific events (see also [Edmans et al., 2007](#)). Furthermore, even though large pharmaceutical companies act as forerunners of R&D activities, it may be less costly for small pharmaceuticals to act as followers in the development of new drugs.¹⁷ However, vaccine production requires more costly and sophisticated technologies than drug production ([Hinman et al., 2006](#)). The cost of new vaccines places a constraint on small pharmaceutical firms. As a result, they are likely to contribute to the development of new vaccines less than large firms.

Hypothesis 4. *DRNs have a greater effect on stock returns of small companies relative to large companies.*

Two commonly employed methodologies – the event-study and regression-based – are used to test the aforementioned hypotheses.

4.2 Event Study Methodology

In the spirit of traditional event studies, we begin our analysis by computing cumulative abnormal returns (CARs) around DRNs. The abnormal returns are defined as the difference between the observed rate of return of a pharmaceutical portfolio and its ex-post expected rate of return over the whole length of the event window. The expected rate of return is estimated based on the Fama-French three-factor model¹⁸. We choose an event window length to cover 14 days prior and 14 days after DRNs. The estimation window for the model is 252 days long.

¹⁷Despite the well-documented first-mover advantage in the pharmaceutical industry, “under the current law, the chemical formula and the efficacy of the cure as established by clinical trials are made available for competitors essentially for free” ([Boldrin and Levine \(2013\)](#), Page 13). When patents expire, low-cost generics are immediately introduced in the market.

¹⁸The daily data for the factors SMB, HML, and the excess return on the market were obtained from Kenneth French’s website (<http://mba.tuck.dartmouth.edu/pages/faculty/ken.french>).

In our sample, we observe temporal clustering of DRNs. This means that if all DRNs were taken into account, the CARs would suffer from overlapping event windows. For this reason, our CAR calculations include only a subset of all available DRNs. The DRNs are selected according to the following two criteria. The first selection procedure, labelled LAST EVENT, chooses a DRN only if it is not followed by other DRNs within 28 days after its occurrence. FIRST EVENT, on the other hand, selects the DRNs in a chronological order. It starts with the first DRN in the sample, ignores all DRNs showing up in the proximate 28 days, takes the next DRN in succession, ignores the following 28 days, and so on. This iteration proceeds until the whole sample is exhausted.

For illustration, assume there are five DRNs taking place at dates $\tau_0, \tau_1, \tau_2, \tau_3,$ and τ_4 where $\tau_1, \tau_2,$ and τ_3 are temporally clustered. Then, LAST EVENT uses DRNs for CAR calculation occurring on days $\tau_0, \tau_3,$ and τ_4 and FIRST EVENT chooses $\tau_0, \tau_1,$ and τ_4 . The top two panels in Figure 2 illustrate graphically these two simple examples.

4.3 Regression-Based Methodology

Following existing empirical studies (see Kamstra et al., 2003; Edmans et al., 2007; Kaplanski and Levy, 2010a,b; Curatola et al., 2016), to evaluate the impact of DRNs on pharmaceutical stock returns, and to identify the negative fear effect, we implement the following regression model:

$$R_{p,t} = \beta_0 + \sum_{i=1}^5 \beta_{1,i} R_{p,t-i} + \sum_{i=1}^4 \beta_{2,i} D_{i,t} + \beta_3 D_t^{TAX} + \beta_4 E_t + \beta_5 FI_t + u_{p,t} \quad (1)$$

where $R_{p,t}$ is the daily rate of return on a portfolio of pharmaceutical stocks p , β_0 is the regression intercept, $R_{p,t-i}$ are lagged dependent variables. D_1, D_2, D_3, D_4 are dummy variables for Monday, Tuesday, Wednesday, and Thursday, respectively, and D_t^{TAX} is a dummy variable for the first five days of the taxation year. Further, E_t represents the DRNs effect variable, FI_t denotes a fear index, and $u_{p,t}$ is an error term. In line with existing studies, the VIX is used to proxy the investment fear index also known as “investor fear gauge” (see Whaley, 2009).¹⁹ Specifically, in the spirit of Bloom (2009), our fear indicator is a dummy

¹⁹We consider the VIX an adequate proxy as the correlation between the 252-days rolling standard devi-

variable that takes on value 1 when the US stock market volatility exceeds by more than 1.65 standard deviations the Hodrick-Prescott detrended ($\lambda = 1600 * (365/4)^4$) mean of the stock-market volatility series (i.e., the raw VIX), and 0 otherwise.²⁰

The coefficient β_4 captures the contemporaneous effect of DRNs on the portfolio rate of return. It should be noted that the majority of DRNs (85%) is published by the WHO which is headquartered in Geneva, Switzerland. Due to different time zones, we assume that the US stock market reacts on the day of DRNs publication. Further, previous days' rates of return, $R_{p,t-i}$, variables are embedded in our main regression to account for possible serial correlation. We choose five lagged returns to be sure that all serial correlations have been accounted for. The dummy variables for the days of the week are employed to account for the so-called "Monday effect".

To account for a possible positive sentiment effect on the days following DRNs, or differently, for a possible reversal effect, we run also the following regression:

$$R_{p,t} = \beta_0 + \sum_{i=1}^5 \beta_{1,i} R_{p,t-i} + \sum_{i=1}^4 \beta_{2,i} D_{i,t} + \beta_3 D_t^{TAX} + \sum_{i=0}^I \beta_{4,i} E_{t-i} + \beta_5 FI_t + u_{p,t}. \quad (2)$$

5 Results

5.1 Event Study Methodology

Figure 2 depicts the CARs around the event date. The black solid (dashed) line illustrates the LAST EVENT (FIRST EVENT) approach. The LAST EVENT approach gives rise to positive abnormal returns following the event day for the EW and the BOTTOM portfolio. The increase prior to the event can be attributed to the sensitivity of the LAST EVENT approach to the contiguous (preceding) events in the overlapping window. The FIRST EVENT approach points to an increase in returns of the EW and BOTTOM portfolios on the event day. This increase is rather persistent on the days following the event, thus, confirming that also those DRNs that were discarded in the CAR calculation had a positive

ation of the S&P 500 index and the pharma portfolios is rather high (average correlations are reported in parentheses): EW (0.79), VW (0.72), TOP (0.82), BOTTOM (0.78).

²⁰Notice that the fear effect FI_t overlaps with the sentiment effect generated by DRNs in 119 out of 146 cases.

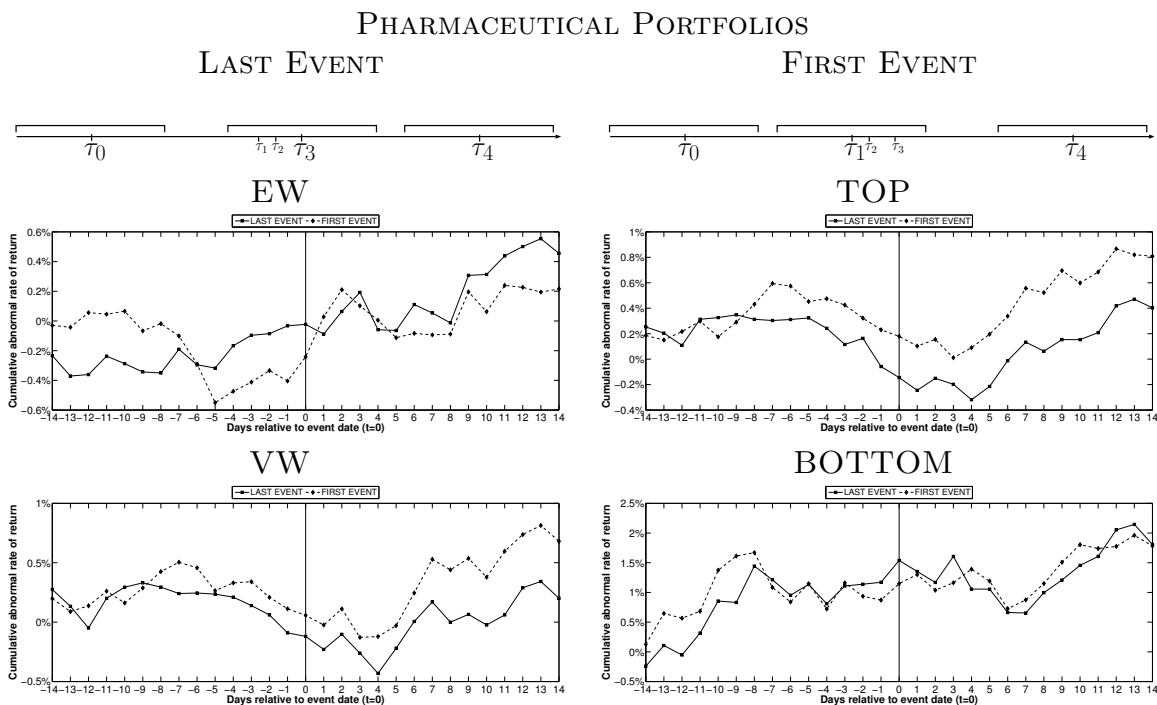
impact on pharmaceutical stock returns. The results are less supporting for the VW and TOP portfolios. We stress that the event study results are weaker than the regression results reported in the next section due to the fact that only 33 out of 146 DRNs were employed in the CAR analysis. In general, EW LAST/FIRST (VW, TOP, BOTTOM) experienced in 27%/30.7% (34.6%/42.3%, 38.4%/42.3%, 53.8%/50%) of all event cases a significant CAR at a 10% level. Still, our CAR analysis provides evidence supporting the persistent (positive) sentiment effect hypothesis. One could anticipate that the SMB factor in the three-factor Fama-French model already captures some of the effect of investment sentiment, biasing the estimate of CARs. Indeed, if investors holding smaller stocks become more optimistic, then the SMB factor increases, and the cumulative abnormal return decreases. We also computed the CARs by employing the excess return on the market in a one-factor model.²¹ The unreported results suggest more pronounced CARs for the BOTTOM portfolio. Overall, our event study analysis reveals a positive and persistent effect of DRNs on stock returns of pharmaceutical companies.

5.2 Regression Analysis

Results examining the effect of the fear gauge and DRN on the pharmaceutical stock market returns are reported in Table 3. Panel A documents our main findings that result from incorporating all events in the regression analysis. For robustness purposes, we also rerun our model on a subsample of DRNs by employing WHO-related announcements only (see Panel B). Consistently with the Investor Fear Gauge Hypothesis (Hypothesis 1), a negative and significant effect of the fear gauge index is obtained. This effect is robust across the five portfolios. The estimated coefficient β_5 ranges from -0.1378 (TOP portfolio) to -0.2056 (VW portfolio). Thus, the effect of investor fear gauge is strongest for diversified portfolios of stocks and weakest for large firms. Further, the DRNs variable effect is always positive and generally significant at the 5% significance level, vindicating Hypothesis 2 (Positive Sentiment Hypothesis). The coefficient estimate ranges from 0.1781 (VW) to 0.3877 (BOTTOM). Thus, in the wake of DRNs, stock returns increase within the range between 18 and 39 basis

²¹In the one-factor model, EW LAST/FIRST (VW, TOP, BOTTOM) experienced in 42.3%/42.3% (46.1%/50%, 46.2%/50%, 53.9%/50%) of all event cases a significant CAR at a 10% level.

Figure 2: CUMULATIVE ABNORMAL RETURNS



Notes: This figure depicts the average cumulative residuals around the event date ($t = 0$) for pharmaceutical portfolios EW, VW, TOP, and BOTTOM. The residual on day t is calculated as the difference between observed rate of return and the ex-post expected rate of return on day t . The three-factor model is $r_t = \alpha + \beta_1(r_{m,t} - r_f) + \beta_2 smb_t + \beta_3 hml_t + \epsilon_t$, where r_t is the pharmaceutical portfolio return and $r_{m,t} - r_f$, smb_t and hml_t are Fama-French factors. The estimation window is 252 days. The solid (dashed) line represents the LAST (FIRST) EVENT approach when estimating the CARs. This ensures that event windows are non-overlapping. The top two panels illustrate the two different estimation procedures graphically. The LAST (FIRST) EVENT approach includes event days τ_0 , τ_3 and τ_4 (τ_0 , τ_1 and τ_4) in the estimation procedure. The events occurred during a 12-year period (March 2003 to December 2014) which includes 33 event days with non-overlapping event windows.

points. This is an interesting finding, insofar as pandemic diseases, such as Ebola, may not actually spread in the US. However, as suggested by existing studies, investor decisions can be guided by sentiment. Paradoxically, while globally dangerous diseases may impose non-negligible costs on the economy and may potentially lead to the depletion of resources, DRNs can produce an optimistic view and a positive sentiment effect among stock market investors located in the US. The investors unreasonably anticipate that pharmaceutical companies whose stocks or ADRs are listed on the NYSE or NASDAQ will invest in R&D and, potentially, raise their future cash flows. However, they overlook the fact that the patent system constrains investment and productivity growth in the pharmaceutical industry (Boldrin and Levine, 2013). At the same time, they underestimate the probability that vaccines and medicines are not necessarily effective (Shortridge, 2004). The results unambiguously indi-

cate that stock market investors should buy stocks when an outbreak of a pandemic disease is announced. Moreover, investment in a relatively diversified portfolio of stocks (such as EW or VW) when a pandemic disease is announced yields a lower return than investment in a portfolio of small stocks (such as BOTTOM), *ceteris paribus*.²² This finding supports Hypothesis 4 wherein small stocks respond stronger to investor sentiment than large stocks. This result resonates well with [Brown and Cliff \(2005\)](#) and [Edmans et al. \(2007\)](#).

Table 4 further shows that the investor fear gauge has the smallest (largest) effect (in absolute value) for the TOP (VW) portfolio (-0.1481 and -0.2163, respectively). The investor fear gauge reflects investor pessimism regarding portfolio investment, which has a negative effect on stock prices and returns of pharmaceutical companies. This result confirms Hypothesis 1, which predicts a negative relation between investor fear gauge and returns on pharmaceutical companies' stocks. It is qualitatively similar to results reported by [Kaplan-ski and Levy \(2012\)](#), wherein the investor fear gauge provoked by the Yom Kippur war is responsible for a negative effect on the stock market return of the Tel Aviv Stock Exchange. Table 4 also indicates that the investor's sentiment effect is positive and persistent. We use six lags of DRNs to capture the persistence. We test the combined effect of the contemporaneous and lagged DRNs on pharmaceutical stock returns. To this end, we test for the significance of the coefficient sum $\sum_{i=0}^I \beta_{4,i}$. Entries related to this coefficient sum highlight that the DRNs positive sentiment effect is stronger among small pharmaceutical firms (0.8169) and is weaker for the value-weighted portfolio (0.4860). In all cases, the coefficient is significant at 1% level. Results in Table 4 build on the assumption that the DRNs positive sentiment effect will last for six trading days due to a continuous flow of information in the stock market. Indeed, as suggested by Figure 1, the number of media articles remains above average during six days in the aftermath of a PHEIC event. The estimated lagged effects are also consistent with [Kaplanski and Levy \(2010b\)](#), who argue that the announcement typically receives headlines several days after the event. The estimation results for the five portfolios show a positive and significant effect (at the significance level of 5% or higher) for at least six working days after DRNs is released. Thus, our results also support Hypothesis

²²It should also be noted that either due to lower expenses related to sub-contracting ([Assid et al., 2015](#)) or less costly imitation of larger pharmaceutical companies ([Boldrin and Levine, 2013](#)), small pharmaceutical stocks can potentially generate higher returns than large stocks.

3 (i.e., Persistent Sentiment Hypothesis), wherein the positive sentiment remains significant several days after the DRNs. This result agrees with [Huberman and Regev \(2001\)](#) who underscore the importance of the information salience of a breakthrough in bio-pharmaceutical research. Taking together contemporaneous and lagged effects, there is unequivocal evidence that DRNs has a positive and significant (either contemporaneous or lagged) effect on the pharmaceutical stock prices.

Finally, it is worth noting that fear gauge and DRNs not only can provoke changes in the pharmaceutical stock prices, but also in the S&P500 Information Technology stock index – an industry unrelated to globally dangerous diseases – thus lending further support to the investment sentiment effect. Specifically, our results indicate that fear gauge (DRNs) has always a negative (positive) and significant effect on returns of the S&P500 Information Technology stock index. This result shows that the investor sentiment effect can be widespread across various industries in the economy and lead to profitable trading strategies in the stock market.

It is worth noting that our research findings were further validated by a number of robustness checks. First, we sought to ascertain the extent to which investor sentiment can spread to other sectors of the economy and even to other countries. In this regard, the presence of investor sentiment was identified in the S&P500 Industrials portfolio – an industry seemingly unrelated to globally dangerous diseases. The impact of fear gauge and DRNs was also tested on regions that were directly affected by globally dangerous diseases. In particular, the estimation results show a negative (positive) and significant effect of fear gauge (DRNs) on returns on the MSCI Emerging Markets stock market index. Second, to account for the presence of conditional heteroscedasticity in daily stock returns, our regression methodology was extended to include a battery of GARCH specifications. As in the benchmark methodology, results show a negative (positive) and significant effect of fear gauge (DRN) on pharmaceutical stock return, endorsing the main findings. Third, as a complementary exercise, we varied the number of lags in Eq. (2). The estimation results broadly support Hypothesis 3. Fourth, we performed all our regressions excluding the control variables (i.e., with the DRNs and fear gauge variables only). Again, the main findings can be upheld. The general conclusion that can be drawn from these robustness checks is

that investor sentiment, triggered by globally dangerous diseases, is neither confined to the pharmaceutical industry nor is model specific. By contrast, the presence of investor sentiment is robust to the type of activity, the geographical scope and the various methodological underpinnings.²³

²³All the additional checks are not reported but are available from the authors upon request.

Table 3: REGRESSION RESULTS – ALL EVENTS (DRNs EFFECT & FEAR EFFECT)

$E_{i,t}$	β_0	$\frac{\beta_{1,1}}{R_{t-1}}$	$\frac{\beta_{1,2}}{R_{t-2}}$	$\frac{\beta_{1,3}}{R_{t-3}}$	$\frac{\beta_{1,4}}{R_{t-4}}$	$\frac{\beta_{1,5}}{R_{t-5}}$	$\frac{\beta_{2,1}}{Mon.}$	$\frac{\beta_{2,2}}{Tues.}$	$\frac{\beta_{2,3}}{Wed.}$	$\frac{\beta_{2,4}}{Thurs.}$	$\frac{\beta_3}{TAX}$	$\frac{\beta_4}{E_t}$	$\frac{\beta_5}{FI_t}$	$LogL$
PANEL A: ALL DRNs + Fear Effect														
EW														
1	0.1304*** (0.0032)	0.0650** (0.0151)	0.0222 (0.4916)	0.0243 (0.3863)	0.0194 (0.4605)	-0.0129 (0.6770)	-0.1093 (0.1037)	0.0098 (0.8746)	-0.0544 (0.3915)	-0.0354 (0.5939)	0.4168*** (0.0009)	0.3861*** (0.0004)	-0.1819*** (0.0000)	-4977.15
VW														
2	0.1134** (0.0165)	-0.0346 (0.1894)	-0.0487 (0.1313)	0.0049 (0.8509)	-0.0047 (0.8568)	-0.0022 (0.9387)	0.0386 (0.5338)	0.1777*** (0.0040)	0.0433 (0.4748)	0.0359 (0.5798)	0.2843** (0.0284)	0.1781* (0.0742)	-0.2056*** (0.0000)	-4774.72
TOP														
3	0.0361 (0.3625)	-0.0393 (0.2301)	-0.0777* (0.0633)	0.0248 (0.4355)	0.0061 (0.8453)	-0.0110 (0.7664)	0.0531 (0.3433)	0.1437*** (0.0090)	0.0373 (0.4877)	0.0249 (0.6678)	0.1972* (0.0893)	0.2274*** (0.0063)	-0.1378*** (0.0000)	-4448.79
BOTTOM														
4	0.2192*** (0.0011)	-0.0309 (0.1472)	0.0181 (0.3684)	-0.0096 (0.6147)	0.0465** (0.0218)	0.0105 (0.5691)	-0.3420*** (0.0001)	-0.2324*** (0.0088)	-0.0475 (0.5946)	-0.1129 (0.2241)	0.5659*** (0.0025)	0.3877** (0.0235)	-0.1842*** (0.0012)	-5872.04
SP500 IT														
5	0.0203 (0.6953)	-0.0837*** (0.0027)	-0.0350 (0.2696)	0.0105 (0.7092)	-0.0056 (0.8526)	-0.0175 (0.6115)	0.1016 (0.1827)	0.2086*** (0.0057)	0.1201 (0.1057)	0.1027 (0.1695)	0.3400* (0.0976)	0.3883*** (0.0007)	-0.1792*** (0.0000)	-5342.82
PANEL B: WHO Disease Outbreak News + WHO Statements + Fear Effect														
EW														
1	0.1426*** (0.0013)	0.0650** (0.0151)	0.0224 (0.4868)	0.0252 (0.3676)	0.0187 (0.4796)	-0.0132 (0.6712)	-0.1289* (0.0552)	0.0013 (0.9834)	-0.0631 (0.3212)	-0.0396 (0.5514)	0.4184*** (0.0009)	0.3968*** (0.0012)	-0.1811*** (0.0000)	-4978.71
VW														
2	0.1184** (0.0124)	-0.0350 (0.1841)	-0.0494 (0.1254)	0.0048 (0.8535)	-0.0062 (0.8141)	-0.0022 (0.9400)	0.0263 (0.6724)	0.1754*** (0.0045)	0.0393 (0.5167)	0.0349 (0.5897)	0.2884** (0.0260)	0.2720** (0.0111)	-0.2089*** (0.0000)	-4773.51
TOP														
3	0.0431 (0.2764)	-0.0399 (0.2236)	-0.0781* (0.0618)	0.0247 (0.4371)	0.0048 (0.8786)	-0.0106 (0.7744)	0.0400 (0.4748)	0.1393** (0.0113)	0.0322 (0.5499)	0.0228 (0.6946)	0.1998* (0.0844)	0.2723*** (0.0068)	-0.1390*** (0.0000)	-4448.62
BOTTOM														
4	0.2335*** (0.0005)	-0.0314 (0.1414)	-0.0087 (0.3422)	0.0087 (0.6487)	0.0472** (0.0198)	0.0112 (0.5440)	-0.3544*** (0.0001)	-0.2450*** (0.0057)	-0.0564 (0.5263)	-0.1190 (0.1999)	0.5605*** (0.0026)	0.2043 (0.2936)	-0.1760*** (0.0020)	-5875.19
SP500 IT														
5	0.0328 (0.5269)	-0.0828*** (0.0030)	-0.0346 (0.2753)	0.0110 (0.6966)	-0.0071 (0.8142)	-0.0169 (0.6244)	0.0830 (0.2769)	0.1994*** (0.0083)	0.1112 (0.1348)	0.0979 (0.1906)	0.3406* (0.0962)	0.3716** (0.0110)	-0.1773*** (0.0000)	-5344.64

Notes: This table reports the results of Eq. (1). Results of regressions of continuously compounded day-to-day percentage returns on an equally weighted portfolio of pharmaceutical stocks (EW), value-weighted portfolio (VW), constant-value-weighted portfolio of 10 largest pharmaceutical stocks (TOP), a constant-value-weighted portfolio of 10 smallest pharmaceutical stocks (BOTTOM), and S&P500 Information Technology index (SP500 IT) are reported. VW is computed using time-varying weights, whereas TOP and BOTTOM are computed using constant weights, based on the initial market capitalization. The estimated equations are in rows, and the estimated coefficients are in columns. E_t represents the DRN effect variable. DRNs (i.e., event days) are reported in Table A.2. In Panel A E_t is composed of all DRNs. In Panel B E_t is composed of WHO Disease Outbreak News and WHO Statements only. The log-likelihood value of the estimated model is shown in the last column. The corresponding p-values are provided in round parentheses. The (Eicker-White) standard error estimates are robust to heteroscedasticity. *, **, and *** asterisks indicate a significance level of 10%, 5% and 1%, respectively. We use daily data for the period 01/01/2003 – 11/13/2014 (a total of 3097 observations).

Table 4: REGRESSION RESULTS – ALL EVENTS (DRNs CONTEMPORANEOUS AND LAGGED EFFECTS & FEAR EFFECT)

$E_{i,t}$	β_0	$\beta_{1,1}$	$\beta_{1,2}$	$\beta_{1,3}$	$\beta_{1,4}$	$\beta_{1,5}$	$\beta_{2,1}$	$\beta_{2,2}$	$\beta_{2,3}$	$\beta_{2,4}$	β_3	$\sum_{i=0}^6 \beta_{4,i}$	β_5	$L_{\log L}$
	R_{t-1}	R_{t-2}	R_{t-3}	R_{t-4}	R_{t-5}	R_{t-5}	Mon.	Tues.	Wed.	Thurs.	TAX	$\sum_{i=0}^6 E_{t-i}$	F_{1t}	
PANEL A: ALL DRNs + Fear Effect														
EW														
1	0.1235*** (0.0055)	0.0616** (0.0214)	0.0196 (0.5431)	0.0229 (0.4153)	0.0163 (0.5375)	-0.0166 (0.5958)	-0.1171* (0.0820)	-0.0005 (0.9941)	-0.0505 (0.4272)	-0.0327 (0.6217)	0.4392*** (0.0005)	0.7597*** (0.0000)	-0.1959*** (0.0000)	-4971.54
VW														
2	0.1099** (0.0195)	-0.0363 (0.1668)	-0.0490 (0.1293)	0.0040 (0.8769)	-0.0071 (0.7851)	-0.0045 (0.8784)	0.0281 (0.6514)	0.1635*** (0.0085)	0.0417 (0.4940)	0.0405 (0.5319)	0.3009** (0.0202)	0.4860*** (0.0011)	-0.2163*** (0.0000)	-4767.39
TOP														
3	0.0333 (0.4030)	-0.0419 (0.2020)	-0.0795* (0.0580)	0.0227 (0.4767)	0.0034 (0.9143)	-0.0134 (0.7182)	0.0442 (0.4309)	0.1316** (0.0173)	0.0351 (0.5157)	0.0253 (0.6630)	0.2134* (0.0658)	0.5171*** (0.0004)	-0.1481*** (0.0000)	-4443.67
BOTTOM														
4	0.2182*** (0.0012)	-0.0335 (0.1180)	0.0159 (0.4290)	-0.0124 (0.5175)	0.0454** (0.0248)	0.0091 (0.6236)	-0.3508*** (0.0001)	-0.2471*** (0.0054)	-0.0638 (0.4761)	-0.1262 (0.1757)	0.5928*** (0.0015)	0.8169*** (0.0018)	-0.1993*** (0.0005)	-5867.43
SP500 IT														
5	0.0160 (0.7577)	-0.0852*** (0.0023)	-0.0360 (0.2570)	0.0096 (0.7338)	-0.0070 (0.8165)	-0.0188 (0.5869)	0.0950 (0.2140)	0.2034*** (0.0072)	0.1237* (0.0979)	0.1041 (0.1652)	0.3527* (0.0862)	0.6166*** (0.0009)	-0.1876*** (0.0000)	-5340.99
PANEL B: WHO Disease Outbreak News + WHO Statements + Fear Effect														
EW														
1	0.1370*** (0.0022)	0.0621** (0.0205)	0.0209 (0.5174)	0.0233 (0.4055)	0.0163 (0.5365)	-0.0169 (0.5883)	-0.1283* (0.0601)	-0.0052 (0.9344)	-0.0550 (0.3936)	-0.0348 (0.6014)	0.4348*** (0.0006)	0.8091*** (0.0001)	-0.1978*** (0.0000)	-4973.93
VW														
2	0.1144** (0.0161)	-0.0363 (0.1682)	-0.0503 (0.1191)	0.0032 (0.9024)	-0.0073 (0.7797)	-0.0044 (0.8792)	0.0266 (0.6713)	0.1727*** (0.0059)	0.0369 (0.5455)	0.0459 (0.4803)	0.2989** (0.0210)	0.5685*** (0.0007)	-0.2208*** (0.0000)	-4769.27
TOP														
3	0.0380 (0.3418)	-0.0414 (0.2077)	-0.0800* (0.0564)	0.0220 (0.4902)	0.0029 (0.9255)	-0.0136 (0.7146)	0.0436 (0.4406)	0.1389** (0.0130)	0.0304 (0.5760)	0.0313 (0.5924)	0.2111* (0.0683)	0.5780*** (0.0009)	-0.1511*** (0.0000)	-4444.44
BOTTOM														
4	0.2305*** (0.0007)	-0.0331 (0.1204)	0.0153 (0.4486)	-0.0113 (0.5544)	0.0447** (0.0279)	0.0084 (0.6506)	-0.3466*** (0.0001)	-0.2614*** (0.0035)	-0.0512 (0.5693)	-0.1401 (0.1356)	0.5886*** (0.0015)	0.8869*** (0.0025)	-0.2025*** (0.0004)	-5868.26
SP500 IT														
5	0.0300 (0.5660)	-0.0839*** (0.0027)	-0.0345 (0.2777)	0.0101 (0.7206)	-0.0089 (0.7701)	-0.0182 (0.5994)	0.0815 (0.2898)	0.1968** (0.0104)	0.1177 (0.1194)	0.1035 (0.1709)	0.3447* (0.0926)	0.4854** (0.0382)	-0.1816*** (0.0000)	-5344.64

Notes: This table reports the results of Eq. (2). Results of regressions of continuously compounded day-to-day percentage returns on an equally weighted portfolio of pharmaceutical stocks (EW), value-weighted portfolio (VW), constant-value-weighted portfolio of 10 largest pharmaceutical stocks (TOP), a constant-value-weighted portfolio of 10 smallest pharmaceutical stocks (BOTTOM), and S&P500 Information Technology index (SP500 IT) are reported. VW is computed using time-varying weights, whereas TOP and BOTTOM are computed using constant weights, based on the initial market capitalization. The estimated equations are in rows, and the estimated coefficients are in columns. E_{t-i} ($i = 0, 1, 2, \dots, 6$) stands for possible DRN effect and reversal (or persistent) effect indicator. $\sum_{i=0}^6 \beta_{4,i}$ measures the accumulated effect of the lagged DRNs. DRNs (i.e., event days) are reported in Table A.2. In Panel A E_t is composed of all DRNs. In Panel B E_t is composed of WHO Disease Outbreak News and WHO Statements only. The log-likelihood value of the estimated model is shown in the last column. The corresponding p-values are provided in round parentheses. The (Eicker-White) standard error estimates are robust to heteroscedasticity. *, **, and *** asterisks indicate a significance level of 10%, 5% and 1%, respectively. We use daily data for the period 01/01/2003 – 11/13/2014 (a total of 3097 observations).

6 Exploiting Sentiment and Fear Effects

Based on the empirical evidence reported in the previous sections, we assume that an investor is willing to exploit both sentiment and fear effects in response to DRNs by reallocating her wealth to pharmaceutical stocks. For this purpose, we consider a zero-cost strategy. On event days that coincide with high-volatility periods, as measured by the fear index, the zero-cost spread portfolio takes a 100% long position in one of the four above mentioned pharmaceutical portfolios and a 100% short position in the VIX. We let the holding period of the spread portfolio vary between one (1D) and three days (3D). To eliminate timing-inconsistencies, the trade is initiated at closing prices of the event day. This procedure ensures that no trade precedes a DRN publication on any given event day.²⁴ Table 5 reports the strategies' average performance. In Panel A all DRNs are taken into account while Panel B considers only the WHO-related subsample. The 1D strategy does not yield a significant performance for all four pharmaceutical portfolios. Differently, a holding period of two or three days is remarkably profitable. Such profitability is higher in the case of the EW and BOTTOM portfolios.

The longer term profitability of overweighting pharmaceutical stocks and underweighting the VIX is illustrated in Figure 3. Differently from the strategies presented in Table 6, we assume in the following full exposure to the stock market. That is, during tranquil times investor's wealth is invested in the market portfolio, which is proxied by the S&P500. On event days that coincide with high-volatility periods, the investor reallocates her funds by going 150% long in a pharmaceutical portfolio and 50% short in the VIX index and holds her position between one (1D) and three (3D) days. The depicted outperformance is calculated as the difference between the cumulative performance of a trading strategy and the market portfolio. A visual inspection suggests a similar performance between the VW and TOP portfolios while EW and BOTTOM are the more profitable strategies for all three investment horizons.

For robustness purposes, we ignore the fear effects and consider a simple buy-and-hold

²⁴A more precise approach would involve the exact publication time of the news in a given country and by taking into account the time zone difference between the US and the respective country. Unfortunately, the majority of DRNs does not have a time stamp. Nevertheless, our trading strategy is consistent in timing for those DRNs that are accompanied with an exact publication time.

Table 5: TRADING STRATEGY

PANEL A: (ALL DRNs)				
	<i>EW</i>	<i>VW</i>	<i>TOP</i>	<i>BOTTOM</i>
1D	0.518 (0.5208)	0.3755 (0.5085)	0.4208 (0.5036)	0.3941 (0.5226)
2D	1.6302** (0.7754)	1.2548** (0.7551)	1.2544** (0.7386)	1.4261** (0.7592)
3D	1.913** (0.8539)	1.433** (0.8076)	1.4542** (0.8006)	1.9172*** (0.8063)
PANEL B: (WHO DISEASE OUTBREAK NEWS + WHO STATEMENTS)				
	<i>EW</i>	<i>VW</i>	<i>TOP</i>	<i>BOTTOM</i>
1D	0.4991 (0.5725)	0.3831 (0.5618)	0.4181 (0.5555)	0.424 (0.5877)
2D	1.6275** (0.8505)	1.2644* (0.8368)	1.2491* (0.8174)	1.3749* (0.8572)
3D	2.0802** (0.9783)	1.6035** (0.9301)	1.6335** (0.9224)	2.1461** (0.9296)

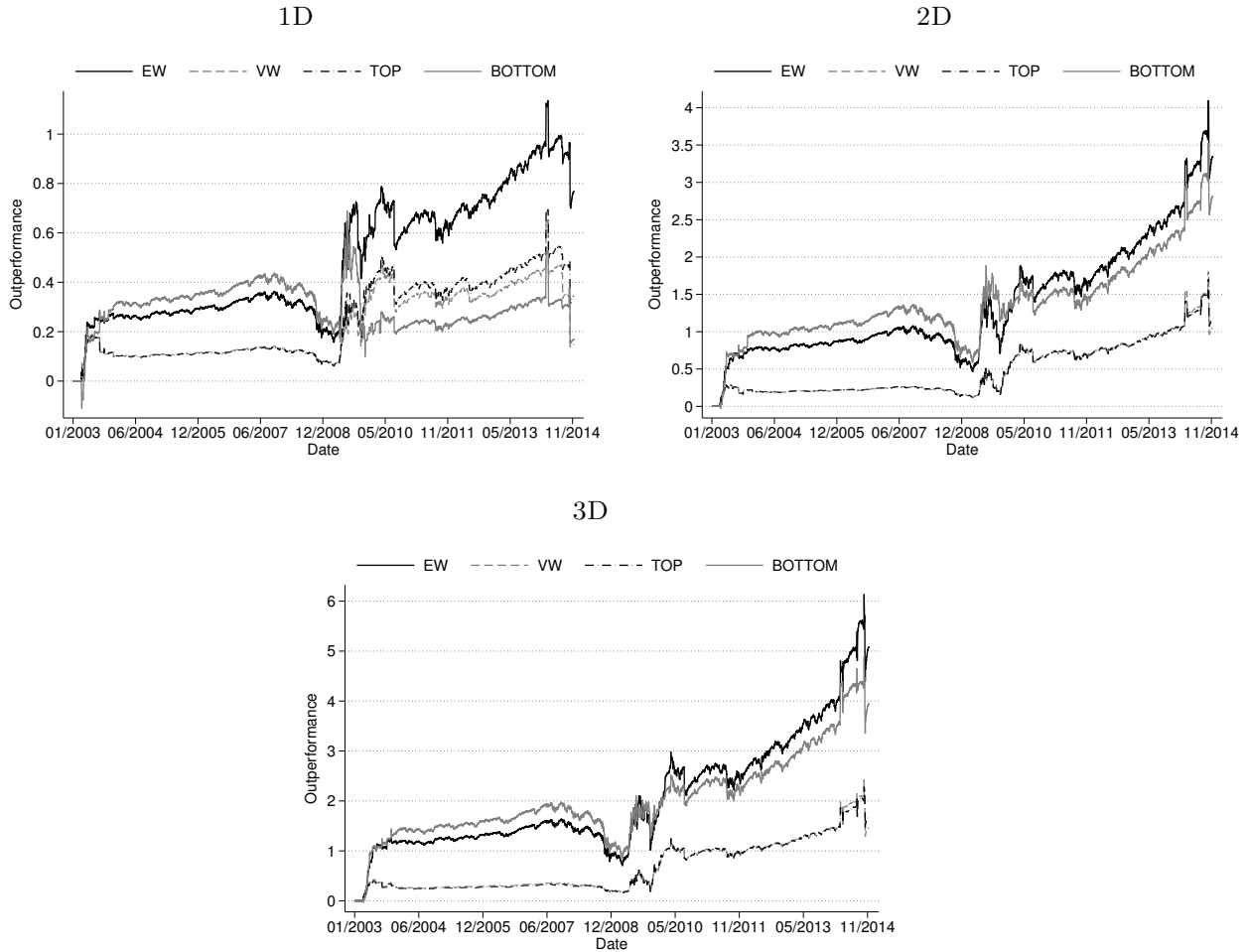
Notes: This table presents the average performance (in %, standard deviations are in parentheses) of a spread portfolio that is invested 100% long in a pharmaceutical portfolio and 100% short in VIX. Long and short positions are taken only during high-volatility states of the world (as indicated by the Fear Index) and using closing prices of the DRN day. The holding period of the portfolio varies between one (1D) and three days (3D). In Panel A the trading strategy is based on all DRNs. In Panel B the trading strategy is based on WHO Disease Outbreak News and WHO Statements only. The trading period runs from January 2003 to November 2014 (3097 trading days). Standard errors are reported in parentheses. *, ** and *** denote significance of a two-tailed t-Test at the 10%, 5% and 1% level, respectively.

strategy that initiates a long position in a pharmaceutical portfolio at the closing prices of an event day and holds it for 14 days. The unreported results confirm that also this strategy would have yielded a positive outperformance over the market.²⁵

Overall, we find that investment strategies exploiting sentiment and fear effect related to DRNs lead to higher profitability. Once again, this result is most pronounced for the BOTTOM portfolio confirming that sentiment tends to have a greater effect on small stocks.

²⁵The EW (VW, TOP, BOTTOM) portfolio has on average a 1.6% (0.7%, 0.3%, 1.7%) higher performance than the S&P500 during a 14 day period.

Figure 3: OUTPERFORMANCE OF DRNs AND FEAR EFFECTS STRATEGIES



Notes: This figure depicts the outperformance of portfolios that follow DRNs-based trading strategies. The strategies initiate a 150% long position in a pharmaceutical portfolio (using closing prices of the DRN day) and a 50% short position in the VIX on those event dates that coincide with high-volatility states of the world as indicated by the Fear Index. During tranquil times (i.e., absence of DRN), the trading portfolio is invested 100% in the S&P500. The holding period of the strategies varies between one (Panel 1D) and three days (Panel 3D). The outperformance is calculated as the difference between the cumulative performance of the four trading portfolios and a long-only position in the market portfolio that is proxied by S&P500. Assuming an initial investment of US\$ 1, the application of the trading strategies 1D–3D to EW (VW, TOP, BOTTOM) yields on average between USD 0.48–2.05 (0.22–0.67, 0.24–0.66, 0.29–2.02) more than a long-only market exposure. The trading period runs from January 2003 to November 2014 (3097 trading days).

7 Concluding remarks

Motivated by the abundance of recent behavioral finance studies showing that particular events (e.g., St. Patrick Day, Yom Kippur War, Rosh Hashanah, International Sporting Games) may have a strong effect on investors' mood, this paper tests whether DRNs have a significant positive sentiment effect among investors interested in US pharmaceutical companies and, thus, on their stock prices. This research builds on the notion that vaccine produc-

tion for globally dangerous diseases is concentrated in a few large pharmaceutical companies. Indeed, the number of vaccine producers in the U.S. decreased dramatically from the sixties – in 1967 there were 37 vaccine producers (Masignani et al., 2003) – to just over a dozen in 2016. Rational investors design trading strategies that are based on expectations of future cash flows of these companies. We argue that rational trading should not occur because of two reasons. First, in the wake of DRNs, uncertainty surrounding distant cash flows of vaccine developers may be too high. Second, resources available for smaller pharmaceutical companies may be too limited to engage in large-scale R&D. For instance, it is required to invest at least USD 850 million to license a new pharmaceutical product (Masignani et al., 2003). As a result, pharmaceutical stock prices should not respond to DRNs. Thus, DRNs can only lead to higher stock prices and returns of other pharmaceutical companies through altering investor sentiment about their future performance and leading to irrational trading (see also Kaplanski and Levy, 2010b). The potential negative sentiment effect induced by fear and anxiety due to DRNs is also tested, allowing us to account for two conflicting sentiment effects.

Our findings are as follows. First, we observe that DRNs exert a positive and significant effect on pharmaceutical firms' stock returns. This effect is relatively stronger for a portfolio of small stocks. We further observe that the DRN effect lasts for several days. Based on the assumption that a DRN can also generate panic, fear and anxiety among international investors, we observe that an ad hoc fear gauge index appears to exert a negative and significant effect on returns of pharmaceutical companies' stocks. Again, the effect is stronger for small relative to large stocks.

Overall, this research shows that optimism and pessimism – induced by DRNs – can significantly influence portfolio investment decisions in the pharmaceutical industry. Our findings are of utmost importance and practical usefulness for institutional and individual investors, portfolio managers, financial analysts and pharmaceutical firms. Indeed, we identify a range of exploitable investment opportunities. To this end, we design a number of trading strategies that involve a portfolio of pharmaceutical stocks and the VIX volatility index.

The results of the exercise unambiguously show that trading strategies yield positive and

significant returns. The outcome of this exercise is also useful for portfolio managers who formulate a professional and qualified advice for investors. Financial analysts can provide a comprehensive analysis of investment opportunities in the pharmaceutical sector. Furthermore, by issuing and selling new stocks to investors, pharmaceutical firms can benefit from increasing market valuation and, hence, from lower cost fundings for R&D spending when a global disease breaks out and accelerates.

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APPENDIX

A Data

NO	NAME	MCAP	CAP WEIGHT	CUM SUM 1	CUM SUM 2
1	PFIZER	188593.1946	15.5172	15.5172	100.0000
2	JOHNSON & JOHNSON	180892.8180	14.8836	30.4008	84.4828
3	GLAXOSMITHKLINE	124710.2614	10.2610	40.6617	69.5992
4	MERCK & COMPANY	114423.0361	9.4146	50.0763	59.3383
5	ABBOTT LABORATORIES	73520.9544	6.0492	56.1255	49.9237
6	ASTRAZENECA	71562.0971	5.8880	62.0135	43.8745
7	AMGEN	68315.0835	5.6209	67.6344	37.9865
8	ELI LILLY	62379.5576	5.1325	72.7669	32.3656
9	BRISTOL MYERS SQUIBB	61626.7479	5.0706	77.8374	27.2331
10	GILEAD SCIENCES	35021.1338	2.8815	80.7189	22.1626
11	NOVO NORDISK	34284.6745	2.8209	83.5398	19.2811
12	TEVA PHARM.INDS	28821.6231	2.3714	85.9112	16.4602
13	BIOGEN IDEC	20895.2112	1.7192	87.6304	14.0888
14	ALLERGAN	17904.0011	1.4731	89.1035	12.3696
15	GENZYME	14939.5048	1.2292	90.3327	10.8965
16	FOREST LABS	13182.6281	1.0846	91.4174	9.6673
17	VALEANT	9007.8462	0.7412	92.1585	8.5826
18	ACTAVIS	7885.8495	0.6488	92.8074	7.8415
19	ELAN	7077.8720	0.5824	93.3897	7.1926
20	MYLAN	6572.2429	0.5408	93.9305	6.6103
21	ALEXION PHARMS	6338.2386	0.5215	94.4520	6.0695
22	SIGMA ALDRICH	5935.0372	0.4883	94.9403	5.5480
23	VERTEX PHARMS	5909.6323	0.4862	95.4265	5.0597
24	REGENERON PHARMS	5319.3428	0.4377	95.8642	4.5735
25	PERRIGO	4580.8478	0.3769	96.2411	4.1358
26	CEPHALON	4198.4394	0.3454	96.5866	3.7589
27	AMYLIN PHARMS	2882.0073	0.2371	96.8237	3.4134
28	IDEXX LABORATORIES	2858.6592	0.2352	97.0589	3.1763
29	OSI PHARMS.	2295.2012	0.1888	97.2477	2.9411
30	ONYX PHARMS.	2212.3014	0.1820	97.4298	2.7523
31	NBTY DEAD	2154.6428	0.1773	97.6070	2.5702
32	BIO-TECHNE	2134.9189	0.1757	97.7827	2.3930
33	PDL BIOPHARMA	1658.8950	0.1365	97.9192	2.2173
34	CUBIST PHARMACEUTICALS	1521.3011	0.1252	98.0444	2.0808
35	PHARMACYCLICS	1377.5567	0.1133	98.1577	1.9556
36	IMMUCOR DEAD	1200.8945	0.0988	98.2565	1.8423
37	ISIS PHARMACEUTICALS	1113.6985	0.0916	98.3482	1.7435
38	PAR PHARMACEUTICAL COS.	1078.8536	0.0888	98.4369	1.6518
39	NEKTAR THERAPEUTICS	1074.3753	0.0884	98.5253	1.5631
40	CHATTEM DEAD	1023.8235	0.0842	98.6096	1.4747
41	VIROPHARMA DEAD	945.5819	0.0778	98.6874	1.3904
42	MARTEK BIOSCIENCES DEAD	906.6911	0.0746	98.7620	1.3126
43	QUESTCOR PHARMS.	857.4462	0.0705	98.8325	1.2380
44	QLT (NAS)	850.3269	0.0700	98.9025	1.1675
45	NPS PHARMACEUTICALS	793.5564	0.0653	98.9678	1.0975
46	ENZON PHARMS.	699.0431	0.0575	99.0253	1.0322
47	MERIDIAN BIOSCIENCE	583.7499	0.0480	99.0733	0.9747
48	USANA HEALTH SCIENCES	524.6496	0.0432	99.1165	0.9267
49	IMMUNOGEN	523.7035	0.0431	99.1596	0.8835
50	CAMBREX	518.7217	0.0427	99.2022	0.8404
51	VIVUS	485.4240	0.0399	99.2422	0.7978
52	NEOGEN	472.8012	0.0389	99.2811	0.7578
53	QUIDEL	396.0453	0.0326	99.3137	0.7189
54	GERON	392.1340	0.0323	99.3459	0.6863
55	CTI BIOPHARMA	354.9887	0.0292	99.3751	0.6541
56	AMAG PHARMACEUTICALS	354.7572	0.0292	99.4043	0.6249
57	AMARIN	353.9426	0.0291	99.4335	0.5957
58	CELLEX THERAPEUTICS	339.2544	0.0279	99.4614	0.5665
59	ASTEX PHARMACEUTICALS	328.9040	0.0271	99.4884	0.5386

60	ORASURE TECHS.	323.2983	0.0266	99.5150	0.5116
61	XOMA	312.4535	0.0257	99.5407	0.4850
62	PROGENICS PHARMS.	311.1469	0.0256	99.5663	0.4593
63	SAREPTA THERAPEUTICS	270.2514	0.0222	99.5886	0.4337
64	CERUS	269.7842	0.0222	99.6108	0.4114
65	NOVAVAX	261.0639	0.0215	99.6323	0.3892
66	FLAMEL TECHS.	252.9481	0.0208	99.6531	0.3677
67	HI-TECH PHML.	230.6911	0.0190	99.6720	0.3469
68	BIOCRYST PHARMS.	227.5715	0.0187	99.6908	0.3280
69	DEPOMED	218.5011	0.0180	99.7087	0.3092
70	ARQULE	211.1096	0.0174	99.7261	0.2913
71	SCICLONE PHARMS.	192.3768	0.0158	99.7419	0.2739
72	VICAL	191.0992	0.0157	99.7577	0.2581
73	PEREGRINE PHARMS.	191.0939	0.0157	99.7734	0.2423
74	ARCA BIOPHARMA	177.9806	0.0146	99.7880	0.2266
75	ONCOTHYREON (NAS)	163.0754	0.0134	99.8015	0.2120
76	TRINITY BIOTECH	161.7711	0.0133	99.8148	0.1985
77	DISCOVERY LABORATORIES	160.3241	0.0132	99.8280	0.1852
78	REPLIGEN	156.1896	0.0129	99.8408	0.1720
79	ANIKA THERAPEUTICS	131.3024	0.0108	99.8516	0.1592
80	SIGA TECHNOLOGIES	130.3700	0.0107	99.8623	0.1484
81	DUSA PHARMACEUTICALS	124.5980	0.0103	99.8726	0.1377
82	CASI PHARMACEUTICALS	121.1209	0.0100	99.8826	0.1274
83	THERAGENICS	117.7449	0.0097	99.8922	0.1174
84	REPROS THERAPEUTICS	101.2414	0.0083	99.9006	0.1078
85	LA JOLLA PHARM.	100.3018	0.0083	99.9088	0.0994
86	ONCOGENEX PHARMS.	99.5011	0.0082	99.9170	0.0912
87	HEMISPHERX BIOPHARMA	99.2742	0.0082	99.9252	0.0830
88	GTC BIOTH.	96.8866	0.0080	99.9332	0.0748
89	PONIARD PHARMS.	90.9323	0.0075	99.9406	0.0668
90	CYTRX	84.8427	0.0070	99.9476	0.0594
91	AASTROM BIOSCIENCES	84.6644	0.0070	99.9546	0.0524
92	HARBOR DIVERSIFIED	74.8975	0.0062	99.9607	0.0454
93	AMPLIPHI BIOSCIENCES	74.3217	0.0061	99.9669	0.0393
94	PALATIN TECHS.	66.2649	0.0055	99.9723	0.0331
95	OXIGENE	64.4941	0.0053	99.9776	0.0277
96	HESKA	56.3439	0.0046	99.9823	0.0224
97	UNITED GUARDIAN	54.0690	0.0044	99.9867	0.0177
98	PROPHASE LABS	52.6426	0.0043	99.9910	0.0133
99	IGI LABORATORIES	39.7254	0.0033	99.9943	0.0090
100	NATURAL ALTS.INTL.	39.0276	0.0032	99.9975	0.0057
101	CYANOTECH	19.0884	0.0016	99.9991	0.0025
102	IMMUCELL	11.1632	0.0009	100.0000	0.0009

Table A.1: PHARMACEUTICAL COMPANIES

Note: In this table, pharmaceutical companies are sorted on market capitalization (in millions of USD) (column MCAP). Market capitalization shares for each company are reported in column CAP WEIGHT. Columns CUM SUM 1 accumulates capitalization. The last column shows capitalization shares in reverse order, i.e., the overall capitalization attributed to the remaining firms, once the largest firms are accounted for.

Date	Disease	Topic	News
12/03/03*	SARS	WHO Statement	PHEIC
17/03/03	SARS	WHO Statement, WHO Disease Outbreak News	WHO issues emergency travel advisory (15/03/03), Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update (16/03/03)
18/03/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) multi-country outbreak - Update 3
19/03/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) multi-country outbreak - Update 4
20/03/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) multi-country outbreak - Update 5
21/03/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) multi-country outbreak - Update 6
01/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 16
03/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 20
07/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 22 (05/04/03)
10/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 26
14/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 29
15/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 30
16/04/03	SARS	WHO Statement	Coronavirus never before seen in humans is the cause of SARS
17/04/03	SARS	WHO Disease Outbreak News, Statement	Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 32, Pasteur Institute signs deal with Glaxo to find SARS vaccine
21/04/03	SARS	Research Funding, WHO Disease Outbreak News	F.D.A. Approval Of Nasal Vaccine For Flu Expected (19/04/03), Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 35 (21/04/03)
24/04/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - Multi-country outbreak Update 38
28/04/03	SARS	Research Funding, Statement	GenVec Wins Government SARS Vaccine Contract, Roche aims to launch Sars test by end July
29/04/03	SARS	WHO Statement, WHO Disease Outbreak News	WHO welcomes ASEAN unity against SARS, Severe Acute Respiratory Syndrome (SARS) - Multi-country outbreak - Update 42
30/04/03	SARS	Statement	Glaxo accelerates work on possible SARS vaccine
01/05/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS) - Multi-country outbreak - Update 44
06/05/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS)-multi-country outbreak - Update 48
09/05/03	SARS	WHO Disease Outbreak News	Severe Acute Respiratory Syndrome (SARS)-multi-country outbreak - Update 51
23/05/03	SARS	WHO Statement	World Health Organization changes Hong Kong, Guangdong travel recommendations
02/06/03	SARS	WHO Disease Outbreak News	Update 71 - Status of diagnostic tests, training course in China
26/06/03	SARS	Statement	Pfizer sees progress against SARS
07/07/03	SARS	WHO Statement	SARS outbreak contained worldwide (05/07/03)
20/08/03	SARS	WHO Statement	Joint WHO, Food and Agriculture Organization and Chinese government mission on SARS animal reservoir and possible transmission to Humans
21/08/03	SARS	WHO Statement	Joint mission on SARS animal reservoir and necessary next steps
26/09/03	SARS	WHO Statement	Inadequate plumbing systems likely contributed to SARS transmission
29/09/03	SARS	Research Funding	Baxter/Aventis receive \$18M SARS funding
05/11/03	SARS	WHO Statement	Global search for SARS vaccine gains momentum
17/12/03	SARS	WHO Statement	SARS case in laboratory worker in Taiwan, China
13/09/04	SARS	Research Funding	Alpha Vax receives \$4.8 million SARS vaccine grant
01/10/04	SARS	Research Funding	ID Biomedical announces NIH grant to develop nasally delivered SARS vaccine
04/02/05	SARS	Research Funding	Novavax Receives SARS Vaccine Funding From NIH
24/04/09	H1N1	WHO Statement	Influenza-like illness in the United States and Mexico
27/04/09*	H1N1	WHO Statement, WHO Disease Outbreak News, Statement	PHEIC, Swine influenza - update 3, Mexico granted \$205m swine flu loan from World Bank
28/04/09	H1N1	WHO Disease Outbreak News	Swine influenza - update 4
29/04/09	H1N1	WHO Statement, WHO Disease Outbreak News	Influenza A(H1N1), Influenza A(H1N1) - update 5

30/04/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 6
01/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 8.1
04/05/09	H1N1	WHO Statement, WHO Disease Outbreak News, WHO Disease Outbreak News,	Joint FAO/WHO/OIE/WTO Statement on influenza A (H1N1) and the safety of pork (02/05/09), Influenza A (H1N1) - update 10 (02/05/09), Influenza A (H1N1) - update 12 (03/05/09), Influenza A (H1N1) - update 14
06/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 18
07/05/09	H1N1	WHO Statement, WHO Disease Outbreak News	WHO statement on pork and pork consumption, Influenza A (H1N1) - update 20
08/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 22
11/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 25
13/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 27
15/05/09	H1N1	Gvt Order	British government orders 90 million dosages of swine flu vaccine from Baxter, Glaxo
18/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 32
20/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 34
22/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 36
25/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 38
27/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 39
28/05/09	H1N1	Gvt Order	Australia orders 10 million H1N1 vaccines
29/05/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 41
01/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 42
03/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 43
08/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 45
10/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 46
11/06/09	H1N1	WHO Statement	World now at the start of 2009 influenza pandemic
15/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 49
17/06/09	H1N1	WHO Statement, WHO Disease Outbreak News	WHO welcomes sanofi-aventis's donation of vaccine , Influenza A (H1N1) - update 50
19/06/09	H1N1	WHO Disease Outbreak News, Statement	Influenza A (H1N1) - update 51, Secretary amended an earlier declaration, providing immunity and enabling compensation (contingent upon appropriations) for the use of the antiviral drugs Tamiflu and Relenza for treatment of illnesses caused by H1N1 pandemic flu
22/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 52
24/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 53
25/06/09	H1N1	Statement	HHS Secretary Kathleen Sebelius issued a declaration under the PREP Act for the use of H1N1 pandemic vaccines that are currently under development, thereby providing immunity and enabling the compensation program, contingent upon appropriations
26/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 54
29/06/09	H1N1	WHO Disease Outbreak News	Influenza A (H1N1) - update 55
01/07/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 56
03/07/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 57
06/07/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 58
08/07/09	H1N1	WHO Statement	Viruses resistant to oseltamivir (Tamiflu) identified
13/07/09	H1N1	WHO Statement	WHO recommendations on pandemic (H1N1) 2009 vaccines
15/07/09	H1N1	Gvt Order	France orders 94 mln doses of flu vaccine; GlaxoSmithKline, Sanofi, Novartis
23/07/09	H1N1	Gvt Order	US Purchases 195 Million Doses of H1N1 Vaccine; CSL Limited, AstraZeneca, Novartis, Sanofi, GlaxoSmithKline
24/07/09	H1N1	WHO Statement	Preliminary information important for understanding the evolving situation
27/07/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 59
31/07/09	H1N1	WHO Statement	Pandemic influenza in pregnant women

04/08/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 60
06/08/09	H1N1	WHO Statement	Safety of pandemic vaccines
12/08/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 61
13/08/09	H1N1	Gvt Order	Australia orders 21 million doses of H1N1 vaccine; Roche, Sanofi, GlaxoSmithKline, Novartis, Baxter, CSL Limited, Solvay
21/08/09	H1N1	WHO Statement, WHO Disease Outbreak News	Recommended use of antivirals, Pandemic (H1N1) 2009 - update 62 (revised 21 August 2009)
28/08/09	H1N1	WHO Statement, WHO Disease Outbreak News	Preparing for the second wave: lessons from current outbreaks, Pandemic (H1N1) 2009 - update 63
04/09/09	H1N1	Gvt Order, WHO Disease Outbreak News	Sinovac Obtains Initial Order of H1N1 Vaccine from Chinese Central Government, Pandemic (H1N1) 2009 - update 64
11/09/09	H1N1	WHO Statement, WHO Disease Outbreak News	Measures in school settings, Pandemic (H1N1) 2009 - update 65
15/09/09	H1N1	Approval	Four companies are licensed to produce the 2009 H1N1 influenza vaccine for the US; CSL Limited, AstraZeneca, Novartis, Sanofi
18/09/09	H1N1	WHO Statement, WHO Disease Outbreak News	Pandemic vaccine donations for the developing world, Pandemic (H1N1) 2009 - update 66
24/09/09	H1N1	WHO Statement	Pandemic influenza vaccines: current status
30/09/09	H1N1	Gvt Order	Sinovac Biotech Receives Second H1N1 Vaccine Order From Chinese Central Government
09/10/09	H1N1	Statement, WHO Disease Outbreak News	NIH Prepares to Launch 2009 H1N1 Influenza Vaccine Trial in People with Asthma, Pandemic (H1N1) 2009 - update 69
16/10/09	H1N1	WHO Statement	Clinical features of severe cases of pandemic influenza
23/10/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 71
30/10/09	H1N1	WHO Statement	Experts advise WHO on pandemic vaccine policies and strategies
05/11/09	H1N1	WHO Statement	Infection of farmed animals with the pandemic virus
06/11/09	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 73
10/11/09	H1N1	WHO Statement, Approval	Agreement for donation of pandemic H1N1 vaccine signed; GlaxoSmithKline, CSL Limited
13/11/09	H1N1	WHO Disease Outbreak News	Swine Flu Vaccine Now Approved For Infants
19/11/09	H1N1	WHO Statement	Pandemic (H1N1) 2009 - update 74
20/11/09	H1N1	WHO Statement	Safety of pandemic vaccines
27/11/09	H1N1	WHO Disease Outbreak News	Public health significance of virus mutation detected in Norway
02/12/09	H1N1	WHO Statement	Pandemic (H1N1) 2009 - update 76
03/12/09	H1N1	WHO Statement	Oseltamivir resistance in immunocompromised hospital patients
11/12/09	H1N1	WHO Disease Outbreak News	WHO use of advisory bodies in responding to the influenza pandemic
22/12/09	H1N1	WHO Statement	Pandemic (H1N1) 2009 - update 78
07/01/10	H1N1	Gvt Order Cancel	Comparing deaths from pandemic and seasonal influenza
11/01/10	H1N1	Statement	German states cancel swine flu vaccine orders
22/01/10	H1N1	WHO Statement, WHO Disease Outbreak News	US scales back H1N1 vaccine, cuts CSL order in half
05/02/10	H1N1	WHO Disease Outbreak News	Statement of the World Health Organization on allegations of conflict of interest and 'fake' pandemic, Pandemic (H1N1) 2009 - update 84
12/02/10	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 86
26/02/10	H1N1	WHO Disease Outbreak News	Pandemic (H1N1) 2009 - update 87
06/04/10	H1N1	Gvt Order Cancel	Pandemic (H1N1) 2009 - update 89
16/04/10	H1N1	WHO Disease Outbreak News	UK Government cuts H1N1 vaccine order by two-thirds
10/08/10	H1N1	WHO Statement	Pandemic (H1N1) 2009 - update 96
22/05/12	SARS	Research Funding	H1N1 in post-pandemic period
05/08/13	Polio	Statement	Baylor College of Medicine receives over \$6 million from NIH to develop SARS vaccine
13/11/13	Polio	WHO Statement	Japan steps up to help stop polio outbreak in Somalia
			WHO update on polio outbreak in Middle East

17/03/14	Polio	WHO Disease Outbreak News	Poliovirus in Cameroon - update
21/03/14	Polio	WHO Disease Outbreak News	Polio outbreak in the Middle East - update
24/03/14	Ebola	WHO Disease Outbreak News	Ebola virus disease in Guinea (23/03/14)
31/03/14	Polio	Statement, WHO Disease Outbreak News	Iraqi Ministry of Health declared a polio outbreak (30/03/14), Ebola virus disease in Liberia (30/03/14)
07/04/14	Polio	WHO Disease Outbreak News, Statement	Ebola virus disease, West Africa - update (05/04/14), First mass vaccination campaigns start since polio found in Iraq (06/04/14)
17/04/14	Polio	WHO Disease Outbreak News	Update on polio in central Africa - polio confirmed in Equatorial Guinea, linked to outbreak in Cameroon
05/05/14*	Polio	WHO Statement	PHEIC
22/05/14	Polio	WHO Disease Outbreak News	Wild poliovirus in the Horn of Africa
23/06/14	Polio	WHO Disease Outbreak News	Detection of poliovirus in sewage, Brazil
25/06/14	Polio	WHO Disease Outbreak News	Update on polio in central Africa
17/07/14	Polio	WHO Disease Outbreak News	Update on polio in Equatorial Guinea
18/07/14	H1N1	Statement	Janssen Pharmaceuticals pays \$30 million to develop Cambridge-based Vertex Pharmaceuticals flu drug
31/07/14	Ebola	WHO Disease Outbreak News	Ebola virus disease, West Africa - update
06/08/14	Ebola	WHO Statement	WHO to convene ethical review of experimental treatment for Ebola
08/08/14*	Ebola	WHO Statement	PHEIC
11/08/14	Polio	Statement	Mass Polio Vaccination Campaign Supported by WHO and UNICEF Kicks Off in Iraq
12/08/14	Ebola	WHO Statement	Ethical considerations for use of unregistered interventions for Ebola virus disease (EVD)
18/08/14	Ebola	WHO Statement	Statement on travel and transport in relation to Ebola virus disease outbreak
27/08/14	Ebola	WHO Disease Outbreak News	Ebola virus disease - Democratic Republic of Congo
28/08/14	Ebola	WHO Statement	WHO issues roadmap to scale up international response to the Ebola outbreak in west Africa
01/09/14	Ebola	WHO Disease Outbreak News	Ebola virus disease update - Senegal (30/08/14)
05/09/14	Ebola	WHO Statement	Statement on the WHO Consultation on potential Ebola therapies and vaccines
08/09/14	Polio	WHO Disease Outbreak News	Poliovirus in Cameroon - update (06/09/14)
16/09/14	Ebola	WHO Statement	WHO welcomes the extensive Ebola support from the United States of America
01/10/14	Ebola	WHO Disease Outbreak News	Ebola virus disease - United States of America
09/10/14	Ebola	WHO Disease Outbreak News	Ebola virus disease - Spain
28/10/14	Ebola	WHO Statement	WHO welcomes Swissmedic approval of Ebola vaccine trial at Lausanne University Hospital
31/10/14	Ebola	WHO Disease Outbreak News	Ebola virus disease - Mali
06/11/14	Ebola	WHO Statement	WHO welcomes strong commitment from Australia to beating Ebola

Table A.2: DISEASE-RELATED NEWS (EVENT DAYS). * INDICATES PUBLIC HEALTH EMERGENCY OF INTERNATIONAL CONCERN (PHEIC) EVENTS.

Recent Issues

No. 157	Steffen Meyer, Linda Urban, Sophie Ahlswede	Does feedback on personal investment success help?
No. 156	Reint Gropp, Thomas Mosk, Steven Ongena, Carlo Wix	Bank Response To Higher Capital Requirements: Evidence From A Quasi-Natural Experiment
No. 155	Vahid Saadi	Mortgage Supply and the US Housing Boom: The Role of the Community Reinvestment Act
No. 154	Brigitte Haar	Shareholder Wealth vs. Stakeholder interests? Evidence from Code Compliance under the German Corporate Governance Code
No. 153	Julia Hirsch, Uwe Walz	The Financing Dynamics of Newly Founded Firms
No. 152	Viral Acharya, Tim Eisert, Christian Eufinger, Christian Hirsch	Whatever it Takes: The Real Effects of Unconventional Monetary Policy
No. 151	Michael Schneider, Fabrizio Lillo, Lorian Pelizzon	How Has Sovereign Bond Markets Liquidity Changed? – An Illiquidity Spillover Analysis
No. 150	Vanya Horneff, Raimond Maurer, Olivia S. Mitchell	Putting the Pension back in 401(k) Plans: Optimal versus Default Longevity Income Annuities
No. 149	Massimiliano Caporin, Aleksey Kolokolov, Roberto Renò	Systemic Co-Jumps
No. 148	Sven-Thorsten Jakusch	On the Applicability of Maximum Likelihood Methods: From Experimental to Financial Data
No. 147	Andreas Hackethal, Sven-Thorsten Jakusch, Steffen Meyer	Taring all Investors with the same Brush? Evidence for Heterogeneity in Individual Preferences from a Maximum Likelihood Approach
No. 146	Sven-Thorsten Jakusch, Steffen Meyer, Andreas Hackethal	Taming Models of Prospect Theory in the Wild? Estimation of Vlcek and Hens (2011)