Stocks and shocks

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1. Introduction

Each and every day, financial markets are subject to news. Stock markets efficiently process the reactions to news. Price changes reflect investors' expectations about the effects of news. Many studies investigate the way stock prices react to news (see Fama *et al*. 1969). Most of them consider specific news about particular events (e.g. earnings forecasts, etc.) and the price of different firms within a single stock market (see Ball and Brown 1968). In this study we are interested in how stock markets in industrialized countries react to news about extreme events. Do stock markets react differently? Is there a (predictable) pattern in their reactions to shocks? Has financial integration affected the way the stock markets react to shocks? We study ten major international events and the stock market's reaction in four countries over a period of fifteen years (1986-2001) with the help of the event study methodology. We analyze the reactions of the US-based New York Stock Exchange as the world's leading stock market and those of three medium sized European stock markets, namely those of Italy, the Netherlands and Sweden.

The structure of the paper is as follows. Section 2 gives some background details and briefly discusses the stock markets and the events analyzed. Section 3 goes into the methodology employed. The results are in Section 4. Section 5 sets out the conclusions.

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2. Background

Why might we expect the impact of a major international event on stock markets to differ qualitatively from that of more ordinary news about individual firms or the macro-economy? The reason is that such events suddenly and unforeseeably affect the overall political and (macro-)economic situation of the economy of a country or a group of countries or even the world as a whole. Neither the direction nor the magnitude, nor for that matter the nature of its effect is known beforehand. Furthermore, both occurrence and impact of these kinds of shocks are highly uncertain in the classical Knightian sense. Psychological effects may play an important role as both traders and investors have to put up with additional uncertainty about how to interpret the consequences of the unique and unprecedented event.

TABLE 1

SELECTED EVENTS

Event	Date (dd/mm/year)	Characteristics
Chernobyl	26 / 4 / 1986	Nuclear power plant meltdown in the Ukraine
Gulf war	2 / 8 / 1990	Iraq army occupies Kuwait
Soviet coup	19 / 8 / 1991	Military coup against Gorbachev
WTC	26 / 2 / 1993	Bombing of WTC buildings New York
Peso crisis	20 / 12 /1994	Devaluation of Mexican peso
Oklahoma bombing	19 / 4 / 1995	Assault on Alfred P. Murrah building
Asia crisis	8 / 1 / 1998	Indonesian rupiah falls sharply, political turmoil
Russian crisis	17 / 8 / 1998	Ruble devaluation, debt moratorium, political turmoil
Kosovo war	24 / 3 / 1999	NATO starts bombing Serbian forces in Kosovo
11/9	11 / 9 / 2001	Al-Qaeda attacks on WTC buildings and Pentagon

We studied ten major events occurring during a period of fifteen years, taking very different events, some of a political nature, others of a technical or economic kind. Table 1 gives a basic description of the events, selected because they can be characterized by a clear beginning (event date) and because – together – they span more than a decade. Table 2 gives the key characteristics of the four stock ex-

TABLE 2

KEY INDICATORS STOCK MARKETS

	Italy	Netherlands	Sweden	US
	Borsa Italiana	Euronext Amsterdam	OM Stockholmsbørsen	New York Stock Exchange
Market value (year-end 2000; US$ bn)	768	640	328	11,535
Market turnover 2000 (US$ bn)	539	471	314	8,945
Stock market value as a percentage of GDP	66	188	156	181
No. domestic firms at year-end 2000	237	375	292	2,442
No. foreign firms at year-end 2000	5	172	19	420
Trade concentration (in %) (top 5)	43	61	44	6
Value concentration (in %) (top 5)	44	63	40	9

Source: http://www.fibv.com.

changes. The markets were selected because they are situated in developed economies, because of data availability and reliability, and for geographic reasons. All four stock exchanges are mature and efficient markets.[1] Clearly, we have one dominant market, the NYSE, that dwarfs the other three markets in our sample. The NYSE is chosen as it is generally considered a benchmark. The three European markets are medium-sized players on a European scale, but smaller than the London, Frankfurt and Paris exchange. However, they all have a reputation for high market liquidity and a large amount of firms are traded on these markets. Furthermore, these three are situated in the same time zone (GMT –1). The highest average return in the period under review is in Sweden (17.8% and standard deviation 32.5%), whereas Italy shows the lowest return (10.4%; standard deviation 28.7%). On average, the correlation coefficient in the returns between all pairs of markets is 0.64. It appears that the Dutch and Swedish

[1] There is overwhelming evidence that the stock markets of industrialized countries are to a great extent informationally efficient (see Cochrane 2001). Furthermore, there is a lot of evidence that these markets are well-integrated (Goetzmann, Li and Rouwenhorst 2001).

stock markets are most closely correlated, namely 0.83; the Italian stock market and the NYSE show the smallest correlation in their returns, namely 0.41. These figures all are quite insensitive for changes in the data period.

3. Methodology and data

To examine the effect of the events in Table 1 on the stock markets, we used a simple event study methodology. Event studies are widely used in financial research. Ball and Brown (1968) and Fama *et al.* (1969) laid the foundations for this application. Ball and Brown (1968) used an event study to analyze the effect of the unanticipated element of the accounting earnings. Fama *et al.* (1969) studied the market's reaction on announcement of a stock split. In general, event studies are used to test market efficiency in response to dated event announcements. When the stock price response to an event is large and concentrated (usually within a day), it can be concluded that the evidence is consistent with market efficiency. We conducted our event study methodology in a slightly different way, with particular focus on *differences* in responses to extreme events. We are not specifically interested in market efficiency as such. Therefore, in this paper, we will not be looking into the speed of the reactions.

In this article, we used the approach suggested by Fama *et al.* (1969). Henderson (1990) discusses the relevant approaches and the pitfalls in this case. The first thing is to define the event. The more specifically the event date can be determined, the more reliable are the results of the event study (Brown and Warner 1985). Given the fact that we study purely exogenous events, we do not come up against the usual problems of insider information about the event (see Bowman 1983). Reliable data about illegal insider trading is rather difficult to come by (see Meulbroek 1992), especially in continental European markets, although we cannot exclude its existence in some of the events studied. Next, the normal ('regular') stock price has to be estimated, i.e. the price to be expected had the event not occurred. Here, it is crucial to determine the estimation window, the event window, and the post-event window (MacKinlay 1997). Given the well-devel-

oped nature of the four exchanges, we will use a short estimation window, namely 10 days. In particular we will be looking into the reaction on day 0 and day 1, but we will also analyze the stock market's reaction over a 5- and 10-day period. The events we analyze can take place in time zones that are different from the ones where our stock markets are located. To estimate the normal price, one may use the mean adjusted return model, the market model or the market adjusted model (Brown and Warner 1985). We will be using the market mode as it is most often used in recent finance literature and since it accounts for both the risk factor of the stock and the market volatility during the event window (Binder 1998):

$$\hat{Y}_{i,t} = \alpha_i + \beta_i Y_{m,t} + \varepsilon_{i,t} \quad (1)$$

with $\hat{Y}_{i,t}$ the expected normal price. $Y_{m,t}$ is the market index. The a_i and b_i are the parameters to be estimated, $e_{i,t}$ is the error term with expected value of 0. Next, the (cumulative) abnormal price or return is to be determined. On the basis of the market model, it is defined as:

$$AP_{i,t} = Y_{i,t} - \alpha_i - \beta_i Y_{m,t} \quad (2)$$

with $AP_{i,t}$ the abnormal price on stock market i at moment t. $Y_{i,t}$ is the actual stock price. Thus, the abnormal price is that part of the actual price that deviates from the expected normal price. As we were investigating the effect of events representing authentic global shocks on the stock exchanges, we had to make some slight amendments to this model. If we were to use a global market index to determine the normal return during the event window, the world index would include the effect of the shock. As such, the effect of the shock would not be analyzed. Therefore, we regressed on the stock market index of the particular exchange in question. On the basis of the price movements during the estimation window, we were able to estimate the normal price during the event window:

$$\hat{Y}_{i,t} = \alpha_i + \beta_i t_i \quad (3)$$

with $\hat{Y}_{i,t}$ the expected normal price on stock exchange i at moment t.

Our event dates where derived from international financial newspapers and checked (and double-checked) with international news agencies. Stock price information was derived from the four stock exchanges. We used the AEX-index for the Netherlands, the MIB 30 for Italy, Stockholmsbørsen All Share Price Index for Sweden,

and the NYSE Composite for the US. Of course, we used daily data. However, some problems may arise when using daily data in event studies (see Henderson 1990). First, daily stock prices may substantially deviate from the normal distribution whereas this is seldom the case with monthly data. Fortunately, this appears not to be the case with abnormal stock prices (see Brown and Warner 1985; Berry, Gallinger and Henderson 1990). Second, should the stock price and the market index be calculated over different time intervals, the quality of the normal stock price estimation might be affected as it hampers estimation of the parameters. However, Scholes and Williams (1977) and Dimson (1979) have concluded that alternative ways to estimate the parameters do not improve their quality in this respect. The same applies to the possibility of increased variance in the abnormal prices during the event (see Brown and Warner 1985). We will be using standard parametric tests to interpret the results (see Bowman 1983, Brown and Warner 1985).

To summarize, we studied the effect of shocks on the stock exchange. We selected ten events. The normal price was determined on the basis of the stock market index during the 10-day estimation window. With the normal price, the standard deviation and the t-statistic, we posited an expected price interval. If the actual stock price on day 0 or 1 of the event came outside this interval, it was regarded as a significant response to the shock. We also tested whether there was a significant difference among our four stock exchanges in their response to the shock.

4. Results

The results of the regression analysis are given in Table 3. The results of the difference tests are set out in Table 4. In this section, we discuss the results. The meltdown of the nuclear power plant in Chernobyl happened on a Saturday. Therefore, we take Monday as day 0. The disaster particularly shook Sweden and the Netherlands, where the stock markets had a significant (95% interval) abnormal low price on both day 0 and day 1. In Italy this was only the case on day 1. The Italian stock market's reaction on day 0 was only significant taking

Tables 3

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Tables 4

a 90% interval. The NYSE showed no significant abnormal reaction in response to the Chernobyl meltdown. We expect distance to have played a role here. The fallout of the meltdown was not expected to reach across the Atlantic, but hit Northwestern Europe particularly badly. Furthermore, the Netherlands and Sweden have a population highly aware of environmental hazards, which might explain the more pronounced abnormal return in these countries than in Southern-European Italy. We used an ordinary t-test for two independent populations to test whether there was a significant difference in the response to the shocks on the different stock exchanges. The difference test revealed that only on day 1 was there a significant difference in the response of the Dutch stock market and the NYSE.

Italy was the only country with a significant negative abnormal price reaction in response to the occupation of Kuwait by Iraqi forces. We found that only on day 3 did the stock prices on the other stock markets came significantly below the expected value, but this seems unlikely to have resulted from the occupation by Iraq. Interesting, too, is the fact that there was a significant positive abnormal return in the Netherlands on day 1, although apparently it was not related to the start of the Gulf War. For example, the price of Royal Dutch, one of the world's biggest oil companies, rose less than 1% on the news of war in this oil-rich region. The difference test also revealed that the behaviour of the Dutch stock exchange was statistically different from that of the other two European exchanges on day 0.

The military coup in Moscow during secretary-general Gorbachev's rule provoked a clear negative reaction on all four stock exchanges on day 0 of the event, but it is remarkable how rapidly the prices returned to their previous normal levels after day 0. The difference test revealed that the Italian stock exchange's reaction to the coup was much more severe than elsewhere. Furthermore, the NYSE responded much more markedly than the Stockholm exchange. Table 4 also shows that the price recovery was much slower in Italy than elsewhere.

We found that the bomb exploding in the World Trade Center in New York in February 1993 provoked no significant abnormal return on the NYSE. Only in Italy and in Sweden was there a significant positive price effect on day 1. However, it seems highly unlikely this was solely due to the event. It is indeed remarkable that all the abnormal price effects on day 0 and day 1 of this event were

positive. Of course, there having been no significant reaction, it makes no sense to test for differences in the markets' reactions.

The same applies to the devaluation of the peso in Mexico in December 1994, when all the abnormal price effects were positive. It is hard to relate the significant positive price effect on the Italian and the Dutch stock markets to the event. We would have expected at least a negative and significant reaction in the US. Again, it makes no sense to test for differences in the markets' reactions.

The explosion that ripped through the Alfred P. Murrah Federal Building in Oklahoma City on April 19 killed 168 people, injured more than 500 and damaged over 300 buildings. The Oklahoma bombing appeared to produce a significant negative reaction on all four stock, but this might also have been due to another occurrence as on day –1 the prices were already showing some downward movement, especially in Italy. Our suspicion that it is not the bombing that is to be held responsible for the pattern observed in Table 3 is confirmed by the difference tests in Table 4, showing no significant results in this case.

The Indonesian currency crisis appears to have provoked a significant response in the Netherlands, Sweden, and the US. During the estimation window stock prices moved gradually upwards, but this came to a halt with the event of the devaluation of the rupiah. Italy behaved differently as there was no significant negative price effect. However, the difference test did not show a significant difference in the reactions of the four markets.

The ruble devaluation during the Russian debt crisis of 1998 occurred in a period of relatively high volatility on the stock markets, which jeopardizes the accuracy of the normal price estimations. We found significant positive effects in Italy and Sweden and, on day 1, in the Netherlands. The positive reaction to the Russian debt crisis in these countries is puzzling as one would have expected a negative effect given the fallout of the devaluation and the debt problems, especially for European finance. The NYSE showed no significant reaction.

To study the effects of the Kosovo War we also took day –1 into account. On day –1, NATO confronted the Serbian leader Milosevic with an ultimatum that would end at midnight. Expectations about the reaction of the two parties will have been taken into account in the stock prices on day –1. This appears to have had a significant abnormal price effect in the Netherlands and the US. When the bomb-

ing actually took place on day 0, a significant effect appeared in all markets, except in Sweden. On day 1, the effect only persisted in Italy. Testing for differences shows that for day –1 we had a significant difference for Sweden from both the Netherlands and the US. On day 0, the Netherlands showed a significant difference from both Sweden and the US.

The Al-Qaeda attacks on the WTC buildings in New York and the Pentagon in Washington resulted in a clear and significant negative price effect. Because of the attack, Wall Street was immediately closed on September 11. It reopened on September 17. Therefore, we used the prices of September 17 and 18 as those for day 0 and 1 respectively, September 17 presenting the first occasion for investors to reveal their preferences with in adjusting their NYSE portfolios. On day 0, the indices fell substantially and significantly everywhere. This continued to be the case on day 1. Exceptional was the reaction of the Stockholm exchange. On day 1, the stock prices returned to within the boundaries as set by the confidence levels. Table 4 also reveals that the reaction in Sweden was significantly different from that elsewhere. Italy and the Netherlands showed similar reactions.

Thus, in the first place we found that there appears to be no standard reaction of the stock markets to extreme events. There is no clear evidence that the response of stock markets to extreme events differs from their reaction to more ordinary news. Of course, the choice of what constitutes a shocking event is crucial in this respect. We selected events that certainly did not go unnoticed; all the events made the headlines for several days, and special newscasts were dedicated to all of them. From our case study of ten events, it turns out that not all of them provoked a negative reaction. During the first assault on the World Trade Center in New York in 1993, the Mexican peso crisis in 1994, and the devaluation of the Russian ruble in 1998, stock prices continued to rise in all four markets under review. We find it hard to believe that they actually rose *because of* the events. Rather, the markets happened to neglect their impact. In contrast, the Soviet military coup in 1991, the Oklahoma bombing in 1995 and the Al-Qaeda attacks in 2001 provoked a significant negative reaction in stock prices.

The second point is that we could not detect a standard pattern in the reactions and the differences therein in the four stock markets in the course of time. We found strong evidence that there is no stan-

dard reaction of stock markets to extreme events. In part, of course, this may be due to the limited number of shocking events analyzed, or because of the different nature and character of the events selected. In the 1991-98 period in particular we had few events that showed statistically significant effects in terms of differences in responses. Our – relatively limited – evidence does not point to an increasing convergence in stock market responses to crises. However, this is an aspect that would merit further analysis on the basis of comparison between the different speeds at which markets adjust.

5. Conclusion

From time to time the whole world is brought up against shocking events. Natural disasters, war, economic crises, terrorist attacks, etc. shake the social, political, and economic order. In this paper, we assessed the stock markets' response to shocks. Stock market reaction to a shock can be manifold. It may or may not affect market expectations and prices. It may have a positive or a negative impact. It may or may not have a significant impact. It may or may not strengthen or weaken any already existing market tendencies. It is almost impossible to get an exact picture of the 'pure' effect of a shock on stock prices since we cannot really compare market behaviour during the shock with 'ordinary' behavior, the market being a truly dynamic phenomenon. Therefore we compared the response to extreme events, in four markets, with reactions to ordinary news, and compared reactions across markets. We looked into ten events that shook the world in the period 1986-2001, among which the nuclear meltdown in Chernobyl, the Gulf War, the Soviet military coup on Gorbachev, the peso crisis, the rupiah crisis, and the 11/9 attack on the US. We used the event study methodology to examine their effect on the stock markets in Europe (Italy, the Netherlands, Sweden) and the US (NYSE). In the first place, we found that there is no significant difference in reaction when compared to the reaction to more ordinary news. Most of the time, but not always, the markets react with a fall in stock prices. Most of the effect occurs on day 0. Effects may also persist on day 1. Secondly, it turned out that there often are

significant differences in reaction among the four stock exchanges to the extreme events. Thus, there is strong evidence that no standard stock market reaction to extreme events exists. The differences may be due to pure chance or related to distance. Here, distance is to be defined not only in geographical terms, although often this is very relevant, but also in political, economic, social and cultural terms. We conclude that response to an unexpected event is unpredictable.

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