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**SHOCK EFFECTS ON STOCKS, BONDS, AND  
EXCHANGE RATES**

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# Shock Effects on Stocks, Bonds, and Exchange Rates

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## Abstract

Tick data and newswire searches are used to find events that led to large and rapid changes in a stock future, a bond future, and three exchange rate futures. Knowledge of these events may be useful in future work. They have the advantages that they are truly surprises and that the sign of their effect on each financial market is known. The events are used in this study to analyze the effects of three types of shocks on the five variables.

## 1 Introduction

Announcements and other events have from time to time large and rapid effects on stock and bond prices and on exchange rates. Tick data on the S&P 500 futures contract and newswire searches were used in Fair (2000) to find 69 events between 1982 and 1999 that led to a one- to five-minute price change greater than .75 percent in absolute value. In this paper 152 additional events have been found that led to such a change in either the S&P 500 future, a bond future, a deutsche mark (euro

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beginning 1999) future, a yen future, or a British pound future. Tick data and newswire searches were also used for this work. Section 2 discusses the data, and Section 3 discusses the procedure used to find the events.

Once the events have been found, the relationships among stock prices, bond prices, and exchange rates can be examined. Each event led to a large and rapid change in at least one of the variables, and it is of interest to see how each variable was affected by the change and whether systematic relationships can be found. The advantage of using the events to examine relationships is that the signal to noise ratio is very high. For each event the many other things that affect the relationships among the variables are swamped by the event, and so these other things are in effect held constant. Section 4 examines the relationships.

## **2 The Data**

The symbols used for the futures contracts are: *SP* for the S&P 500, *US* for the 30 year U.S. Treasury bond, *DM* for the deutsche mark, *JY* for the yen, *BP* for the British pound, and *EC* for the euro. All but the *US* contract are traded on the Chicago Mercantile Exchange (CME). The *US* contract is traded on the Chicago Board of Trade (CBT). The first date used in this study is April 2, 1982, the first day that *SP* and *US* data are available. (The *BP* and *DM* data go back to 1974, and the *JY* data go back to 1977.) The last date used for all the contracts is March 31, 2000. The *DM* data were replaced by the *EC* data beginning June 1, 1999, although both contracts traded somewhat before and after this date.

The regular trading hours for the *SP* contract are 9:30–16:15 Eastern time

(10:00–16:15 prior to September 30, 1985).<sup>1</sup> The regular trading hours for the other contracts are 8:20–15:00. Many U.S. government data announcements occur at 8:30, which means that the prices of all the contracts except the *SP* contract can respond to them. In 1994 the “GLOBEX” market began on the CME, where contracts are traded after regular trading hours. The GLOBEX market roughly covers all the remaining hours in the week except from Friday at 16:16 through Sunday at 18:29. All the above contracts are traded on the GLOBEX market except the *US* contract. The main advantage of the GLOBEX market from the perspective of this study is that the *SP* contract is trading at the time of 8:30 announcements. GLOBEX data are missing for the last five months of 1998.

For each variable, such as *SP*, there are a number of contracts trading at the same time, each with a different terminal date. There is, however, always one most actively traded contract, and this is the one that was used.<sup>2</sup>

The tick data were used to create price observations per minute. The price of the last trade in a given minute was taken to be the price for that minute. (Typically many trades take place per minute, and so there are typically many tick prices per minute.) A  $k$ -minute percentage price change is then simply the price for a given minute divided by the price  $k$  minutes ago (with 1 then subtracted and the resulting value multiplied by 100). Table 1 presents a summary of the data. For the *SP* contract, for example, there are 2,200,079 price-level observations, 1,980,091

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<sup>1</sup>All times in this paper are Eastern even though the CME and CBT are in the Central time zone.

<sup>2</sup>The tick data were purchased from the Futures Industry Institute and Tick Data Inc. Tick data were also purchased for the Nikkei 225 futures contract and the T-Bill futures contract, both traded on the CME. The trading in these contracts, however, was too thin for the data to be useful. The Nikkei 225 data began September 25, 1990, and there were 169,044 price-level observations. The T-Bill data began January 4, 1982, and there were 270,700 price-level observations.

one-minute changes, and 1,940,153 five-minute changes. There are fewer changes than levels because a  $k$ -minute change requires price levels  $k$  minutes apart, and this is not always the case. (In some minutes no trades take place.) For the *SP* contract the standard deviation is .048 for the one-minute changes and .107 for the five-minute changes. The standard deviations for the other contracts range from .032 to .037 for the one-minute changes and from .064 to .070 for the five-minute changes. The means of all the changes, which are not presented in the table, are very close to zero.

The one-through five-minute percentage price changes were then searched for large and rapid changes. Any change was considered large if it was greater than .75 percentage points in absolute value. Given that the above standard deviations range from .032 to .107, a change of .75 in absolute value is unusual, i.e., very large. Each minute was flagged if it ended a large one- or two- or three- or four- or five-minute change. Some minutes were, of course, flagged more than once. Counting multiple flagging as only one flag, there were 2,220 flagged minutes for *SP*, 371 for *US*, 293 for *DM*, 17 for *EC*, 427 for *JY*, and 187 for *BP*. The same minute was sometimes flagged for more than one contract. The flagged minutes were then searched in the manner discussed next.

**Table 1**  
**Summary of the Data**

	<i>SP</i>	<i>US</i>	<i>DM</i>	<i>EC</i>	<i>JY</i>	<i>BP</i>
# price levels	2,200,079	1,474,055	1,455,219	97,621	1,610,040	1,214,151
# 1-minute changes	1,980,091	1,350,952	1,160,009	53,579	1,241,717	867,750
# 5-minute changes	1,942,153	1,325,089	1,132,719	50,787	1,205,830	835,171
SD of 1-minute changes	.048	.037	.034	.035	.032	.034
SD of 5-minute changes	.107	.070	.064	.065	.066	.069

Period: April 2, 1982–March 31, 2000.

Price level: last tick price of the minute.

*SP* = S&P 500.

*US* = 30 year U.S. Treasury bond.

*DM* = deutsche mark.

*EC* = euro.

*JY* = yen.

*BP* = British pound.

### 3 Searching for Events

For each flagged minute a search was undertaken to see if some announcement or other event occurred within about five minutes of the flagged minute. (Remember that a change for a flagged minute can be anywhere from a one- to a five-minute change, where the flagged minute is at the *end* of the change.) The Dow Jones Interactive service on the internet was used for this purpose. This service allows one to search for news reports by time of day. The following four news services were searched: *Dow Jones News Service*, *Associated Press Newswire*, *New York Times*, and *Wall Street Journal*.

As noted in Section 1, 69 events were found in Fair (2000) for the *SP* contract. The additional searching came up with 152 more events, for a total of 221. These events are listed in Table 2, and the rest of this section is a discussion of this table.







Table 2 (continued)

#	Day	Base Min.	5-minute change (percentage points)					a	b	Event
			SP	US	DM	JY	BP			
161	8/13/97	8:29	1.42	0.78	-0.26	-0.27	-0.14	sp	P	8:30: PPI down .1%; core down .1%.
162	9/2/97	10:00	0.68	0.47	-0.04	0.04	0.01	sp	Y	10:00: NAPM 56.8 vs. 58.6 last month.
163	10/3/97	8:29	0.75	0.88	0.23	0.08	0.11	sp	Y	8:30: Payrolls up 215,000; wage up .3%.
164	10/10/97	8:29	-0.99	-0.84	-0.03	0.08	0.04	sp	P	8:30: PPI up .5%; core up .4%.
165	12/5/97	8:29	-1.12	-0.95	-0.35	-0.13	-0.10	sp	Y	8:30: Payrolls up 404,000; wage up .6%.
166	1/5/98	19:50	-0.05		0.04	0.89	0.04	JY	I	?time: Japan intervened.
167	3/19/98	19:38	0.02			0.74		JY	I	?time: Japan intervened.
168	4/9/98	4:05	0.04		-0.16	-0.58		JY	J	?time: Hashimoto announced tax cuts.
169	4/30/98	8:29	1.05	0.74	-0.07	-0.04	0.06	sp	Z	8:30: ECI up .7%; GDP up 4.2%; deflator up .9%.
170	6/17/98	7:54	0.05		0.27	1.23	0.23	JY	I	?time: US and Japan intervened.
171	6/24/98	2:31	0.04		0.22	0.92		JY	I	?time: Japan intervened.
172	7/2/98	24:14				0.75		JY	J	?time: Hashimoto talked of permanent tax cuts.
173	8/11/98	20:16			0.12	0.70		JY	X	?time: Kuroda: will take necessary FX steps.
174	9/9/98	5:17			-0.09	-1.33	-0.07	JY	J	?time: BOJ cut rate to .25.
175	9/29/98	14:16	-1.55	0.24	-0.23	-0.46	-0.11	sp	R	14:17: Fed cut funds rate 25bp to 5.25.
176	10/13/98	3:09			0.30	0.83		JY	J	?time: BOJ kept policy unchanged.
177	10/15/98	15:14	5.07					sp	R	15:14: Fed cut funds rate 25bp—not normal meeting.
178	11/12/98	11:45	0.02	-0.05	0.10	0.23	0.04	JY	J	?time: Japan stimulus package announced.
179	11/16/98	20:58			-0.03	-0.22		JY	X	9:01: Moody's cuts Japan's FX rating to AA1.
180	11/17/98	14:18	0.97	0.10	0.12	0.12	0.04	sp	R	14:15: Fed cut funds rate 25bp.
181	11/19/98	21:37			-0.10	-1.03		JY	J	?time: Miyazawa: no sales tax cut for now, debate possible.
182	1/7/99	5:22	0.00		-0.08	-0.86	0.02	JY	J	?time: Japan's consumer spending up; recovery seems distant.
183	1/11/99	20:05	0.05			-0.91		JY	X	?time: Miyazawa: no comment on whether will intervene.
184	1/12/99	2:12	0.04			-0.86		JY	X	?time: Nonaka: excessive yen rise not good.
185	1/15/99	8:07	0.81					sp	X	8:10: Estado said Brazil won't intervene in FX market.
186	2/23/99	9:59	-0.82	-0.08	0.09	0.12	0.05	sp	R	10:00: Greenspan testimony: economy may be stretched.
187	3/5/99	8:29	0.73	1.04	0.29	0.22	0.10	sp	Y	8:30: Payrolls up 275,000; wage up .1%.
188	3/11/99	11:44	-0.05	0.08	0.61	0.44	0.16	DM	G	?time: Lafontaine resigned.
189	5/7/99	8:29	0.45	0.53	-0.20	-0.16	-0.11	US	Y	8:30: Payrolls up 234,000; wage up .2%.
190	5/12/99	9:45	-1.29	-0.11	0.35	0.75	0.16	sp	F	?time: Rubin to announce resignation; Summers is successor.
191	5/14/99	8:29	-0.52	-0.91	0.00	0.02	0.02	US	P	8:30: CPI up .7%; core up .4%.
192	5/18/99	14:10	-0.65	-0.37	-0.11	-0.15	0.02	sp	R	14:11: Fed let rates stand; adopted tightening bias.
193	6/1/99	10:00	-0.85	-0.37	0.10	0.19	0.05	sp	Y	10:00: NAPM 55.2 vs. 52.8 last month.
194	6/4/99	8:29	-0.22	-0.19	0.00	-0.17	-0.04	sp	Y	8:30: Payrolls up 11,000; wage up .4%.
195	6/13/99	20:10			-0.06	-0.56	-0.06	JY	I	?time: Japan intervened.
196	6/16/99	8:29	0.44	0.19	-0.06	-0.08	0.11	sp	P	8:30: CPI unchanged; core up .1%.
197	6/30/99	14:15	1.33	0.62	0.27	0.01	0.06	sp	R	14:15: Fed raised funds rate 25 bp; adapted neutral bias.
198	7/20/99	9:07	0.04	-0.05	-0.29	-0.87	-0.09	JY	I	?time: US intervened.
199	8/6/99	8:29	-0.57	-0.38	0.08	0.10	0.02	sp	Y	8:30: Payrolls up 310,000; wage up .5%.
200	8/13/99	8:57	0.11	0.00	-0.52	-0.98	-0.26	JY	J	?time: Ozawa's Liberal party to stay in ruling block.
201	8/24/99	20:12	-0.01			-0.61		JY	X	?time: Mitoguchi: will watch FX market after Fed meeting.
202	9/3/99	8:29	1.09	0.77	-0.36	-0.16	-0.15	sp	Y	8:30: Payrolls up 124,000; wage up .2%.
203	9/8/99	19:49	-0.08			1.02		JY	J	?time: Japanese GDP .9%; deflator -.7%.
204	9/10/99	8:29	0.40	-0.05	-0.10	-0.11	-0.06	sp	P	8:30: PPI up .5%; core down .1%.
205	9/15/99	8:29	0.83	0.41	-0.42	0.22	-0.17	sp	P	8:30: CPI up .3%; core up .1%.
206	9/21/99	3:54	-0.31			1.80		JY	J	?time: BOJ policy unchanged.
207	10/5/99	14:11	-0.72	-0.28	0.25	0.05	0.08	sp	R	14:12: Fed let rates stand; adopted tightening bias.
208	10/8/99	8:29	0.56	0.14	-0.05	0.04	-0.07	sp	Y	8:30: Payrolls down 8,000; wage up .5%.
209	10/13/99	5:15	0.00		0.05	-0.90		JY	J	?time: BOJ policy eased.
210	10/15/99	8:29	-1.03	-0.48	0.27	0.23	0.18	sp	P	8:30: PPI up 1.1%; core up .8%.
211	10/27/99	3:13	0.02		-0.02	-0.54		JY	J	?time: Sony's profits down 24.5%.
212	11/5/99	8:29	0.95	0.38	-0.30	-0.16	-0.18	SP	Y	8:30: Payrolls up 310,000; wage up .1%.
213	11/30/99	1:20				-0.56		JY	I	?time: Japan intervention rumored.
214	12/3/99	8:29	0.64	0.34	-0.05	0.04	-0.04	SP	Y	8:30: Payrolls up 234,000; wage up .1%.
215	12/14/99	8:29	-0.80	-0.33	0.00	-0.04	0.04	SP	P	8:30: CPI up .1%; core up .2%.
216	12/21/99	14:11	0.73	-0.17	-0.10	-0.05	-0.06	SP	R	14:13: Fed let rates stand; maintained neutral bias.
217	1/6/00	16:04	-0.85		0.10	0.03		SP	C	?time: Lucent's earnings below expectations.
218	1/7/00	8:29	-0.13		-0.08	-0.05		SP	Y	8:30: Payrolls up 315,000; wage up .4%.
219	1/28/00	8:29	-1.41		0.24	0.29		SP	Z	8:30: ECI up 1.1%; GDP up 5.8%; deflator up 2.0%.
220	2/4/00	8:29	0.68		-0.20	0.03		SP	Y	8:30: Payrolls up 387,000; wage up .4%.
221	3/3/00	8:29	0.80		0.08	-0.10		SP	Y	8:30: Payrolls up 43,000; wage up .3%.

**Notes:**

a = contract being used when the event was found. sp means the event was found in Fair (2000).

b = type of event: R = monetary, P = price, Y = real, F = fiscal policy, Z = ECI, C = company, T = trade gap,

X = international rumors and comments, W = international conflicts, I = foreign exchange intervention, J = Japan, G = Germany.

Percentage changes are at quarterly rates for ECI, annual rates for GDP and the GDP deflator, and monthly rates for all others.

**Abbreviations:**

BOJ = Bank of Japan.

bp = basis points.

CPI = consumer price index; core excludes food and energy.

ECI = employment cost index.

FX = foreign exchange.

GDP = real GDP.

NAPM = National Association of Purchasing Managers.

PPI = producers price index; core excludes food and energy.

wage = average hourly earnings from the establishment survey.

As can be seen in Table 2, many of the events are 8:30 government announcements. One of these announcements is the monthly employment report. It contains data from both the household survey and the establishment survey. The main variable of interest from the household survey is the unemployment rate, and the main two variables of interest from the establishment survey are the number of jobs (called “payrolls”) and average hourly earnings. The variable that gets the most attention is the payroll variable, with the average hourly earnings variable second. The payroll value is listed in Table 2 along with the average hourly earnings value (called “wage” in the table) when it was available from the press reports. The “event” for this announcement is, of course, the entire employment report.

The other monthly 8:30 announcements are those for 1) the consumer price index (CPI), 2) the producer price index (PPI), 3) the U.S. balance of trade (the “trade gap”), 4) retail sales, 5) orders for durable goods, and 6) housing starts. The two quarterly 8:30 announcements are for the employment cost index (ECI), a measure of wage costs, and the national income and product accounts. The two variables listed in the table from the national income and product accounts are real GDP and the GDP deflator. In the early part of the period the retail sales announcement was at 14:30.

Another announcement is for industrial production. In the early part of the period it was at 9:30, and it is now at 9:15. In the early part of the period the money supply (M1) announcement was important, and it was at 16:10. An important non government announcement is the report of the National Association of Purchasing Managers (NAPM), and this is at 10:00.

The exact times for the events that are not regularly scheduled announcements

are not always clear. The exact times of the news reports are not always given, and even when they are, it may be that the report was written a few minutes after the event (rather than, say, just one minute after the event). If a time was given in the report, it is indicated in Table 2; otherwise, “?time” is listed in the table. Remember, then, that when a time is given in the table for a non regularly scheduled announcement, the event may have taken place a few minutes earlier.

The order of the searching for events using the large changes was *SP*, *US*, *DM*, *EC*, *JY*, and *BP*. Table 2 indicates which contract observations were being used when the particular event was found.<sup>3</sup>

Many of the 8:30 announcements were not found using the *SP* contract (but instead using the *US* or *DM* contract) because the *SP* contract was not traded at 8:30 until 1994. All the trade gap announcements were found using the exchange rate contracts.

For reference purposes the 221 events were divided into 12 kinds, and each kind is denoted by a letter in Table 2. *R* denotes monetary events, primarily money supply announcements and interest rate announcements. In October 1982 the Fed announced that it was going to put less weight on monetary aggregate targets in the future, and soon after that the money supply announcements ceased being important, with interest rate announcements taking their place. The interest rate announcements are regarding the federal funds and/or discount rate. The funds rate is more important than the discount rate, and it is listed in Table 2 over the discount rate if both were mentioned in the newswires. *P* denotes price announcements, either the CPI or the PPI. *Y* denotes macro announcements about real variables,

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<sup>3</sup>A lower case sp means the event was one of the 69 events found in Fair (2000).

primarily payrolls, GDP, and NAPM. *Z* denotes ECI (wage) announcements. *F* denotes U.S. fiscal policy events. *C* denotes announcement of individual company earnings. *T* denotes trade gap announcements. *X* is a catch all that denotes foreign exchange comments by various government officials and rumors. *W* denotes events related to international conflicts or potential conflicts (all Iraq except for one Russia). *I* denotes the intervention of central banks in foreign exchange markets. Interventions are usually not announced, but simply observed by market participants as they are happening. Finally, *J* denotes events that are specific to Japan, and *G* denotes events that are specific to Germany. The events are organized into these 12 categories in Table 3. This table is used in the next section.

Five-minute changes are also presented in Table 2 (and Table 3) for each event. Although the searching for large changes was done using one- through five-minute changes for each contract, only five-minute changes are presented in the table. The five-minute change is from a “base” minute (minute 0) to the minute five minutes away (minute 5). For each scheduled announcement, the base minute was taken to be the minute right before the announcement, such as 8:29 for a 8:30 announcement. For the other events a plot of the price level per minute for each variable was made around the approximate time of the event (which is known from the searching), and the plots were examined for price jumps. The base minute was taken to be the minute right before the price jump. In almost all cases it was obvious where the price jump occurred—at most the error in choosing the base minute is a minute. In the few cases where it was not obvious, judgment had to be used, and in these cases the error could be as large as three or four minutes. The



Table 3 (continued)

#	Day	Base Min.	5-minute change (percentage points)					a	b	Event	
			SP	US	DM	JY	BP				
<b>Real Shocks (continued)</b>											
94	1/10/92	8:29		-0.12	-0.91	-0.29	-1.24	DM	Y	8:30: Payrolls up 31,000 (-74,000 expected); wage up .7%	
96	2/13/92	8:29		-0.40	-0.93	-0.29	-0.65	DM	Y	8:30: Retail sales up .6%	
97	7/2/92	8:29		1.24	0.88	0.39	0.54	US	Y	8:30: Payrolls down 117,000; wage up .2%	
101	9/4/92	8:29		0.98	1.14	0.53	0.68	US	Y	8:30: Payrolls down 83,000; wage up .7%	
103	10/2/92	8:29		-0.35	-1.13	-0.53	-0.87	DM	Y	8:30: Payrolls down 57,000; wage down .2%	
104	11/19/92	8:29		0.15	-0.62	-0.12	-0.47	DM	Y	8:30: Housing starts down 1.1%	
105	3/5/93	8:29		-0.75	-0.53	-0.38	-0.45	US	Y	8:30: Payrolls up 365,000.	
107	6/4/93	8:29		-0.54	-0.99	-0.33	-0.72	DM	Y	8:30: Payrolls up 209,000; wage up .6%	
109	7/2/93	8:29		0.44	0.43	0.46	0.50	DM	Y	8:30: Payrolls up 13,000; wage down .1%	
111	9/3/93	8:29		0.37	0.76	0.42	0.67	DM	Y	8:30: Payrolls down 39,000; wage up .5%	
114	10/8/93	8:29		-0.05	0.46	0.10	0.35	DM	Y	8:30: Payrolls up 156,000; wage unchanged.	
116	1/7/94	8:29	0.10		0.90	0.07	0.10	0.01	US	Y	8:30: Payrolls up 183,000; wage up .2%
117	2/4/94	8:29	0.15	0.48	0.40	0.24	0.44	US	Y	8:30: Payrolls up 62,000; wage up .7%	
118	4/1/94	8:29		-0.97	-0.57	-0.24	-0.29	US	Y	8:30: Payrolls up 456,000; wage up .1%	
119	5/6/94	8:29	-0.24	-0.60	-0.18	-0.12	-0.03	US	Y	8:30: Payrolls up 267,000; wage up .3%	
121	7/8/94	8:29	-0.30	-0.55	-0.11	-0.06	-0.10	US	Y	8:30: Payrolls up 379,000; wage down .1%	
122	7/29/94	8:29	0.31	0.70	-0.11	-0.10	-0.07	US	Y	8:30: GDP up 3.7%; deflator up 2.9%	
123	8/5/94	8:29	-0.35	-1.16	-0.40	-0.14	-0.16	US	Y	8:30: Payrolls up 259,000; wage up .4%	
128	2/3/95	8:29	0.22	0.62	0.08	0.09	0.11	US	Y	8:30: Payrolls up 134,000; wage up .6%	
129	3/10/95	8:29	-0.24	-0.61	0.28	0.44	0.10	DM	Y	8:30: Payrolls up 318,000; wage unchanged.	
130	3/31/95	8:29	-0.02	-0.21	-0.03	0.00	0.02	JY	Y	8:30: GDP revised up to 5.1% from 4.7%	
133	6/2/95	8:29	-0.03	1.21	0.96	0.72	0.39	US	Y	8:30: Payrolls down 101,000; wage down .3%	
134	7/7/95	8:29	-0.20	-0.75	-0.25	-0.21	-0.19	US	Y	8:30: Payrolls up 215,000; wage up .4%	
136	9/1/95	8:29	-0.12	-0.53	-0.10	-0.22	-0.14	US	Y	8:30: Payrolls up 249,000; wage down .2%	
138	3/8/96	8:29	-1.54	-1.39	-0.25	-0.19		sp	Y	8:30: Payrolls up 705,000 (most in 12 years); wage down .1%	
139	4/5/96	8:29		-0.70	-0.28	-0.09	-0.21	US	Y	8:30: Payrolls up 140,000; wage up .3%	
140	5/2/96	8:29	-0.35	-0.74	0.00	0.01	0.04	US	Y	8:30: GDP up 2.8%; deflator up 2.1%	
141	5/3/96	8:29	0.53	0.29	0.14	0.10	-0.01	sp	Y	8:30: Payrolls up 2,000; wage up .6%	
143	6/7/96	8:29	-1.86	-2.15	0.15	0.12	0.10	sp	Y	8:30: Payrolls up 348,000; wage up .3%	
144	7/5/96	8:29	-0.93	-1.54	-0.15	-0.10	-0.10	US	Y	8:30: Payrolls up 239,000; wage up .8%	
145	8/1/96	10:00	0.72	1.03	0.04	0.04	0.05	US	Y	10:00: NAPM down.	
146	8/2/96	8:29	1.38	0.93	-0.12	-0.05	0.01	sp	Y	8:30: Payrolls up 193,000; wage down .2%	
147	9/6/96	8:29	-0.25	-0.41	-0.13	-0.08	-0.06	sp	Y	8:30: Payrolls up 250,000; wage up .5%	
149	10/4/96	8:29	0.31	0.39	-0.08	-0.04	-0.06	US	Y	8:30: Payrolls down 40,000; wage up .5%	
150	1/10/97	8:29	-0.61	-0.90	0.13	0.14	-0.07	US	Y	8:30: Payrolls up 262,000; wage up .5%	
152	1/29/97	8:29	0.59	0.34	-0.11	-0.13	-0.05	sp	Y	8:30: Durable goods down 1.7%	
154	3/7/97	8:29	-0.24	-0.34	-0.05	-0.01	-0.02	sp	Y	8:30: Payrolls up 339,000; wage up .2%	
158	6/6/97	8:29	-0.48	-0.23	-0.24	-0.07	0.00	sp	Y	8:30: Payrolls up 138,000; wage up .3%	
160	8/1/97	10:00	-0.63	-0.40	-0.06	0.07	0.01	sp	Y	10:00: New orders up 1.2%; strong NAPM report.	
162	9/2/97	10:00	0.68	0.47	-0.04	0.04	0.01	sp	Y	10:00: NAPM 56.8 vs. 58.6 last month.	
163	10/3/97	8:29	0.75	0.88	0.23	0.08	0.11	sp	Y	8:30: Payrolls up 215,000; wage up .3%	
165	12/5/97	8:29	-1.12	-0.95	-0.35	-0.13	-0.10	sp	Y	8:30: Payrolls up 404,000; wage up .6%	
187	3/5/99	8:29	0.73	1.04	0.29	0.22	0.10	sp	Y	8:30: Payrolls up 275,000; wage up .1%	
189	5/7/99	8:29	0.45	0.53	-0.20	-0.16	-0.11	US	Y	8:30: Payrolls up 234,000; wage up .2%	
193	6/1/99	10:00	-0.85	-0.37	0.10	0.19	0.05	sp	Y	10:00: NAPM 55.2 vs. 52.8 last month.	
194	6/4/99	8:29	-0.22	-0.19	0.00	-0.17	-0.04	sp	Y	8:30: Payrolls up 11,000; wage up .4%	
199	8/6/99	8:29	-0.57	-0.38	0.08	0.10	0.02	sp	Y	8:30: Payrolls up 310,000; wage up .5%	
202	9/3/99	8:29	1.09	0.77	-0.36	-0.16	-0.15	sp	Y	8:30: Payrolls up 124,000; wage up .2%	
208	10/8/99	8:29	0.56	0.14	-0.05	0.04	-0.07	sp	Y	8:30: Payrolls down 8,000; wage up .5%	
212	11/5/99	8:29	0.95	0.38	-0.30	-0.16	-0.18	SP	Y	8:30: Payrolls up 310,000; wage up .1%	
214	12/3/99	8:29	0.64	0.34	-0.05	0.04	-0.04	SP	Y	8:30: Payrolls up 234,000; wage up .1%	
218	1/7/00	8:29	-0.13		-0.08	-0.05		SP	Y	8:30: Payrolls up 315,000; wage up .4%	
220	2/4/00	8:29	0.68		-0.20	0.03		SP	Y	8:30: Payrolls up 387,000; wage up .4%	
221	3/3/00	8:29	0.80		0.08	-0.10		SP	Y	8:30: Payrolls up 43,000; wage up .3%	
<b>Fiscal Policy Shocks</b>											
9	9/14/82	15:29	-0.88					sp	F	15:27: Rostenkowski said tax boost needed for defense.	
17	12/9/82	15:21	-0.92					sp	F	?time: Howard Baker withdrew capital gains bill.	
18	12/15/82	10:55	-0.73		-0.02	-0.07	0.00	sp	F	10:56: Murray Weidenbaum testified deficit hurts recovery.	
24	2/7/86	11:59	-0.98	-0.33	-0.41	-0.13	-0.07	sp	F	12:00:03 judge panel ruled Gramm-Rudman unconstitutional.	
190	5/12/99	9:45	-1.29	-0.11	0.35	0.75	0.16	sp	F	?time: Rubin to announce resignation; Summers is successor.	
<b>Wage Shocks</b>											
151	1/28/97	8:29	0.58	0.60	-0.10	-0.04	-0.01	US	Z	8:30: ECI up .8%	
156	4/29/97	8:29	1.09	1.37	0.17	0.06	0.10	sp	Z	8:30: ECI up .6%	
169	4/30/98	8:29	1.05	0.74	-0.07	-0.04	0.06	sp	Z	8:30: ECI up .7%; GDP up 4.2%; deflator up .9%	
219	1/28/00	8:29	-1.41		0.24	0.29		SP	Z	8:30: ECI up 1.1%; GDP up 5.8%; deflator up 2.0%	
<b>Company Shocks</b>											
3	7/13/82	12:18	0.67		0.05	0.08	0.09	sp	C	12:20: IBM profits \$1.68 vs. \$1.37 year ago.	
8	8/24/82	13:38	-0.35		-0.07	0.03	-0.08	sp	C	13:40: GM mid August sales down to 81,597 from 134,949.	
22	1/17/86	9:54	-0.55	-0.07	-0.02	0.00		sp	C	9:54: IBM profits \$4.36 vs. \$3.55 year ago.	
217	1/6/00	16:04	-0.85		0.10	0.03		SP	C	?time: Lucent's earnings below expectations.	

Table 3 (continued)

#	Day	Base Min.	5-minute change (percentage points)					a	b	Event
			SP	US	DM	JY	BP			
<b>Trade Gap Shocks</b>										
34	12/31/86	8:29			0.50	0.38	0.31	DM	T	8:30: Trade gap widened to \$19.22 billion.
35	1/30/87	8:29			-1.36	-0.67	-0.25	DM	T	8:30: Trade gap narrowed to \$10.66 billion.
36	7/15/87	8:29			0.52	0.63	0.32	JY	T	8:30: Trade gap widened to \$14.40 billion.
37	8/14/87	8:29			1.17	1.49	0.60	DM	T	8:30: Trade gap widened to \$15.71 billion.
38	9/11/87	8:29			1.06	1.02	0.75	DM	T	8:30: Trade gap widened to \$16.47 billion.
39	10/14/87	8:29			0.51	0.67	0.32	DM	T	8:30: Trade gap narrowed to \$15.68 billion.
41	11/12/87	8:29			-0.74	-0.54	-0.40	DM	T	8:30: Trade gap narrowed to \$14.05 billion.
42	12/10/87	8:29			2.37	1.27	2.37	DM	T	8:30: Trade gap widened to \$17.63 billion.
43	1/15/88	8:29			-2.50	-3.16	-1.95	DM	T	8:30: Trade gap narrowed to \$13.22 billion.
44	2/12/88	8:29			-1.00	-1.78	-1.05	DM	T	8:30: Trade gap narrowed to \$12.20 billion.
45	3/17/88	8:29			-0.20	-0.66	-0.17	JY	T	8:30: Trade gap widened to \$12.44 billion.
46	4/14/88	8:29			1.58	1.59	1.30	DM	T	8:30: Trade gap widened to \$13.83 billion.
47	5/17/88	8:29			-1.11	-1.12	-1.15	DM	T	8:30: Trade gap narrowed to \$9.75 billion.
48	6/14/88	8:29			-0.62	-0.19	-0.75	DM	T	8:30: Trade gap narrowed to \$9.89 billion.
49	8/16/88	8:29			1.60	0.26	0.35	DM	T	8:30: Trade gap widened to \$12.54 billion.
50	9/14/88	8:29			-0.79	-0.85	-0.60	DM	T	8:30: Trade gap narrowed to \$9.53 billion.
51	10/13/88	8:29			0.84	0.89	0.64	DM	T	8:30: Trade gap widened to \$12.18 billion.
54	1/18/89	8:29		-0.28	0.46	0.51	0.63	BP	T	8:30: Trade gap widened to \$12.51 billion.
60	5/17/89	8:29		-0.07	-0.85	-0.75	-0.94	DM	T	8:30: Trade gap narrowed to \$8.86 billion.
62	6/15/89	8:29		0.10	-0.71	-0.48	-0.34	DM	T	8:30: Trade gap narrowed to \$8.26 billion.
65	8/17/89	8:29		0.29	-0.68	-0.43	-0.77	BP	T	8:30: Trade gap narrowed to \$8.17 billion.
66	9/15/89	8:29		0.29	-1.00	-0.66	-0.94	DM	T	8:30: Trade gap narrowed to \$7.58 billion.
70	10/17/89	8:29		0.00	0.56	0.55	0.58	DM	T	8:30: Trade gap widened to \$10.77 billion.
110	7/16/93	8:29		0.05	-0.19	-0.78	-0.27	JY	T	8:30: Trade gap narrowed to \$8.37 billion.
137	10/18/95	8:29	0.07	0.03	-0.89	-0.55	-0.35	DM	T	8:30: Trade gap narrowed to \$8.80 billion.
<b>Rumor and Comment Shocks</b>										
7	8/19/82	14:02	-0.55		0.05	0.05	0.00	sp	X	?time: Rumor major US bank in trouble over Mexican loans.
20	2/26/85	11:20	0.17	0.04	1.07	0.13	0.48	DM	X	?time: Volcker testified maybe more FX intervention needed.
25	2/19/86	11:37	-0.04	-0.04	-0.73	-0.64	-0.50	JY	X	?time: Volcker testimony.
26	2/19/86	12:36	0.02	-0.28	-0.48	-0.48	-0.44	DM	X	?time: Volcker voiced worry over value of dollar.
27	2/27/86	10:54	0.07	0.03	-0.55	-0.65	-0.24	DM	X	?time: Preston Martin denied rumor about G5 meeting.
33	10/31/86	8:29			-0.49	-0.16	-0.14	DM	X	?time: James Baker hailed Japanese rate cut.
40	11/10/87	10:45	0.48	0.14	-0.36	-0.23	-0.29	DM	X	?time: Reagan said he wanted no further dollar decline.
77	10/5/90	11:03	0.32	0.10	-0.69	-0.04	0.46	DM	X	11:09: UK cut rate by 100bp; pound to enter ERM.
78	10/9/90	15:41	-0.81					sp	X	15:39: Brazil's central bank pres. said rescheduling needed.
84	4/5/91	9:32	0.01	0.00	-0.74	-0.49	-0.54	DM	X	9:32: Bundesbank said dollar rise not from fundamentals.
95	1/17/92	13:28	-0.08	0.00	0.36	0.85	0.31	JY	X	13:32: Schlesinger said monetary stability in peril.
102	9/16/92	14:46	-0.08	-0.21	0.85	0.41	1.69	DM	X	14:43: Bank of England to suspend pound from ERM.
131	4/26/95	10:12	0.06	0.06	-0.22	-0.54	-0.19	JY	X	?time: G10 concerned over recent FX moves.
159	6/11/97	23:36			-0.03	-1.17		JY	X	?time: Sakakibana warned about too strong a yen.
173	8/11/98	20:16			0.12	0.70		JY	X	?time: Kuroda: will take necessary FX steps.
179	11/16/98	20:58			-0.03	-0.22		JY	X	9:01: Moody's cuts Japan's FX rating to A.A1.
183	1/11/99	20:05	0.05			-0.91		JY	X	?time: Miyazawa: no comment on whether will intervene.
184	1/12/99	2:12	0.04			-0.86		JY	X	?time: Nonaka: excessive yen rise not good.
185	1/15/99	8:07	0.81					sp	X	8:10: Estado said Brazil won't intervene in FX market.
201	8/24/99	20:12	-0.01			-0.61		JY	X	?time: Mitoguchi: will watch FX market after Fed meeting.
<b>International Conflict Shocks</b>										
74	8/3/90	9:46	-0.72	0.20	0.13	0.13	0.09	sp	W	?time: Iraq invaded Kuwait.
75	8/17/90	12:13	-0.46	0.11	0.06	0.07	-0.01	sp	W	12:11: Pentagon recommended maybe calling up reserves.
76	8/21/90	11:13	0.98	0.11	-0.03	-0.10	-0.02	sp	W	11:13: Iraq's Aziz said he is ready to discuss Gulf situation.
79	10/12/90	11:53	0.50	-0.17	0.06	0.05	0.02	sp	W	11:51: Exile party said Iraq considering withdrawal.
80	12/4/90	15:32	0.99					sp	W	?time: British TV reported Iraq made new offer on Kuwait.
113	9/21/93	12:16	-0.01	0.03	-0.72	-0.12	-0.79	DM	W	12:16: Yeltsin suspended parliament.
135	8/17/95	14:42	0.03	-0.03	0.43	0.84	0.34	JY	W	?time: Iraq warned US military steps will backfire.
<b>Intervention Shocks</b>										
19	10/25/84	10:15	-0.03	-0.13	0.87	0.41	0.45	DM	I	10:21: Bundesbank intervened.
99	7/20/92	10:15	0.19	-0.03	-0.51	-0.31	-0.32	DM	I	?time: Coordinated intervention.
100	8/21/92	9:19		-0.03	-0.78	-0.24	-0.46	DM	I	?time: Fed intervention.
126	11/2/94	11:00	0.12	0.13	-0.66	-0.69	-0.48	DM	I	?time: US intervention.
132	5/31/95	8:35	-0.03	0.08	-0.86	-1.16	-0.47	DM	I	?time: US intervention.
166	1/5/98	19:50	-0.05		0.04	0.89	0.04	JY	I	?time: Japan intervened.
167	3/19/98	19:38	0.02			0.74		JY	I	?time: Japan intervened.
170	6/17/98	7:54	0.05		0.27	1.23	0.23	JY	I	?time: US and Japan intervened.
171	6/24/98	2:31	0.04		0.22	0.92		JY	I	?time: Japan intervened.
195	6/13/99	20:10			-0.06	-0.56	-0.06	JY	I	?time: Japan intervened.
198	7/20/99	9:07	0.04	-0.05	-0.29	-0.87	-0.09	JY	I	?time: US intervened.
213	11/30/99	1:20				-0.56		JY	I	?time: Japan intervention rumored.

Table 3 (continued)

#	Day	Base Min.	5-minute change (percentage points)						a	b	Event
			SP	US	DM	JY	BP				
<b>Japan Shocks</b>											
28	3/6/86	9:44	-0.11	-0.66	0.07	0.31	0.03	US	J	9:43: Source said BOJ reducing discount rate by 50bp.	
168	4/9/98	4:05	0.04		-0.16	-0.58		JY	J	?time: Hashimoto announced tax cuts.	
172	7/2/98	24:14				0.75		JY	J	?time: Hashimoto talked of permanent tax cuts.	
174	9/9/98	5:17			-0.09	-1.33	-0.07	JY	J	?time: BOJ cut rate to .25.	
176	10/13/98	3:09			0.30	0.83		JY	J	?time: BOJ kept policy unchanged.	
178	11/12/98	11:45	0.02	-0.05	0.10	0.23	0.04	JY	J	?time: Japan stimulus package announced.	
181	11/19/98	21:37			-0.10	-1.03		JY	J	?time: Miyazama: no sales tax cut for now, debate possible.	
182	1/7/99	5:22	0.00		-0.08	-0.86	0.02	JY	J	?time: Japan's consumer spending up; recovery seems distant.	
200	8/13/99	8:57	0.11	0.00	-0.52	-0.98	-0.26	JY	J	?time: Ozawa's Liberal party to stay in ruling block.	
203	9/8/99	19:49	-0.08			1.02		JY	J	?time: Japanese GDP .9%; deflator -.7%.	
206	9/21/99	3:54	-0.31			1.80		JY	J	?time: BOJ policy unchanged.	
209	10/13/99	5:15	0.00		0.05	-0.90		JY	J	?time: BOJ policy eased.	
211	10/27/99	3:13	0.02		-0.02	-0.54		JY	J	?time: Sony's profits down 24.5%.	
<b>Germany Shocks</b>											
67	10/5/89	9:00		-0.10	0.49	0.31	0.68	BP	G	9:02: Bundesbank raised rate by 100bp.	
87	7/12/91	9:15		0.00	0.93	0.21	0.62	DM	G	9:14: Germany to takes phased approach to inflation.	
106	4/22/93	9:15		-0.08	-0.08	0.02	-0.01	DM	G	9:16: Bundesbank cut Lombard rate and discount rate.	
188	3/11/99	11:44	-0.05	0.08	0.61	0.44	0.16	DM	G	?time: Lafontaine resigned.	

See Table 2 for notes and abbreviations.

base minute chosen for each event is presented in Table 2.

It may be for a given variable that the price level for minute 0 and/or minute 5 does not exist. When this was true, the following price-level pairs were tried in the order specified, and the procedure was stopped when data for a pair existed. If at the end no pairs existed, no change is presented in Table 2. (The notation -i is the i'th minute before minute 0.) The order of the pairs tried is (when 5/0 does not exist): 6/0, 4/0, 3/0, 2/0, 1/0, 5/-1, 5/-2, 5/-3, 5/-4, 6/-1, 4/-1, 3/-1, 2/-1, 1/-1, 6/-2, 4/-2, 3/-2, 2/-2, 1/-2, 6/-3, 4/-3, 3/-3, 2/-3, 1/-3, 6/-4, 4/-4, 3/-4, 2/-4, 1/-4.

Note that it may be that no change for an event in Table 2 is greater than .75 in absolute value. It may be, for example, that only the three-minute change was this large, and it is not presented in the table. The maximum of the one- through five-minute changes for each variable could have been used in Table 2, but for comparison purposes across variables it seemed better to use (whenever possible) the same change for each.

It is important to stress that each event in Table 2 is causal in that it caused



the large price changes. For example, it is almost certain that the five-minute *SP* price increase of 1.05 percent on June 25, 1982, was essentially all due to the 16:10 money supply announcement (event 1, Table 2). There would likely have been, of course, a price change had there been no announcement, since the price generally changes each minute, but with a standard deviation of 0.107 percent, a typical price change is very small relative to a change of 1.05 percent. For all intents and purposes one can attribute all of the price change to the money supply announcement. A way of thinking about the events is the following. Consider asking stock or bond or exchange rate brokers a few minutes after the occurrence of one of the large price changes in Table 2 what led, if anything, to the change. The main point here is that almost without exception the brokers would say the event.

There are two types of possible errors regarding the construction of Table 2. One is that the event that was chosen did not in fact cause the large price changes. It may be that a few events, especially those put in category *X*, have been chosen in error, but there are not likely to be many of these. Almost all the chosen events are the obvious causal events for the large price changes. When, for example, there is a large price jump between the end of minute 8:29 and the end of minute 8:30 and there was a widely followed announcement at 8:30, it is obvious that the announcement was the cause. There is little possibility of error here.

The other type of possible error is that an event was missed for a large price change. The most likely error is an event for which there was no news report. Less likely is a news report that was listed in the search but that was not noticed as an important event. It is difficult to know how many errors of this type were made, but

there are clearly likely to be some. So Table 2 should at least be a little larger than it is. Note also that many more large price changes and events would likely have been found had the GLOBEX market been in existence prior to 1994. For sake of the analysis in Section 4, the missing of events cuts the number of observations that are available for study, so efficiency is lost, but there is no necessary bias introduced.

It should be stressed that the events that have been found are not necessarily surprises in the sense of an actual value differing from an expected value, although most of them probably are. Even if the actual value is equal to the expected value, the relieving of uncertainty may affect prices. In the rest of this paper, however, the words ‘surprise’ and ‘shock’ will be used to describe the events, but keep in mind this caveat.

Aside from examining the relationship among variables, which is done in the next section, Table 2 may be of interest in its own right for other studies. The events are large shocks, and knowledge of them may prove useful in both macroeconomic studies and studies of individual stock prices.

Regarding the previous literature, there do not appear to be other studies in which events have been identified in the way done in this paper, i.e., focusing on large, rapid changes and using newswire searches. Related studies on stock prices include the following. Niederhoffer (1971) examines the effects of world events on daily stock prices. Wood, McInish, and Ord (1985) examine the behavior of a minute-by-minute market return index. French and Roll (1986) examine the volatility of individual stock prices during trading and non trading hours. Harris (1986) examines the behavior of portfolio returns over 15-minute intervals.

Mitchell and Mulherin (1994) and Berry and Howe (1994) examine the effects of the amount of news per unit of time on stock prices and trading volume. Studies that have examined the effects of announcements on daily changes in stock prices include Schwert (1981), Pearce and Roley (1985), Hardouvelis (1987), Jain (1988), Cutler, Poterba, and Summers (1989), Haugen, Talmor, and Torous (1991), McQueen and Roley (1993), and Boyd, Hu, and Jagannathan (1999).

Using bond data, Fleming and Remolona (1997) examine five-minute price changes for the five year U.S. Treasury note for the period August 23, 1993–August 19, 1995. They chose the 25 largest five-minute price changes over this period, and they found that each of these changes was preceded by a macroeconomic announcement.

Ederington and Lee (1993) use tick data for the November 7, 1988–November 29, 1991 period to examine one-minute changes in the U.S. Treasury bond future, the DM future, and the Eurodollar future. In Ederington and Lee (1995) 10-second changes are examined. They find that most of the price reaction to an announcement occurs within the first minute. Becker, Finnerty, and Friedman (1995) examine 30-minute changes in the U.K. FTSE-100; Becker, Finnerty, and Kopecky (1995) examine 15-minute changes in U.S., U.K., German, and Japanese interest rates; and Becker, Finnerty, and Kopecky (1996) examine 15-minute changes in the U.S. Treasury bond future and the Eurodollar future. Jones, Lamont, and Lumsdaine (1998) examine daily returns on 5, 10, and 30 year bonds for the 1979-1995 period. Almeida, Goodhart, and Payne (1998) use quotation data on the DM exchange rate to examine 5-minute changes for the period January 1, 1992–December 31, 1994. Andersen and Bollersley (1998) examine five-minute changes in the DM rate for

the October 1, 1992–September 30, 1993 period. Gwilym, McMillan, and Speight (1999) examine five-minute stock price changes using FTSE-100 data. The data are for the January 24, 1992–June 30, 1995 period. Clare and Courtenay (2000) examine five-minute changes using FTSE-100 data and data on the dollar/pound and DM/pound exchange rates.

A general finding in this literature is that both trading volume and price volatility are quite high around announcement times—much higher than otherwise.

Some of the exchange rate data that have been used, such as in Andersen and Bollersley (1998), Almeida, Goodhart, and Payne (1998), and Clare and Courtenay (2000) are not transactions data. An advantage of tick data is that they are transactions data. A trade took place at each tick price.

Some of the above studies have been concerned with estimating surprise components of announcements, where the surprise is the difference between the announced value and an estimate of its expected value. The expected value is usually either taken from a survey or to be a prediction from an autoregressive equation. Estimating surprises in this way is crude, especially if autoregressive equations are used, and it may be that even a large difference is not a surprise. Also, even if the difference is a surprise, it may have essentially no impact on financial markets.

The events in Table 2 have the advantage that they are truly surprises in that they caused a large and rapid change in at least one financial market. The *sign* of the effect of each surprise on each financial market is also known, which indicates whether the surprise was positive or negative. If, for example, a CPI announcement led to a decrease in *US* (i.e., an increase in the long rate), this indicates that the surprise part of the change in the CPI was positive (the CPI was larger than

expected).

## 4 Relationships Among the Variables

### The Bond Price ( $US$ ) and Stock Price ( $SP$ )

A monetary shock ( $R$ ) or price shock ( $P$ ) or real shock ( $Y$ ) is defined here to be positive if it results in a decrease in the bond price ( $US$ ). If  $US$  depends negatively on expected future short term interest rates, which is assumed here, then a positive shock is one in which there is an increase in expected future short rates. All three types of shocks affect  $US$  if they affect expectations about future Fed behavior. A positive shock is one that leads to expectations of future Fed tightening, which immediately decreases  $US$ .

It will be useful to organize the discussion around three “propositions.” These propositions are hypotheses about the signs of the three types of shocks on various expectations and the signs of the expectations on the stock price ( $SP$ ). It will be seen that the propositions have implications that are supported by the data in Table 3. The propositions are stated in terms of positive shocks, but everything is meant to hold in reverse for negative shocks.

**Proposition 1** *A positive monetary shock ( $R$ ) has two negative effects on  $SP$ . The first (effect 1) is because expected future discount rates for expected future earnings are higher. The second (effect 2) is because expected future earnings are lower due to an expected slower future economy caused by the expected higher interest rates.*

**Proposition 2** *A positive price shock ( $P$ ) has negative effects on  $SP$  through effects 1 and 2. It also has a positive effect on  $SP$  (effect 3) because it has a positive effect on expected future earnings in nominal terms.*

**Proposition 3** *A positive real shock ( $Y$ ) has negative effects on  $SP$  through effects 1 and 2. If expected future prices have increased because of the real shock, the real shock is also in part a price shock, and so effect 3, which is positive, is working. The real shock also has a positive effect on  $SP$  (effect 4) because it has a positive effect on the expected future economy and thus on expected future earnings.*

What do these three propositions imply about the data in Table 3? The relevant data are the  $R$ ,  $P$ , and  $Y$  shocks for which observations on both  $\Delta SP$  and  $\Delta US$  exist, where  $\Delta SP$  and  $\Delta US$  are the five-minute percentage changes in  $SP$  and  $US$  in the table. There are 12  $R$  shocks, 14  $P$  shocks, and 38  $Y$  shocks that meet this requirement, for a total of 64 observations.

Only 4 of the 64 observations have  $\Delta SP$  and  $\Delta US$  of opposite signs—2 for the  $R$  shocks (events 175 and 216), 1 for the  $P$  shocks (event 204), and 1 for the  $Y$  shocks (event 133). Although Proposition 1 says that the signs should be the same for the  $R$  shocks (effects 1 and 2 are both negative), Propositions 2 and 3 say that the signs could go either way for the  $P$  and  $Y$  shocks (effects 3 and 4 are positive). Given that the signs for the  $P$  and  $Y$  shocks are almost always the same, it is clear that effects 1 and 2 dominate effects 3 and 4.

The key implication from the three propositions, however, does not concern the sign of the changes, which as just noted can go either way for the  $P$  and  $Y$  shocks, but the *size* of  $\Delta SP$  relative to *size* of  $\Delta US$ . The three propositions imply that the  $SP$  response relative to the  $US$  response should be smaller for the  $P$  and  $Y$  shocks than for the  $R$  shocks. This is because effects 3 and 4 are positive and therefore offset some of effects 1 and 2, which are negative.

Note that having observations on both  $SP$  and  $US$  is crucial for examining this implication. Shocks differ in the sizes of their impacts on expected future

short term interest rates, and a measure of the size of the impact of a given shock on expected future rates is  $\Delta US$ . Examining  $\Delta SP$  relative to  $\Delta US$  is a way of accounting for the different sizes of the impacts.

The propositions also imply that the  $SP$  response relative to the  $US$  response is likely to be smaller for  $Y$  shocks than for  $P$  shocks because effect 4 is only operating for  $Y$  shocks. This is true unless effect 3 is much larger for a  $P$  shock than for a  $Y$  shock and results in effect 3 for the  $P$  shock being larger than the sum of effects 3 and 4 for the  $Y$  shock. As will be seen, the data suggest that this is not the case.

These implications can be examined by regressing  $\Delta SP_i$  on  $\Delta US_i$ :

$$\Delta SP_i = \alpha \Delta US_i + \epsilon_i$$

where  $i$  denotes either a  $R$ ,  $P$ , or  $Y$  observation. The propositions imply that  $\alpha$  should be larger for the  $R$  observations than for the  $P$  and  $Y$  ones. They also imply that  $\alpha$  is likely to be larger for the  $P$  observations than for the  $Y$  ones.

The estimates of  $\alpha$  are presented in Table 4 for the three sets of observations. The estimate is 1.68 for the  $R$  observations, 1.03 for the  $P$  observations, and .75 for the  $Y$  observations. This is exactly as expected. The difference between 1.68 and 1.03 has a t-statistic of 1.37, and the difference between 1.68 and .75 has a

**Table 4**  
**Estimates of  $\alpha$  for Different Shocks**

$\Delta SP_i = \alpha \Delta US_i + \epsilon_i$						
Shock Observations						
	<i>R</i>	<i>P</i>	<i>Y</i>			
(# obs.)	(12)	(14)	(38)			
$\hat{\alpha}$	1.68	1.03	.75	t-stat. <i>R</i> vs. <i>P</i> = 1.37	t-stat. <i>R</i> vs. <i>Y</i> = 2.08	
				t-stat. <i>P</i> vs. <i>Y</i> = 1.28		
$\Delta DM_i \text{ or } \Delta JY_i \text{ or } \Delta BP_i = \alpha \Delta US_i + \epsilon_i$						
Shock Observations						
	<i>R</i>	<i>P</i>	<i>Y</i>			
(# obs.)	(14)	(27)	(66)			
<i>DM</i> $\hat{\alpha}$	.41	.15	.34	t-stat. <i>R</i> vs. <i>P</i> = 1.11	t-stat. <i>Y</i> vs. <i>P</i> = 1.72	
<i>JY</i> $\hat{\alpha}$	.17	.09	.21	t-stat. <i>R</i> vs. <i>P</i> = 0.52	t-stat. <i>Y</i> vs. <i>P</i> = 1.64	
<i>BP</i> $\hat{\alpha}$	.53	.14	.24	t-stat. <i>R</i> vs. <i>P</i> = 2.02	t-stat. <i>Y</i> vs. <i>P</i> = 1.15	

Observations used for the regressions are from Table 3.

*R* = monetary shocks

*P* = price shocks

*Y* = real shocks

t-statistic of 2.08.<sup>4</sup> The *R* and *Y* difference is thus statistically significant, but the *R* and *P* difference is not. The t-statistic for the difference between 1.03 and .75 is 1.28, and so the *P* and *Y* difference is also not statistically significant. Given the small sample sizes, however, one cannot expect much precision, and it is at least encouraging that the relative sizes are as expected. If the two *R* observations are omitted that have the opposite signs for  $\Delta US_i$  and  $\Delta SP_i$  (events 175 and 216),

<sup>4</sup>These t-statistics were computed by regressing over all 64 observations  $\Delta SP_i$  on  $\Delta US_i$ ,  $DP_i \Delta US_i$ , and  $DY_i \Delta US_i$ , where  $DP_i$  is 1 for the *P* observations and 0 otherwise and  $DY_i$  is 1 for the *Y* observations and 0 otherwise. The t-statistic for the estimate of the coefficient of  $DP_i \Delta US_i$  is the t-statistic for the difference between the *R* observations  $\alpha$  and the *P* observations  $\alpha$ , and the t-statistic for the estimate of the coefficient of  $DY_i \Delta US_i$  is the t-statistic for the difference between the *R* observations  $\alpha$  and the *Y* observations  $\alpha$ . The t-statistic for the difference between the *P* observations  $\alpha$  and the *Y* observations  $\alpha$  is obtained in a similar manner—from a regression of  $\Delta SP_i$  on  $\Delta US_i$ ,  $DY_i \Delta US_i$ , and  $DR_i \Delta US_i$ , where  $DR_i$  is 1 for the *R* observations and 0 otherwise.



the estimate of  $\alpha$  for the  $R$  observations rises to 2.25 with the t-statistic for the difference between the  $R$  and  $Y$  observations rising to 4.00 and the t-statistic for the difference between the  $R$  and  $P$  observations rising to 3.08. The results thus provide some support to the existence of effects 3 and 4, especially effect 4.

Some of the other results in Table 3 regarding  $\Delta SP$  and  $\Delta US$  are the following. The three wage ( $Z$ ) observations are similar to the price ones. The estimate of  $\alpha$  for the three observations is .94, which is close to the 1.03 for the  $P$  observations. One might expect wage shocks to have a smaller effect on expected future nominal earnings than do price shocks because of higher expected wage bills, which means that  $\alpha$  should be larger for the wage shocks than for the price shocks. In fact the estimates are essentially the same.

The fiscal policy ( $F$ ), company ( $C$ ), and international conflict ( $W$ ) shocks seem likely to have more effect on expected future earnings than on expected future interest rates. It is generally the case in Table 3 that the large changes from these shocks are on  $SP$  and not on  $US$ . My favorite event is event 190, where fear of Larry Summers drove  $SP$  down by 1.29 percent in five minutes.

### **The Bond Price ( $US$ ) and Exchange Rates ( $DM, JY, BP$ )**

Consider now the relationship between the bond price ( $US$ ) and the exchange rates ( $DM, JY, BP$ ). (Remember that the euro replaces the deutsche mark beginning June 1, 1999.) The exchange rates are nominal rates per dollar, so that an increase in an exchange rate is an appreciation of the currency and thus a depreciation of the dollar. In what follows all changes in U.S. variables are both absolute and *relative*

to the respective variables for Germany, Japan, and the United Kingdom. Again, it will be useful to organize the discussion around three propositions.

**Proposition 4** *A positive U.S. monetary shock ( $R$ ) has two effects on  $DM$ ,  $JY$ , and  $BP$ , one negative and one positive. The negative effect (effect 5) is because investors seek the higher expected rates of return in the United States, which drives the price of the dollar up. The positive effect (effect 6) is because of an expected slower U.S. economy and lower stock prices caused by the expected higher U.S. interest rates.*

**Proposition 5** *A positive U.S. price shock ( $P$ ) has one negative effect and one positive effect on the  $DM$ ,  $JY$ , and  $BP$  (effects 5 and 6). It also has a positive effect on the exchange rates (effect 7) because expected future U.S. prices are higher, which encourages investors to seek to move out of dollars and thus drives the price of the dollar down.*

**Proposition 6** *A positive real U.S. shock ( $Y$ ) has one negative effect and one positive effect on the  $DM$ ,  $JY$ , and  $BP$  (effects 5 and 6). If expected future U.S. prices have increased because of the real shock, the real shock is also in part a price shock, and so effect 7, which is positive, is working. The real shock also has a negative effect on the exchange rates (effect 8) because it has a positive effect on the expected future U.S. economy and U.S. stock prices. This encourages investors to seek to move into dollars and thus drives the price of the dollar up.*

The relevant data in Table 3 for these three propositions are the  $R$ ,  $P$ , and  $Y$  shocks for which observations on  $\Delta US$ ,  $\Delta DM$ ,  $\Delta JY$ , and  $\Delta BP$  exist. There are 14  $R$  shocks, 27  $P$  shocks, and 66  $Y$  shocks that meet this requirement, for a total of 107 observations.

In the following discussion  $DM$  will be used as the exchange rate, but the same analysis holds for  $JY$  and  $BP$ . A key implication from Propositions 4 and 5 is that the size of  $\Delta DM$  relative to size of  $\Delta US$  should be smaller for the  $P$  shocks than for the  $R$  shocks. This is because effect 7 for the  $P$  shock is positive and therefore offsets some of the negative effect from effect 5 for the  $P$  shock.

The propositions also imply that  $\Delta DM$  relative to  $\Delta US$  should be smaller for the  $P$  shocks than for the  $Y$  shocks because effect 8 is only operating for the  $Y$  shocks. This is true unless effect 7 is much larger for a  $P$  shock than for a  $Y$  shock and results in effect 7 for the  $P$  shock being larger than the sum of effects 7 and 8 for the  $Y$  shock. As will be seen, the data suggest that this is not the case.

Propositions 4 and 6 have no implications for  $R$  versus  $Y$  shocks. Effects 7 and 8 are working for  $Y$  shocks and not for  $R$  shocks, but effect 7 is positive and effect 8 is negative.

These implications can be examined by regressing  $\Delta DM_i$  on  $\Delta US_i$ :

$$\Delta DM_i = \alpha \Delta US_i + \epsilon_i$$

where  $i$  denotes either a  $R$ ,  $P$ , or  $Y$  observation. The propositions imply that  $\alpha$  should be smaller for the  $P$  observations than for the  $R$  ones. They also imply that  $\alpha$  is likely to be smaller for the  $P$  observations than for the  $Y$  ones.

The estimates of  $\alpha$  are presented in Table 4 for the three sets of observations and the three exchange rates. For all three exchange rates the estimate of  $\alpha$  is smaller for the  $P$  observations than for the  $R$  and  $Y$  observations, which is as expected. The three t-statistics for the  $R$  versus  $P$  differences are 1.11, 0.52, and 2.02, and the three t-statistics for the  $Y$  versus  $P$  differences are 1.72, 1.64, and 1.15. Again, even though the precision is not high, it is at least encouraging that all six of the relative sizes are as expected. The results provide some support to the existence of effects 7 and 8.

The other results in Table 3 for the exchange rates require little further discussion. For all 25 of the U.S. trade gap ( $T$ ) shocks the signs of the three exchange rate

changes are the same, as expected. The trade shocks are shocks to the U.S. trade balance, and so the dollar should be affected across all currencies. It is interesting to note that the last trade gap announcement to have a large effect was October 18, 1995 (event 137). Market participants no longer seem to worry much about the U.S. trade deficit. Each intervention (an  $I$  shock) has a large effect on at least one of the exchange rates.

## 5 Conclusion

The 221 events in Table 2 are important shocks in that they caused a large and rapid change in one or more of the U.S. stock market, the U.S. bond market, the market for deutsche marks, the market for yen, and the market for British pounds. Knowledge of these events may be useful in future work. As discussed at the end of Section 2, the events have the advantages that they are truly surprises and that the sign of their effect of each surprise on each financial market is known.

The organization of the shocks into different types in Table 3 can be used to examine the effects of the different types. The implications of Propositions 1-6 are supported by the data. The change in the stock price ( $SP$ ) relative to the change in the bond price ( $US$ ) is larger for monetary shocks than for price and real shocks and larger for price shocks than for real shocks. The change in an exchange rate ( $DM$ ,  $JY$ , or  $BP$ ) relative to the change in the bond price is smaller for price shocks than for monetary and real shocks. In terms of the effects listed in the propositions, the results suggest that while effects 1, 2, 5, and 6 are strong, there is some support for the existence of effects 3, 4, 7, and 8.

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