An Economic Analysis of the Determinants of Lumber Futures Price Movements

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INTRODUCTION

Lumber prices in the United States have exhibited extreme volatility in recent years. From early January to early March of 1993, for example, lumber futures prices increased from about $240 to $490 per thousand board feet (mbf). By early July 1993, futures prices had declined to less than $230 per mbf. [1] There has been considerable debate over the primary causes of the volatility.[2] Likely culprits include domestic supply factors such as cutbacks in logging due to court rulings regarding the spotted owl and other endangered species, and demand factors such as housing starts. Other possible sources of volatility include trade factors such as exchange rates, the level of Canadian wood products imported into the United States, countervailing import duties on Canadian products, and Canadian log export bans.

We investigate the impacts of these factors on lumber futures contract prices, and in the process contribute two innovations to the event analysis literature. First, we compare and contrast the impact of three sets of events that have been monitored and reported on extensively by lumber industry publications, but that differ in the way information enters the market: (1) regular, periodic events in the form of housing start announcements; (2) irregular information releases in the form of court rulings related primarily to the northern spotted owl, and policy decisions related to U.S.-Canada lumber trade disputes. We hypothesize that the magnitude and speed of market response will differ systematically across these types of events due to systematic

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[1] Cash prices showed similar variation. Between October 1992 and March 1993, for example, monthly average cash lumber prices increased from roughly $250 to almost $500 per mbf. By July 1993, prices had declined to about $300. More recently, futures contract prices rose from $337 per mbf in early May 1999 to $432 per mbf in early July, an increase of almost thirty percent.

[2] The debate on this issue reached a peak, at least in the popular press, in 1993. Information sources cited by the news media at that time included Gorte (1993), Wilderness Society (undated), and Sierra Club Legal Defense Fund (1993).

differences in the way in which information enters the market. We then empirically investigate this hypothesis.

Second, in addition to performing a number of previously developed statistical tests of information event effects on futures prices (e.g., Fama, et al. (1969), Schwert (1981), Ball and Torous (1988), Sumner and Mueller (1989), Mackinlay (1997)), we introduce a model that parameterizes the time path of market response to events. This model provides an easily interpretable method of comparing the rate of market response to different events. Consistent with our expectations, we find evidence that news from regular periodic announcements tends to be incorporated into the lumber futures market price more rapidly than events whose content is multi-dimensional and whose announcement dates are not known in advance by market participants.

We base our analysis on daily movements in lumber futures contract prices. While considerable previous research uses annual and monthly price series, these futures contracts provide the best available measures of short-term movements in the national lumber market prices. We know of no recent lumber market research based on these high-frequency data.

Policy makers interested in state or regional economies may be concerned about the relevance of a single national lumber price series. Previous research by Uri and Boyd (1990), Jung and Doroodian (1994), Yoder (1994), and Murray and Wear (1998) suggests that lumber price movements are highly correlated across regions, and that the U.S. lumber market can therefore be analyzed as a national market. Thus, to a considerable extent, prices in state or regional lumber markets move with the national price series that we analyze.

The three types of information events examined in this paper relate to trade policy events, supply conditions, and demand conditions. The trade policy events examined here are related to quasi-legislative agreements negotiated by the U.S. International Trade Administration (ITA) and the U.S. International Trade Commission (ITC). There are a number of interesting issues concerning the factors that reflect supply conditions in the U.S. wood products industry. Most notable for present purposes are the impacts of environmental regulations such as the protection of the Northern spotted owl. Previous analyses of the impacts of such regulations include Gorte (1993) and Montgomery, Brown, and Adams (1994), and Yoder (1994). In the present analysis, we compile a legal history of the spotted owl controversy and use this history to develop empirical measures of environmental regulations and to examine the impacts of court rulings regarding these factors on lumber price movements. Demand conditions are represented by the impact of the periodic release of housing starts housing starts estimates, and by daily data on long-term interest rates.

The paper proceeds as follows. Predictions concerning the differential impacts of different types of events are developed in Section I. In Section II we describe the data. In Section III, we present the results of our empirical analysis using tests developed previously in the event literature. An alternative method of estimating the impacts of events is developed and empirical results are discussed in Section IV. Section V contains concluding comments.

I. DIFFERENTIAL IMPACTS OF DIFFERENT TYPES OF EVENTS

Numerous previous studies have examined the impacts of particular types of events on futures prices in various markets. Sumner and Mueller, for example, examine the information content of USDA harvest forecasts by analyzing movements in corn and soybean futures prices. Robenstein and Thurman (1996) investigate the impacts of the release of reports concerning the adverse health effects of red meat on cattle futures market prices. To our knowledge, however, there has been no analysis—either theoretical or empirical—of the relative impacts of different types of potential information-revealing events. The analysis presented below estimates and contrasts the impacts of three different types of events: regular, periodic announcements concerning conditions in a particular segment of the wood products market; irregular releases of potentially important information in the form of court decisions; and sporadic releases of information through the passage of legislation and through quasi-legislative rulings by government agencies and bureaucracies.

We hypothesize that the magnitude and nature of the potential impacts of these events will be systematically different. To begin this discussion, consider the first type of event listed above. In the context of the wood products industry, an example of this type of an event—and the event we actually use in the empirical analysis below—is the monthly release of U.S. housing starts estimates. These estimates are released at a time known in advance to market participants and measures are taken to assure that private market participants do not know the content of the announcements prior to their release.[3] Moreover, to the extent that the housing starts estimates are different from the market's expectations, market participants know from experience how to quickly interpret and respond to the information. We predict therefore that, insofar as the release of housing starts estimates have impacts on lumber futures prices (because they are different from the market's expectations) the market (lumber futures contract prices) will adjust relatively rapidly. Because market participants' expectations are not observable, we are not able to predict the direction of the impact of housing start announcements. For example, an announcement that

[3]The U.S. Census Bureau schedules housing starts announcements to be released at 8:30 a.m. on the twelfth working day of each month. The release date is delayed by one day if the twelfth workday is the first workday of the week. The actual release date is always listed in the prior release. Security is tight, with lockdowns from the time the data are all on one computer (data are collected by numerous individuals in the field) until release time.

indicates a substantial increase in housing starts can result in a decrease in lumber futures prices if the announced increase is less than expected.

Consider next the releases of potentially important information in the form of court decisions. The court decisions considered in the empirical analysis below all relate to rulings regarding the Endangered Species Act that potentially affected lumber markets. Court decisions have at least three features that are important for our analysis. First, the timing of court decisions cannot be predicted very far in advance. Second, the content of the court ruling is not known with certainty in advance. Third, whereas housing starts estimates are a one dimensional piece of information, court decisions can be multidimensional and can contain considerable ambiguity. Thus, we predict that, relative to the release of housing starts estimates, it will take longer for futures markets to absorb and react to the information contained in court decisions. We have no prediction concerning the relative magnitudes of the market responses to the release of housing starts estimates relative to court decisions. A given court decision may be very different from the market's expectations and therefore have a relatively large impact. On the other hand, even if a court decision is quite different than expected, it may have little impact because the decision directly affects only a small segment of the total wood products market.

Finally, consider the release of information through the passage of legislation and through quasi-legislative rulings by government agencies and bureaucracies. Events in this category that we include in our empirical analysis all relate to legislation, rulings, and agreements that affect trade conditions. The legislative and rule making processes are potentially quite different from the other two categories of events (discussed above) in at least one dimension. There likely is considerably less uncertainty concerning the nature of the information to be revealed in this category of events. This is because these processes involve public hearings and meetings, and by the time decisions are made and announced, they may contain little news for the market.

Thus, we predict that the market's response to housing start announcements will be quicker than its response to court rulings. We also predict that the magnitudes of the responses to both housing starts announcement and to court rulings will be greater than the responses to announcements regarding trade events.

II. DATA

CME LUMBER DATA

The Chicago Mercantile Exchange Lumber Futures price data we use for our analysis spans the period from February 1982 to April 1998. Contracts mature every two months, in January, March, May, July, September, and November. The last trading day for any contract is the 15th of the month in which the contract matures.

All econometrics presented below, as well as the data displayed in figures 1-5, apply to the two-to-four-month-out contract. The rollover date we use for contracts two-to-four months out is the last trading day of the month, two months before delivery. The price used for the first trading day in March through the last trading day in May 1991, for example, are prices from the July 1991 contract. The prices used for the first day of June through the last day of July are prices from the September 1991 contract, and so on. The price series constructed in this manner is displayed in figure 1. When calculating daily price changes and rates of return on closing prices, the price changes and rates of return associated with rollover dates are discarded (such as the rate of return between the last day of May and the first day of June), so that each price change and rate of return is calculated using a single contract.

Various authors have concerned themselves with price limits, treating limit price moves as censored, non-equilibrium observations on price (Yang and Brorsen 1995, Sutrick 1993, Mann and Dowen 1996). The Lumber Futures price series is subject to an upper limit on daily price changes. On March 8, 1993, the limit on price changes went from a fixed limit of ±$5 to a limit of ±$10 expandable to ±$15 after two days of limit moves.[4] These limit changes have potentially important impacts on the results that follow, and we consider these impacts below. Day-to-day price changes for the contracts two-to-four months out are shown in figure 2. As can be seen, limit moves account for a considerable proportion (approximately 11%) of the observations. Also note that in spite of the price limits, some closing-price changes are slightly larger than the limits. Settlement prices, however, are cut off exactly at the price limits (not shown). The rate of return on the futures contract is displayed in figure 3 and is defined as $R_t=\ln(P_t/P_{t-1})$, where P_t is the closing price on trading day *t*.

The trading volume is another potentially important factor affecting the volatility of rates of return, and a factor to be considered when choosing rollover dates and contract positions. Figure 4 shows the general trend in trading volume over the time series. A number of studies examine the impact of informational events on trading volume (e.g., Beaver 1968, Morse 1981). Mann and Dowen (1996) examine the information content of hog and pig reports by estimating the impact of these events on both rates of return and normalized trading volume (volume divided by open interest). Figure 5 displays the normalized futures series for lumber futures contracts. Their analysis also takes into account the dampening effects of price limits on trading

[4] There is no limit on price changes in the spot month.

volume when estimating the event effects. Figure 6 shows the trading volume by number of days to maturity, where each value displayed is the average volume over all lumber futures contracts for a given number of days to maturity. For consistency and brevity, we use data associated only with two-to-four-month-out positions. It is clear from figure 6 that the two-to-four-month-out trading dates carry the heaviest volume, so a market efficiency argument can justify this focus. In any case, results are quite similar across contract positions.

EVENT DESCRIPTIONS

As indicated in section I above, three sets of events are examined: housing starts releases, Endangered Species Act (ESA) events, and trade policy events. "ESA Events" are Spotted Owl court rulings that had the potential to affect timber sales and harvests in the Pacific Northwest. "Trade Events" are mostly Canada-United States lumber trade policy decision announcements. The ESA and Trade events that we use for our empirical analysis are listed below. Housing Starts release dates are not shown below. We have release dates beginning in 1985, with monthly releases usually between the 15th and the 20th of each month. Figure 7 shows the distribution of each set of events over time and includes the lumber futures price and rate of return series as references. Event descriptions follow:[5]

ESA

Event # **Event Description**

1. **March 24, 1989:** U.S. District Court Judge William Dwyer prohibits timber sales from Spotted Owl Habitat on U.S. Forest Service land until a final judicial hearing. Dwyer argues that the 1988 Forest Service management plan likely violated the

[5] In addition to ESA and Trade events and housing start announcements, we also examined the impacts of three hurricanes that struck during the period of our analysis — Hugo (September 22, 1989), Andrew (August 24, 1992), and Fran (September 5, 1996). Because none of the hurricanes had significant effects on futures prices, we do not discuss them further.

National Forest Management Act and the National Environmental Policy Act. (ELR 19:20545, Washington Post 1993, Wilderness Society 1996).

2. **May 11, 1990:** Judge Dwyer prohibits a timber sale in an Oregon National Forest because it violates the Department of Interior and Related Agencies Act's (1990) requirement to minimize fragmentation of ecologically significant old growth forest (Environmental Law Reporter 20:21167).

3. **May 23, 1991:** Judge Dwyer prohibits timber sales on 17 National Forests until the Forest Service complies with requirements of the National Forest Management Act, finding that "the Forest Service and the Fish and Wildlife Service deliberately and systematically refused to comply with the laws protecting wildlife" (Environmental Law Reporter 21:21505).

4. **December 23, 1991:** The 9th Circuit Court of Appeals upholds Judge Dwyer's May 23, 1991 ruling (Environmental Law Reporter 22:20372).

5. **February 19, 1992:** U.S. District Court Judge Helen Frye prohibits 26 timber sale awards and 23 timber sale offers by the Bureau of Land Management in order to allow further review by the court. The plaintiff (Portland Audubon Society) claims that the BLM is in violation of the National Environmental Policy Act (NEPA) by not preparing an environmental impact statement regarding new Spotted Owl related information (Environmental Law Reporter 22:20889). The court rules that "the destruction of owl habitat without compliance of the law is significant and irreparable injury," and that the plaintiff is likely to prevail in its contentions that the BLM awards and offers are illegal under NEPA.

6. **June 8, 1992:** Judge Frye halts Bureau of Land Management timber sales (Wildlife Society 1996).

7. **June 6, 1994:** Judge Dwyer lifts injunction on timber sales in Spotted Owl habitat (Wildlife Society 1996).

8. **August 24, 1995:** U.S. District Court Judge Carl Muecke issues an injunction against all timber harvests on New Mexico and Arizona national forests until the federal agencies involved study the effects of harvest on Mexican Spotted Owl populations (Arizona republic 1995).

9. **September 6, 1995:** District Judge Michael Hogan allows a fire salvage sale, citing the timber salvage rider (Wilderness Society 1996).

10. **October 17, 1995:** Judge Hogan releases previously prohibited timber sales on National Forest land in Oregon and Washington and Bureau of Land Management land in Western Oregon, based on the language of the timber salvage rider (Wilderness Society 1996).

11. **October 25, 1995:** Judge Hogan's October 17 ruling is upheld by the 9th Circuit Court of Appeals (Wilderness Society 1996).

12. **May 27, 1996:** The Supreme Court upholds U.S. Department of Interior Secretary Bruce Babbitt's designation of 6.8 million acres as Spotted Owl Habitat. The case was brought because Babbitt failed to file environmental impact statements required by the National Environmental Policy Act, but the Supreme Court upheld the 9th Circuit court's finding of an exemption for critical-habitat decisions. Case: Douglas County v. Babbitt, 95-371 (USA Today 1996).

TRADE

Event # **Event Description**

1. **October 21, 1986:** The Department of Commerce International Trade Administration (ITA) announces that Canadian producers of rough, dressed or worked softwood lumber, siding, and flooring were effectively receiving fifteen percent *ad valorem* subsidy under U.S. countervailing duty laws. The ITA therefore requires the U.S. Customs Service to immediately suspend the sale of all relevant merchandise and require a cash deposit or bond (a countervailing duty) equal to the 15% subsidy (U.S. Dept. of Commerce 1986).

2. **December 30, 1986:** United States and Canada agree upon a Memorandum of Understanding (MOU) that requires Canada to impose a 15% export tax (revenues to be retained by Canada) instead of the 15% countervailing duty imposed by the ITA in October of 1986 (Joshi 1997).

3. **June 15, 1990:** US/Japan Super 301 agreement is announced. This agreement provides more market access for U.S. products into the Japanese market.

4. **August 20, 1990:** Forest Resource Conservation and Shortage Relief Act (104 Stat 714) is enacted, reinforcing the existing ban on logs from federal timber lands, and extending the ban to the export of unprocessed logs from state lands.

5. **September 3, 1991:** Canada terminates the MOU claiming the agreement is no longer needed because most of the Canadian provincial policies in question had been changed. (Joshi 1997).

6. **October 4, 1991:** In response to Canada's termination of the MOU, the U.S. Department of Commerce International Trade Administration imposes an interim bonding measure on all Canadian exports entering the United States (Joshi 1997).

7. **March 13, 1992:** The ITA imposes an interim 14.48 percent Countervailing duty on Canadian lumber.

8. **May 15, 1992:** The ITA imposes a final countervailing duty of 6.51 percent (Joshi 1997).

9. **July 21, 1992:** The International Trade Commission (ITC) affirms injury to the United States, and supports the ITA countervailing duty ruling.[6]

10. **December 17, 1993:** A binational panel (3 Canadians, 2 U.S. representatives) nullifies ITA findings of injury. The vote was split along country lines.

11. **February 16, 1996:** An "Agreement in Principle" between the United States and Canada is announced in which the U.S. agrees not to pursue anti-dumping or countervailing duty actions. In exchange, Canada imposes fees on British Columbia lumber exports to the United States exceeding nine billion board feet per year. The fees are to be US$50 per thousand board feet on the first 250 million board feet (above 9 billion) and US$100 per thousand board feet for higher quantities. These fees are to be collected and remitted to the involved Canadian provinces. The three other affected provinces (Quebec, Ontario, and Albert) agree to pursue other measures to avert U.S. trade action, such as increasing stumpage fees and timber license fees (Office of the United States Trade Representative 1996, Canadian Department of Foreign Affairs and International Trade 1996, Press releases).

12. **April 2, 1996:** A Final Canada-U.S. Softwood Lumber Agreement is announced that results in export fees similar to the British Columbia export agreement of February 16, 1996, for all four affected provinces. Combined volumes of lumber originating from the four provinces in excess of 14.7 billion board feet are to be assessed US$50 per thousand board feet for the first 650 million board feet, and US$100 per thousand board feet for higher quantities. Based on 1995 exports from these four provinces to the U.S. of 16.2 billion board feet, this fee would have been applied to about 9 percent of the total trading volume (Office of the United States Trade Representative 1996, Canadian Department of Foreign Affairs and International Trade 1996, press releases.).

[6] The International trade Commission (ITC) is an independent quasi-judicial federal agency. It makes a preliminary determination in title 7 (Tariff Act of 1930) investigations such as this as to whether a U.S. industry is threatened or injured by alleged dumping or subsidies on the part of a U.S. trade partner. If their finding is affirmative, the International Trade Administration (ITA) of the Department of Commerce determines whether and to what degree a U.S. trade partner is practicing dumping or providing subsidies to one of its industries. If the ITA finds in the affirmative, then the ITC makes a final determination as to whether this dumping or subsidy imposes injury on a U.S. industry. If and only if both the ITC and the ITA rule in the affirmative, the ITA officially issues policy orders (with regard to countervailing duties, for example).

III. EMPIRICAL ANALYSIS

The statistical analysis below models lumber futures price as a function of several exogenous variables and a set of event dummies. Following common practice in the literature, and to reduce serial correlation, we use rates of return on the lumber futures price series as the dependent variable, rather than price levels. In portions of the following analysis, we include four variables to control for non-event factors that we expect to affect lumber prices. These variables are the rates of return on the Commodity Research Bureau (CRB) futures market index, treasury securities, Japan/U.S. exchange rates, and Canada/U.S. exchange rates. Daily data are used for all of these variables.

Various methods have been developed in the literature to test the effects of information events on futures markets. Below, we present results from several tests that apply these methods. The first issue we address is whether limit moves on lumber futures contracts occur more frequently on event and near-event days than on non-event days. The next set of test results we report are based on simple F-tests for differences in price volatility on event days and surrounding days relative to other days in our sample.

We then report results from regression specifications that use two different definitions of event dummies: Individual Event dummies and Event Day Relative dummies. The differences in the definitions are illustrated in table 1, where it is assumed that two distinct events occur, the first on day #3, the second on day #7. As can be seen, for the Individual Event dummy variables, a variable is defined for each event, with a fixed response window. Thus, the Event #1 variable is assigned a value of one on the day of the event and on surrounding days, and a value of zero otherwise. The Event #2 variable is specified similarly. In table 1, the event window spans the period from one day before an event to one day after. The determination of the actual window width we use is discussed below in the context of our empirical results. The Individual Event formulation imposes the constraint that all days in the window for any given event have equal impact.

The second formulation uses Event Day Relative dummies. In the example in table 1, a Day (-1) variable is assigned a value of one on the day before each event. Similarly, a Day (+1) variable is assigned a value of one the day after each event. A Day (0) variable is assigned a value of one the day that each event occurs. Additional variables could be defined for other days before or after the event.[7] This definition imposes the constraint that the impact of all events is the same on, for example, the day prior to the events. Because these two event dummy formulations provide different information about the market response to a set of information events, both of the definitions in table 1 are examined in our empirical analysis.

Other previously developed tests whose results we report include tests for the impacts of events on lumber futures contract trading volume. In Section IV we develop and report results from a regression-based estimation method that allows for increased flexibility in the measured impacts of events relative to the dummy variable specifications that are standard in the literature.

A. Tests for the Coincidence of Events and Limit Moves

The number of limit moves in the lumber futures price data is relatively large – about ten percent of the observations involve limit moves. Insofar as limit moves occur frequently on (or around) event days, our estimates of the impacts of events may be affected. To examine the relationship between limit moves and event days, we create a dichotomous variable called “Limit Move” that we assign a value of one for each day that there is a limit move in lumber futures

[7] A window width issue arises in the construction of the Event Day Relative dummies; one must decide how long before the events one wishes to try to measure the events’ influences. But this event window issue can be resolved

prices and a value of zero otherwise. We then construct contingency tables, one for each set of events.

Based on preliminary empirical analysis, regarding the speed of the market reaction to the events, we define the dichotomous Individual Event variables (see table 1) as follows. Market reactions to housing starts releases tend to happen within a day, so we assign the START variable a value of one on event days, and zero otherwise. Each ESA event is represented by a variable that we assign the value one for the period from one day before through three days after the event. Each TRADE event is represented by a variable that we assign the value one for the period from the day of the event through two days after the event. The results displayed in Tables 2-4 suggest that housing starts release dates and ESA events are positively correlated with limit moves (although the statistical significance of the ESA events is rather marginal), and that TRADE events are statistically independent of limit moves.

These results are generally consistent with other results that we report below. Housing starts apparently affect the market strongly, while the impacts of ESA events are somewhat weaker. The results for the impacts of TRADE events reported in sub-sections A-E are somewhat mixed.

There are at least three approaches to dealing with the issues associated with limit moves: (1) ignore the problem; (2) omit the limit move observations from the analysis; and (3) use a censored regression model such as a Tobit-like model. Preliminary analysis suggests that the choice between the first and second options has little effect on the results. The third option we

empirically with reference to the statistical significance of Event Day Relative dummies far away from the actual event.

do not pursue.[8] We take the correlation between housing start events and limit moves as evidence that we underestimate what would be the response of unrestricted prices to those events. Similarly for ESA events, but not for Trade events. Other than recognizing these relationships, our analysis does not treat limit moves any differently than non-limit moves.

B. F-tests for Larger Variance Surrounding Event Days

A question of fundamental interest is whether the volatility of the rates of return on futures prices increases relative to non-event days on the day of an event or on the days surrounding an event. Sumner and Mueller (1989) test the information content of harvest forecasts by (among other methods) testing for systematic differences between the estimated variances of price movements on event days relative to non-event days. The ratio of these estimated variances, $\hat{\sigma}^2_{event} / \hat{\sigma}^2_{nonevent}$, is distributed $F^{n^e-1}_{n^{ne}-1}$ under the null hypothesis of equal variances, where n^e and n^{ne} are the number of event-related observations and non-event observations, respectively (Mendenhall et al. 1990). To implement this test, we calculate separate variances of the rates of return for event and non-event days for the 2-4 month out contracts.[9] The definitions of the dichotomous Individual Event variables are the same as in the preceding section---the day of the event for Housing Start announcements, one day before through three days after for ESA events, and the day of the event through two days after for the TRADE events.

The results of F-tests for systematic differences in the variances of the rates of return between event and non-event days are as follows:

[8] Note that a standard Tobit model would not be applicable in the present context because the limits are on the size of the price movements (e.g., $10/mbf per day), whereas the dependent variable in our analysis is the daily rate of return on lumber prices.
[9] The results reported below are qualitatively the same for the other contracts that we examined (nearby and 4-6 months out).

Housing Starts: $F_{2971}^{144} = 1.38$, P=.002;
ESA: $F_{3053}^{62} = 1.324$, P=.05;
TRADE: $F_{3080}^{35} = 1.049$, P=.309

Thus, the variance for both housing starts and ESA event days is seen to be significantly larger than the variance for non-event days. The variance for Trade event days is not significantly higher than for non-event days. These results are consistent with the tests of independence of limit moves and event days presented in section IIIA above.

C. Analysis of Individual Events

The next results that we report are from tests in which we estimate regressions with the event variables taking the form of the dichotomous Individual Event variables illustrated in table 1. This component of our empirical work uses regression analysis to determine if the events of interest have measurable impacts on the *level* of the rate of return. Following Fama, et al. (1969), Robenstein and Thurman (1996), and others, the rate of return on lumber futures can be regressed on one or more market indexes to pick up market and macroeconomic effects not specific to the lumber industry, and on dichotomous variables that represent the set of events of interest. The specification of this regression is

$$R_t = \alpha_0 + \alpha_1 M_t + \gamma' \mathrm{E} + \varepsilon_t , \qquad (1)$$

where $R_t \equiv \log(P_t / P_{t-1})$ is the rate of return on the lumber futures closing prices P_t, M_t is the analogous rate of return on the market index, **E** is a vector of dichotomous Individual Event variables, (see table 1) and ε_t is an error term.

The results of this regression are presented in table 5. The significance of the estimated coefficients on the daily non-event variables provides support for our general approach. Further, the algebraic signs of the estimated coefficients make economic sense. The coefficient on the rate of return on the market index (RRCRB) is positive and significant, consistent with a standard market model and a risky asset. The coefficient on the rate of return on the 30-year treasury securities (RRTBILL), which we include as a proxy for mortgage rates, is negative and significant. Our interpretation of this result is that an increase in mortgage rates reduces lumber demand (through the housing markets), leading to lower lumber prices. Here and in other specifications reported below, the Japanese exchange rate (RRJAPAN) seems to have no impact on lumber futures price changes, but the rate of change in Canadian exchange rates (RRCAN) has a negative and marginally significant effect. We interpret the latter result as follows: a decrease in the exchange rate ($ Canadian per $ U.S.) makes Canadian dollars more expensive, causing U.S. demand for Canadian lumber to decrease and U.S. demand for U.S. lumber to increase, thereby causing U.S. lumber prices to rise. Given that the United States is a net importer of softwood lumber in its lumber trade with Canada, these demand effects outweigh the offsetting supply shifts caused by the exchange rate.

Of primary interest in table 5 are the estimated impacts of the individual events on the lumber rate of return. For this specification, each event is allowed to have a different estimated impact, but the impacts across days surrounding a particular event are constrained to be equal. We also impose the constraint that the event windows for a given type of event are the same for all the events of that type (for example, all of the ESA events windows the same width). Because we have no theory to guide us in defining the duration of the event window, we choose the duration of the event window that provides the best statistical fit.[10] Following an examination of alternative event windows, the restrictions we impose are that (1) the duration of the window for every START event is just the day of the event, (2) the window for every ESA event is one day before through three days after the event, and (3) the window for every TRADE event is the day of the event through two days after (the window widths used in sections IIIA and IIIB were based on this regression).

The results displayed in table 5 indicate that of the twelve ESA events, three are significant at the 10% level, and of the twelve TRADE events, two are significant at the 10% level (see the list of event descriptions in section II above). Notice also that the F-test for the joint significance of all ESA events is significant, but the F-test for all TRADE events is not significant. The START dichotomous variables also are included in the regression (as indicated by the large number of degrees of freedom used by the model), but they are not included in the results presented in table 5. Twenty-one of the 147 estimated coefficients on the START variables are significant at the 10% level. Further, as indicated by the reported F-statistic at the bottom of the table, the housing start event variables are jointly significant.

D. Pre-Event, Post-Event, and Event-Day Market Responses

The second set of results that we report are from tests in which the event variables take the Event Day Relative form illustrated in table 1, but with eleven day windows (five days prior to five days after each event of interest). The variable ESA Event Day is assigned a value of one on each of the thirteen ESA event days, and a value of zero otherwise. ESA (-1) is assigned a value of one on the day before each event day, and ESA (+1) is assigned a value of one on the first day after each event. The other Event variables are defined similarly. The same structure is used for the Housing Start and Trade Event variables.[11]

[10] The Mean Squared Error for regressions with a wide range of window definitions were identical to the fifth decimal place (the highest precision provided by SAS PROC REG). Therefore, the "best statistical fit" was determined to be that which provided the highest joint significance of each event set.
[11] Exploratory results suggest that the use of wider event windows does not substantively change any of our results.

There is a problem, however, with running the regression specified in equation (1) with the Event Day Relative dummies. Suppose, for example, that on the day of the event, half of the ESA variables have strong positive impacts on lumber futures prices and the other half have equally strong negative impacts. These positive and negative impacts may cancel each other out and the estimated coefficient on the ESA Event Day variable may be statistically insignificant, even though these events had strong impacts on lumber markets.

To deal with this problem, we shift to measuring the influence of the events, positive or negative, by examining absolute rates of return. More specifically, we use a two-stage estimation procedure. In the first stage we regress the rate of return on lumber futures prices on the four daily non-event variables. The results from this regression are displayed in table 6. As can be seen, the signs and significance of the estimated coefficients on the non-event variables are similar to those in table 5. In the second-stage regression, the absolute values of the residuals from the first-stage regression are used as the dependent variable in a regression with day-of-week dummy variables, a quadratic time trend, and the Event Day Relative dummies as the regressors. A positive coefficient on an Event Day Relative dummy in the second stage indicates that the component of the lumber rate of return not explained in the first stage regression tends to be larger (either in a positive or a negative direction) on the days represented by that event variable. This two-step method of estimating the effects of events on the magnitudes of price changes is reasonable as long as the regressors in the first regression are uncorrelated with the regressors in the second regression.[12]

The results of the second-stage regression are presented in table 7. Of the control variables, all of the day dummies and both of the time trend variables are significantly different

[12] Less than 10 percent of the relevant pair-wise correlations between first and second stage regressors are significant at the ten percent level.

from zero.[13] The estimated coefficient on the Housing Start Event Day variable, which measures the day-of-the- event impacts of housing start announcements, is strongly positive and significant. Only three of the ten estimated coefficients for the surrounding days are significant. The F-statistics displayed at the bottom of the table indicate that both pre- and post- housing starts announcement days are jointly insignificant. We interpret this result as indicating that the market adjusts very rapidly (essentially on the day of the event) to housing starts announcements. None of the twenty-two estimated ESA or TRADE event variables is significant. Further, none of the pre- and post-event groups of variables for the ESA and TRADE events are jointly significant at the 10% level.

Note that although the coefficients for the days surrounding the TRADE events are all insignificant, eight out of ten of them are negative. This negative tendency is consistent with the results of other tests that we present below.[14]

E. Regressions on Trading Volume

Trading volume, as well as price movements, may be affected by changes in information structure. Low trading volume is expected when little or no new information enters the market, and high volume is expected as the market reacts to relevant new information. We examine the determinants of trading volume in a regression framework with the following specification:

$$V_t = \beta_0 + \beta_1 M_t + \lambda' \mathbf{E} + \eta_t, \qquad (2)$$

[13] This model also was estimated with specifications that included a dichotomous variable to distinguish the periods before and after the increase in the price change limit on March 8, 1993 as an additional explanatory variable. The results from those specifications are not substantively different from those reported and discussed in the text.
[14] To remove any systematic changes in variance from the rate of return on lumber futures prices, we also estimate a GARCH model using the daily nonevent variables. The results, which are available from the authors on request, indicate that the ARCH and GARCH coefficients are highly significant. We then calculate the residuals from this model, and use the absolute values of the residuals as the regressors in the second stage. The results from this approach are not qualitatively different from the results reported in table 7.

where V_t is the trade volume on day t, M_t and **E** are defined as in equation 1 above, and η_t is an error term.

In table 8 we present the estimation results using the Individual Event variables. The housing start coefficients are seen to be jointly significant and most (16 of 23) of the significant coefficients are positive (not shown for space considerations), suggesting that trading volume tends to be higher on housing start release dates and surrounding days. The ESA event coefficients also are jointly significant, but six of the twelve estimated coefficients are negative, a result that is inconsistent with our expectations. Only two of the twelve estimated ESA coefficients are positive and significantly different from zero. The estimated Trade event coefficients are not jointly significant, and none of the individual coefficients is positive and significant.

Table 9 displays the results for the Event Day Relative dummies. As can be seen, housing start announcements have positive and significant impacts on trade volume on the days of the events. Further, the coefficients for four of the five days following the release of housing start announcements are jointly significant. The five pre-Trade Event coefficients are not jointly significant, but seven of the eleven coefficients are negative. This evidence that trading activities slow down substantially in the period surrounding the Trade Events in our sample is consistent with other results that we report.

F. THE DISTRIBUTIONAL EVENT RESPONSE MODEL

The Individual Event and Event Day Relative dichotomous variables used in the previous section impose different constraints on the structure of the time path of market reactions. The Individual Event variables allow the estimated impacts of different events to vary, but they restrict the impacts of each individual event to be equal for all days in the event window. The Event Day Relative variables allow the impacts of events to be different for different days within the event window, but the impacts of all events are constrained to be the same for any given day in the event window. Neither model is nested within the other and there is empirical evidence, as well, that they capture different effects. For example, in Table 7, the groups of pre- and post-event dummy variables (the Event Day Relative variables) are statistically insignificant for all three event types. Yet, in Table 5, the sets of individual event dummies are significant for two of the three types of events. One interpretation of this result is that there are real abnormal price movements surrounding (at least some) event days—some are positive some are negative. But constraining the effects of days relative to events to be the same across events has the effect of averaging over these positive and negative effects to result in estimated effects statistically indistinguishable from zero. We seek an empirical model that allows us to nest the two approaches described so far.

In this section we describe and implement such an estimation method. It allows both (1) the estimated impacts of different events to vary and (2) the impacts of events to be different for different days within the event window. The estimation method we develop does impose the constraint that the market responses to all of the events in a given set (for example, ESA events) conform to a specific distribution. This technique provides easily interpretable estimates of the speed of the market response to a set of events. We dub the model the Distributional Event Response Model (DERM). It is closely related to an empirical model developed by Ellison and Mullin (1995), but is more general.

As with the Individual Event variable analysis, the dependent variable is the rate of return on lumber futures prices, and not its absolute value. But, the parameters of the model enter the regression specification nonlinearly:

$$y_t = \alpha + \delta' X_t + \sum_{i=1}^{k} \beta_i \cdot f(d_t^i; \mu, \sigma) \cdot D_i + \varepsilon_t \,,$$

where y_t are rates of return on lumber future prices, $\boldsymbol{\delta' X_t}$ is a vector of continuous explanatory variables and its associated coefficient vector, D_t^i is an indicator variable taking the value *one* when an observation falls within the window of event *i* (*zero* otherwise); d_t^i is the number of days from event *i* given that the observation falls within the event window for *i*:

$$d_t^i = \begin{cases} t - \tau_i, & |t - t_i| \le W \\ 0, & \text{otherwise;} \end{cases}$$

where *W* is chosen so the event window is sufficiently wide to capture the event impact. $f\left(d_t^i; \mu, \sigma^2\right)$ is a density function for d_t^i with mean μ and variance σ^2; and β_i is a scaling coefficient on the i^{th} event.

The model implies that the price response for event *i* takes the form of a normal distribution centered around μ, with variance σ^2, and scaled by β_i. If β_i=0, the event has no impact on the market. If $\sigma^2 = \infty$, the impact of all events is infinitely diffuse. In either of these cases, the density function over d_t^i is flat. Alternatively, as σ^2 approaches zero the density function becomes a spike at μ for all events.

The model as described posits a single type of event, of which there are *k* individual instances. We analyze three types of events: trade policy events, housing starts announcements, and ESA litigation rulings. We, therefore, add two more terms to the Distributional Event

Response Model to capture separately the three types. Each of the three event types has its own normal p.d.f., with its own mean and variance, to describe the expected response of futures prices to a specific event type.

Given this event grouping, d_t^i represents all events of a particular event type, as long as events within that group are far enough apart that event windows do not overlap. For example, if an event type contains two events (underlined and in bold below) and an event window of size E=3, the counter variable d_t^i and the event indicator D_t^i look like the following:

Time –>
d_t^i –> (.. 0 0 0-3-2-1 **<u>0</u>** 1 2 3 0 0 0 .. 0 0 0-3-2-1 **<u>0</u>** 1 2 3 0 0 0..)
D_t^i –> (.. 0 0 0 1 1 1 **<u>1</u>** 1 1 1 0 0 0 .. 0 0 0 1 1 1 **<u>1</u>** 1 1 1 0 0 0..).

The results of the parametric response model, estimated by nonlinear least squares (PROC NLIN in SAS) are presented in table 10. The β_i coefficients for the 147 housing starts events are not shown due to space limitations. The γ coefficients estimated by the Individual Event model are consistent with the estimated β_i coefficients from the DERM.[15]

The parametric influence model provides insight on the speed of market adjustment and the timing of an event's influence relative to the day of the event. The variance estimate for the housing starts response function, σ^2_{starts}, is less than one (its 95% confidence interval ranges from .14 to .40). Based on the estimate, approximately 95% of the influence of housing starts happens on the day of the event. The variance for the trade events, σ^2_{trade}, is similar. In contrast, the variance estimated for the response function of ESA events is about 20.5, which coincides with an estimated standard deviation of about 4.5. This means that approximately 95% of the ESA event influence is accounted by the 4.5 days surrounding the event. The means (which, for the normal distribution, are also the modes) of all influence functions, μ_{starts}, μ_{trade} and μ_{ESA}, are near one, which implies that all distributions are centered approximately on the day of the event itself.

Likelihood Ratio test results are reported at the bottom of Table 10 to test the joint significance of event responses for the three different event types. There are 14 coefficients associated with ESA events (μ_{ESA}, σ_{ESA} and 12 event-specific β_is). The ESA event effect disappears from the model when the 14 ESA coefficients are set to zero. The test statistic obtained from such a restriction has a p-value of .178, indicating a statistically weak impact of ESA events. The p-value for Trade Events (.095) suggests a more clearly discernible effect, while the p-value for Housing Start Events (.0004) indicates a strong influence.

The DERM combines aspects of the models reported in the previous section. It posits and allows measurement of, first, a systematic response shape to all the events of a certain type and, second, a response that is unique to a specific event. With regard to the second type of effect, one can examine Table 10 and identify which events are large relative to their sampling variability. Among the Trade Events, Event #7 has a positive effect with a t-ratio of 1.63 and Event #11 has a larger negative estimated effect with a t-ratio of –2.72. Event #7 was the 1992 imposition of a quite large (14.45%) countervailing duty on Canadian lumber imports; we infer that it was unanticipated, or at least underpredicted, by the market. Event #11 marked the adoption of an agreement between Canadian and U.S. trade negotiators, four years after the

[15] For the ESA coefficients to be directly comparable across the two models, the Individual Event coefficients must be multiplied by 5 (or the DERM coefficients must be divided by 5). This is because the normal distribution over the event window in the DERM model integrated to one, whereas the Individual Event windows integrate to 5.

imposition of the first countervailing duty, that arguably forestalled a U.S. trade action. Relative to market expectations, the announcement implied lower equilibrium U.S. lumber prices.

Among the ESA events, Event #3 has a t-ratio of 1.97 and Event #10 has a t-ratio of –2.16. The former marked a broad 1991 proscription of timber sales on 17 national forests, an event that caused lumber prices to rise. The latter marked a 1995 decision to release previously prohibited timber sales in Oregon and Washington, which apparently was unanticipated or under anticipated.[16]

It is interesting to note that in each of the four significant ESA and Trade Events, the market's response reinforced the natural change in prices. For example, if the event is one that marked a rightward shift in supply then the measured response was a reduction in price, implying that the price-lowering effect of the announcement was not fully incorporated into the lumber futures price prior to the announcement. This reinforcing effect is consistent with an observation made by Milton Friedman in the context of a 1960s devaluation of the Mexican peso: conditional on the occurrence of a price-lowering event, the prospects of which are not *a priori* certain, the observed effect in financial markets will appear to be a surprise. The rational market's expectation prior to the event must be a weighted average of the price expectations conditional on the two possible outcomes (event and no event) weighted by the probabilities of the two outcomes.

The second sort of information revealed by the DERM results in Table 10 concerns market speeds of adjustment to information of different sorts. Housing starts announcements are routinely absorbed and processed by markets and the variance measure in the DERM for Housing starts is appropriately small. We find that the market seems similarly well adapted to

[16] Among the 147 housing start events, 33 are found to have surprised the market in the sense of t-ratios that would reject a null of no effect at a 10% critical value or smaller.

processing the information from the trade events in that the spread (variance) of the response function is somewhat larger than, but similar to, that for housing starts. By contrast, the ESA events take a much larger time to be fully reflected in lumber futures prices, as indicated by a much larger measure of temporal influence spread.

Summary

The evidence presented in this paper suggests that housing start releases contain information that affects both the level and variability of lumber futures prices. Moreover, the impacts of these releases are absorbed quickly by the market, often within a day of the release. Trading volumes also are affected by housing start releases.

Evidence concerning the impacts of ESA events is somewhat more mixed. The thirteen individual ESA events that we identify are jointly significant in explaining both the level and variability of lumber futures prices. None of the estimated coefficients on the Pre- or Post-ESA Event variables is significant, however, either individually or jointly; this result refers to regressions in which the dependent variable is the absolute rate of return on futures contracts. Further, our results suggest that ESA events do not have the expected impacts on trading volumes. At the same time, our Distributional Event Response Model applied to rates of return imply only weak joint significance for the ESA events, but statistically discernible effects for two court decision announcements. In that same model, the influence that we do measure is spread out over a fairly wide interval surrounding the ESA-related announcements—one that encompasses about a 10-day interval.

The statistical significance of the trade events, summarized across models is similar to that for the ESA events. Two individual events, described in the previous section, appear to have had an impact on lumber futures prices. Further, and unlike the slow absorption of ESA-related news, the trade events appear to be digested quickly. Most of the impact is impounded in futures prices within a one-to-two day period. Curiously, the absolute value regression models (in event specific form) indicate that in most of the instances where trade events do have significant impacts, they dampen the size of price movements, be they positive or negative. This suggests a sort of quiescence associated with trade announcements, an effect documented elsewhere in a study by the Irland Group (1993).

Finally, a methodological contribution of the paper is our comparison of the impacts of different types of events in the Distributional Event Response Model. The model allows a market's typical response to different event types to be compared, while allowing individual events to have their own sign and size of impacts. The DERM is a more flexible alternative to the use of standard dichotomous variable models for measuring the impacts of various types of events that affect markets.

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Figure 1. Lumber Futures Closing Prices, Two-to-Four Months Out

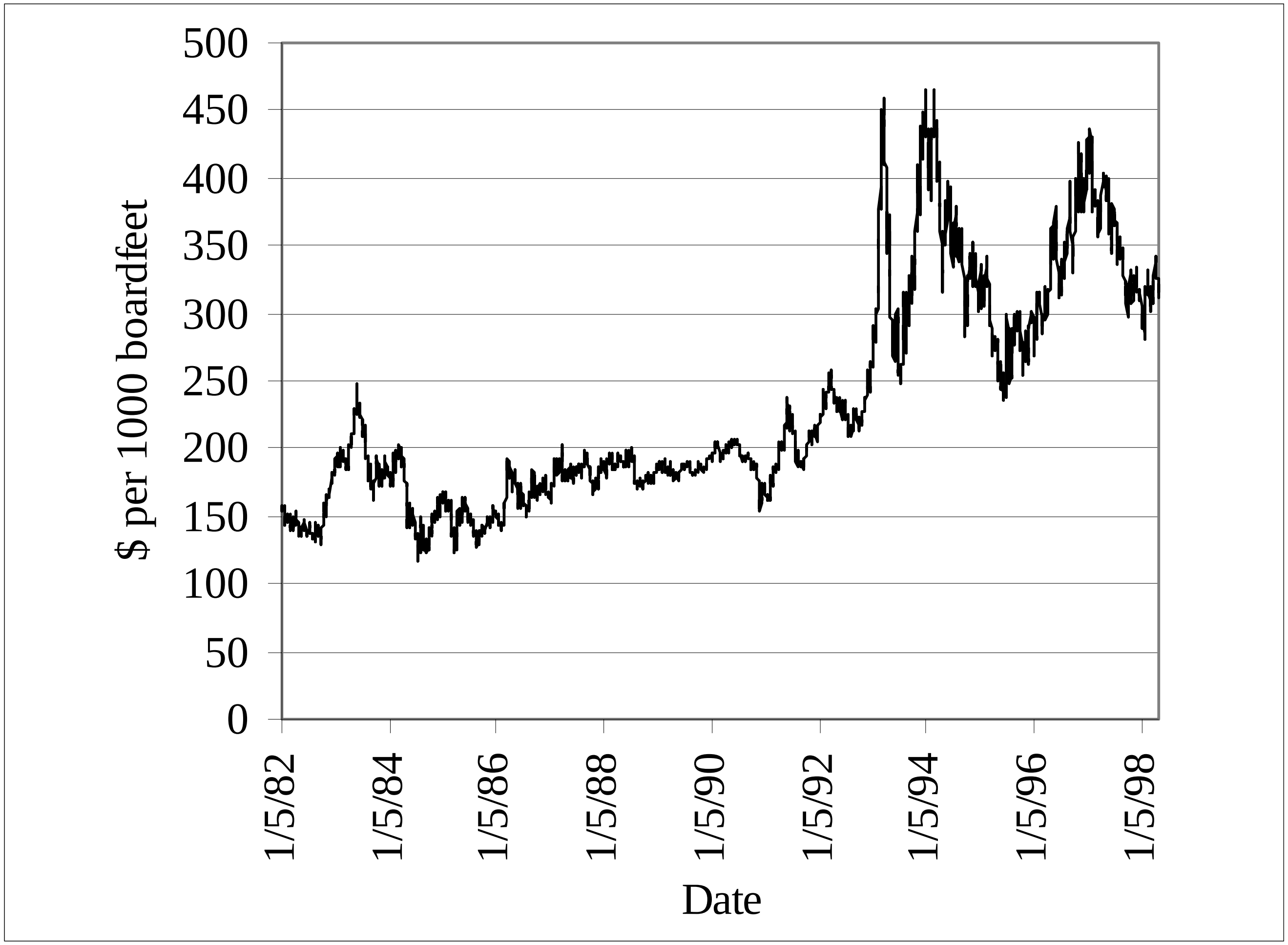

Figure 2. Lumber Futures Day-to-Day Price Differences, Two-to-Four Months Out

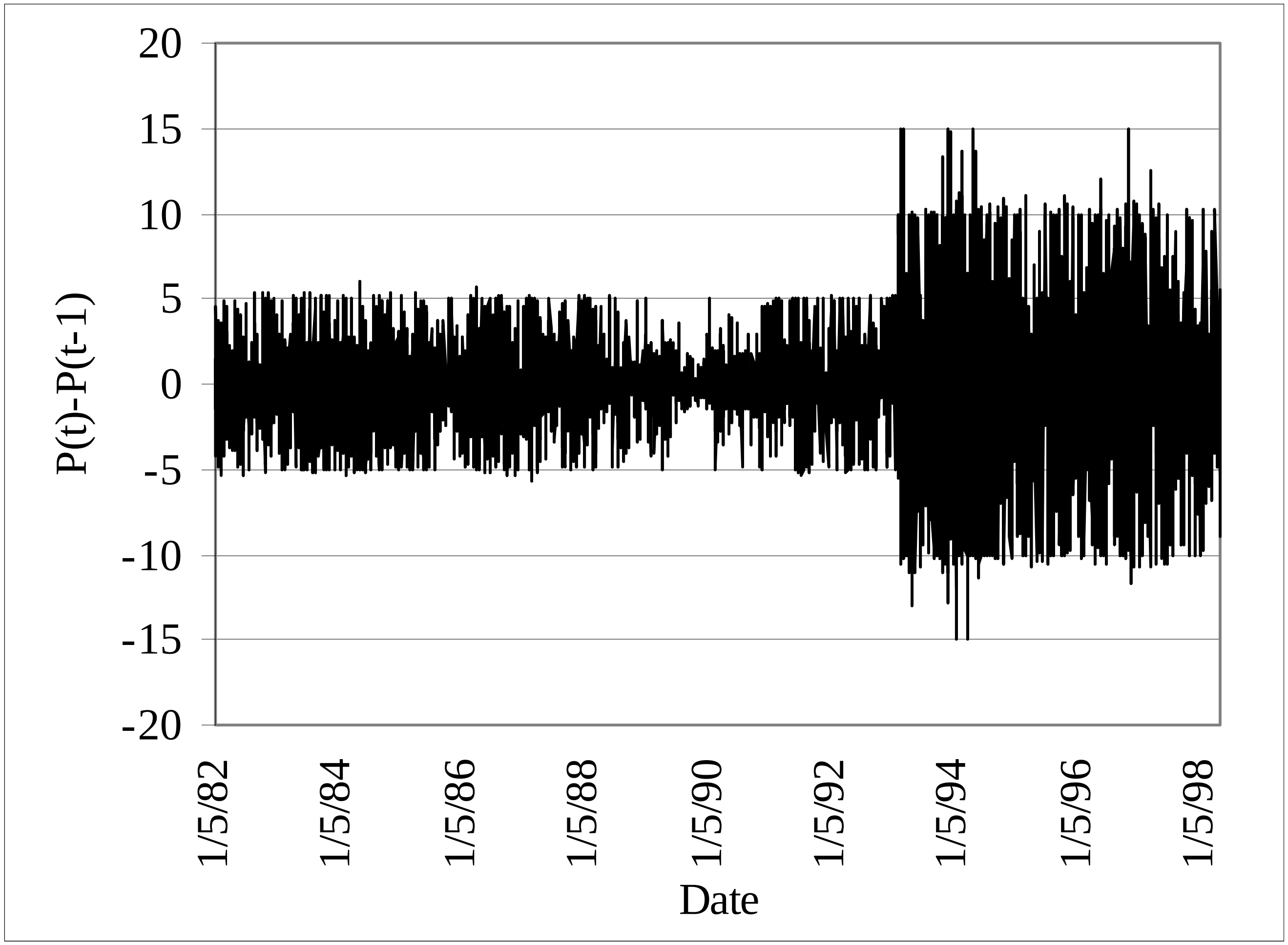

Figure 3. Lumber Futures Prices: Day-to-Day Rate of Return, Two-to-Four Months Out

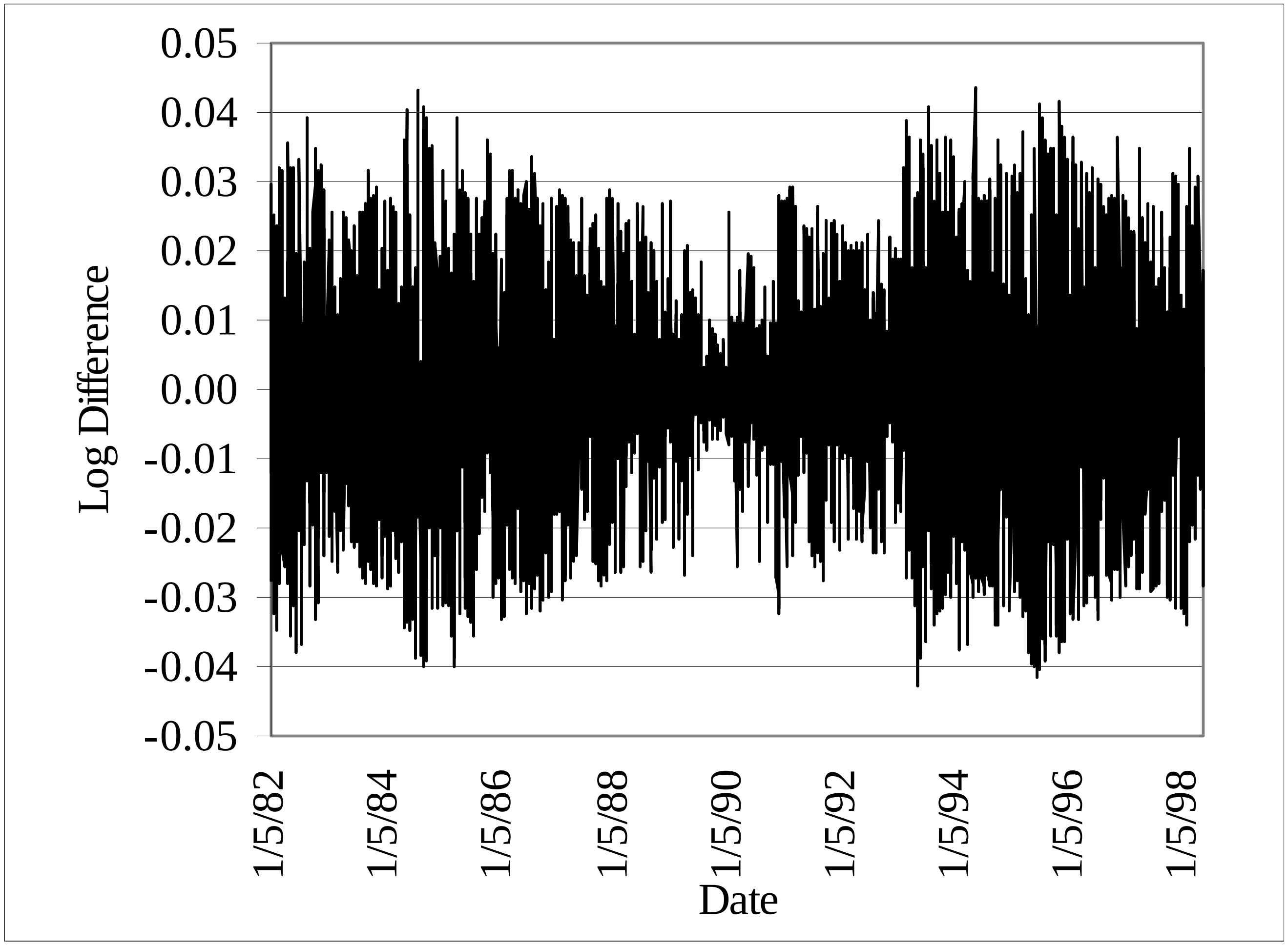

Figure 4. Lumber Futures Daily Trading Volume, Two-to-Four Months Out

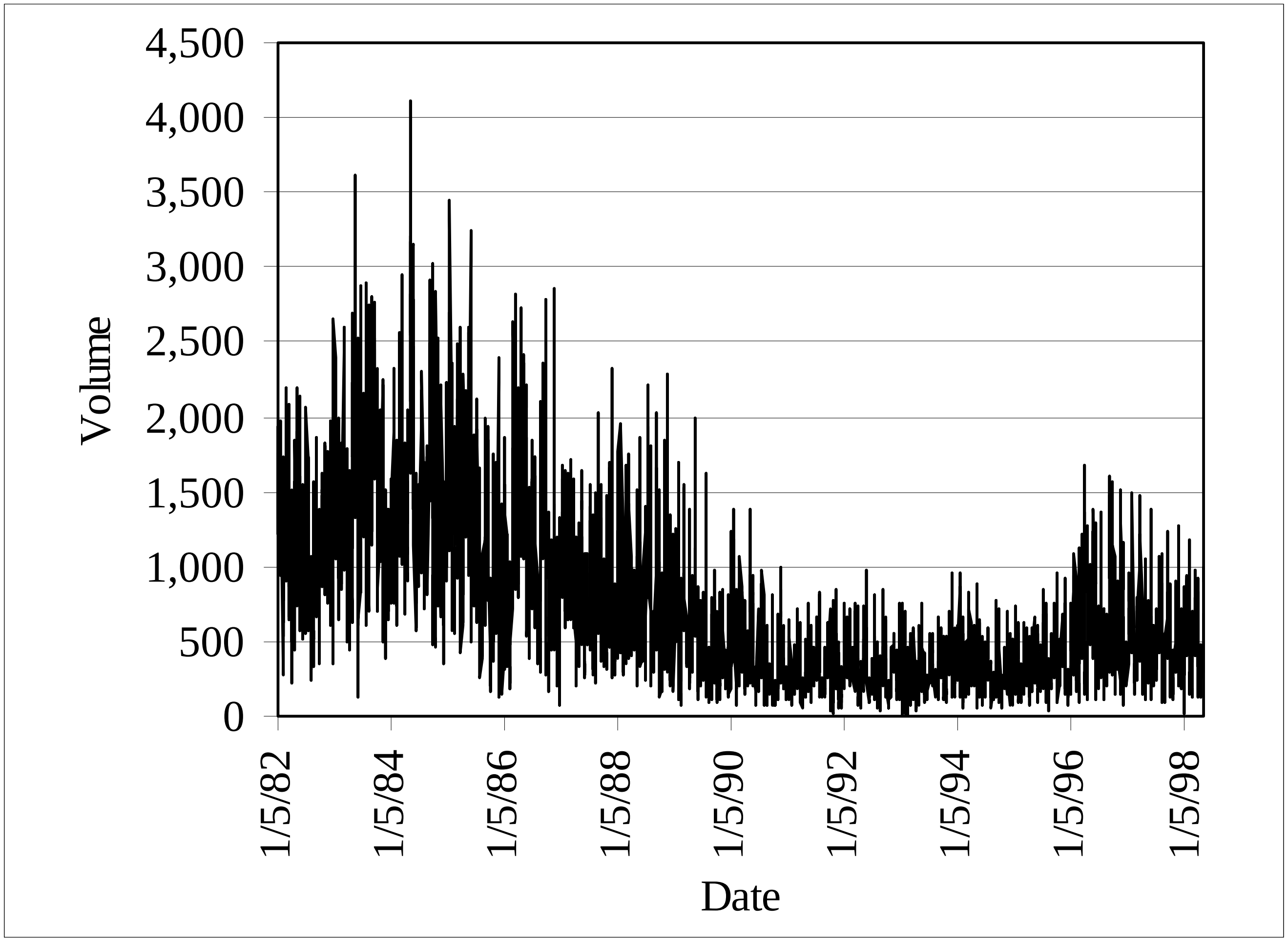

Figure 5. Normalized Lumber Futures Daily Trading Volume, Two-to-Four Months Out

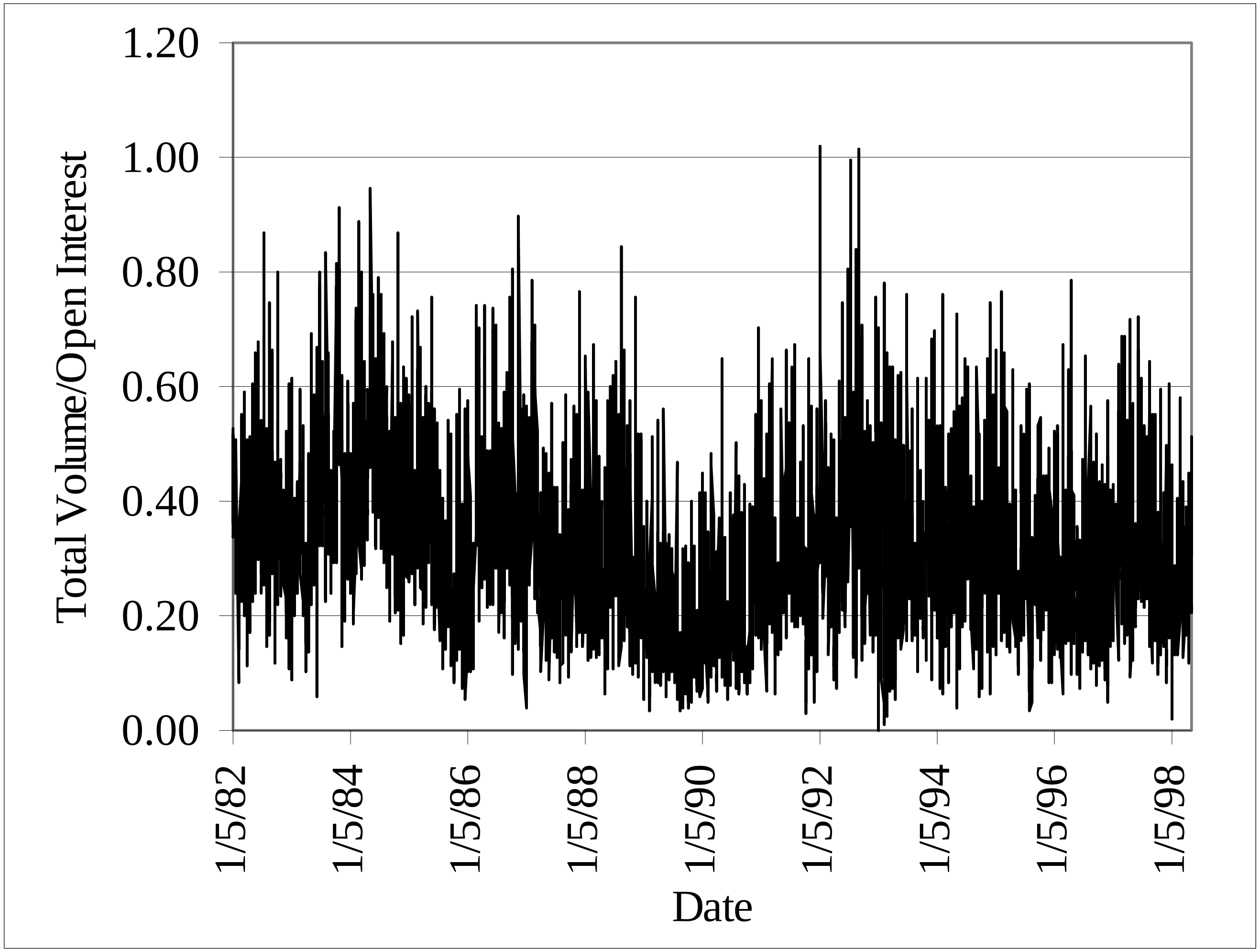

Figure 6. Lumber Futures Trading Volume by Number of Days to Maturity

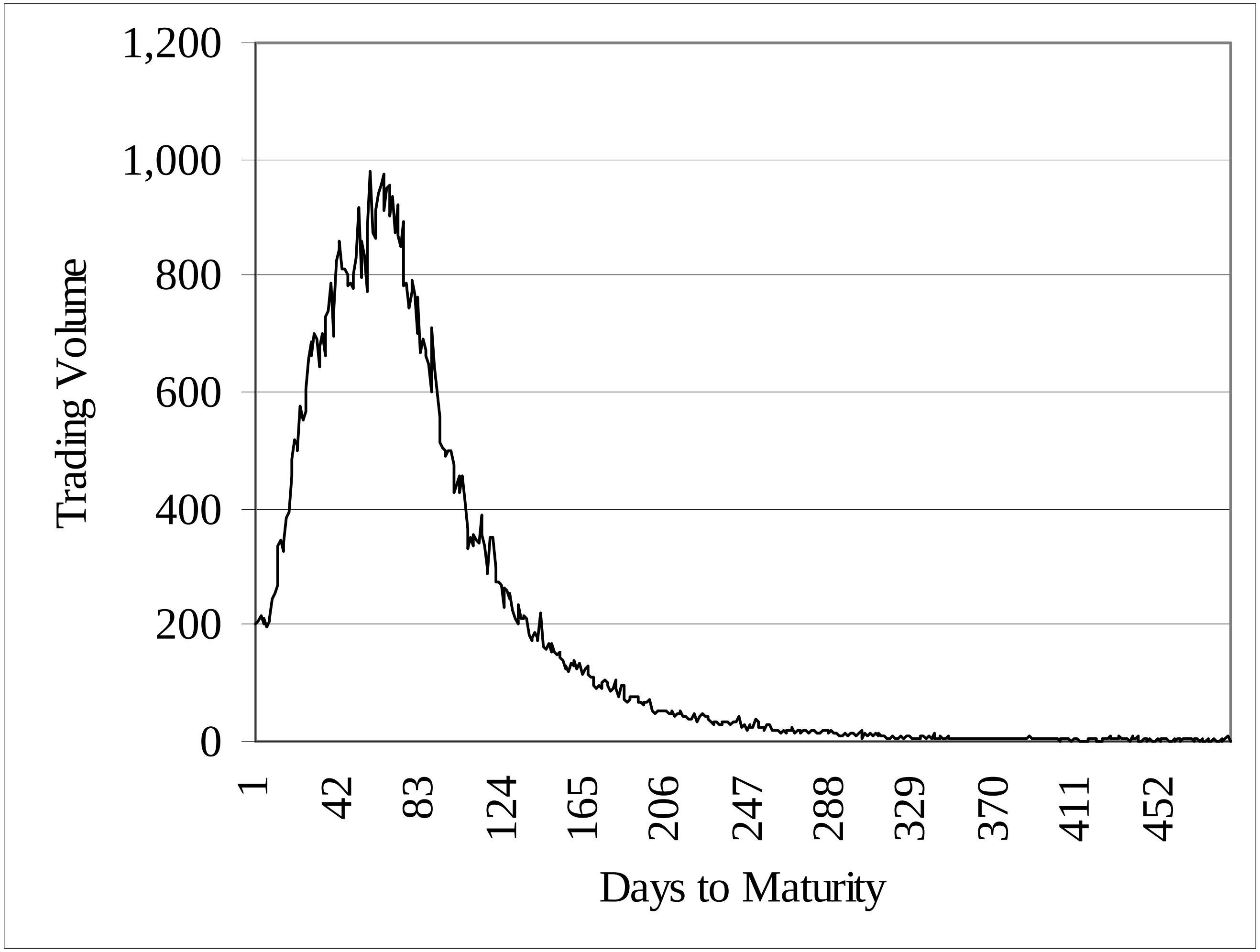

Figure 7. Lumber Futures Prices, Rates of Return, and Trade and ESA Events

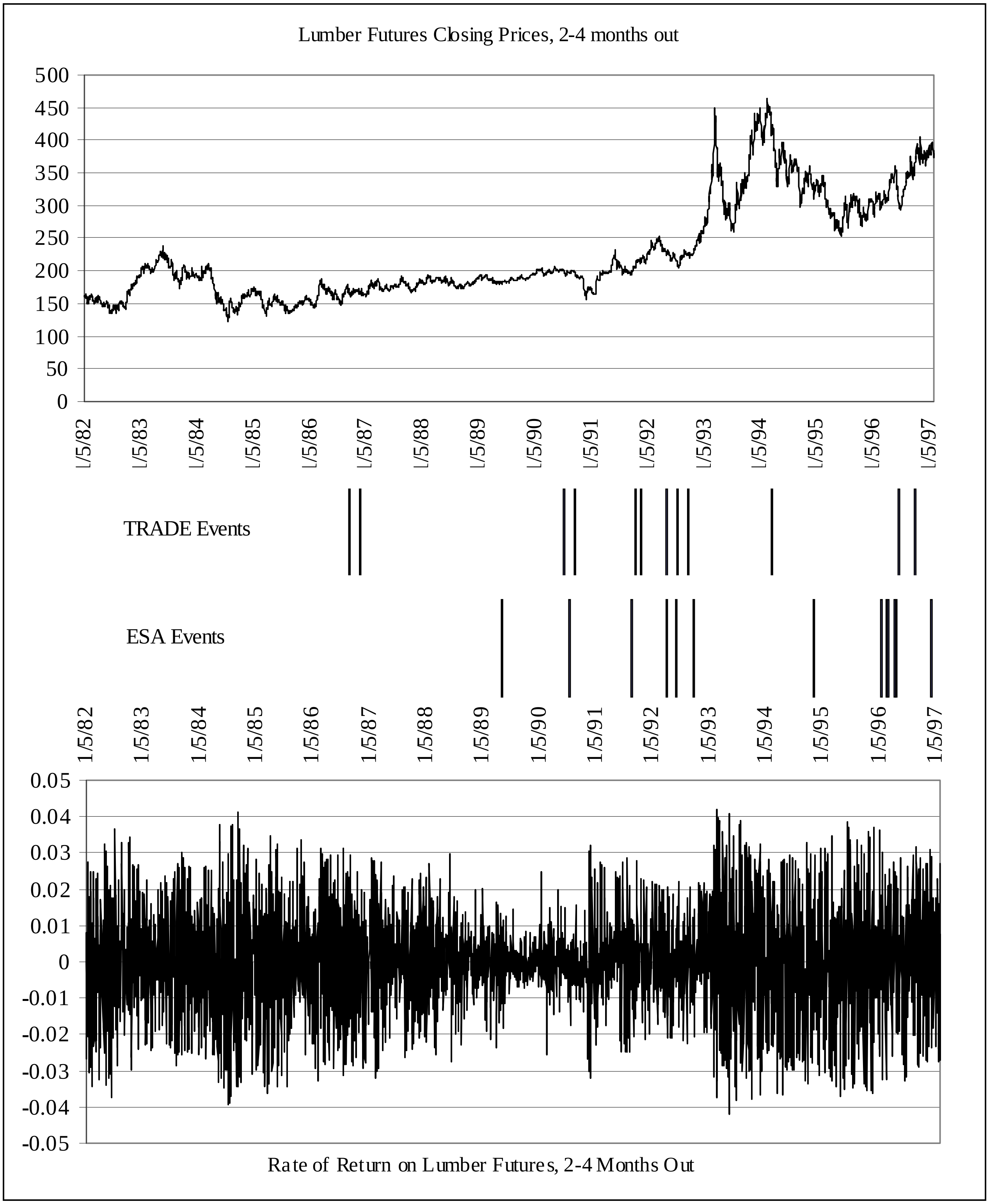

Table 1. Illustration of Dichotomous Variables used to represent two events, with event days (3 and 7) in italicized bold.

Day #	Individual Event		Event Day Relative		
	Event 1	Event 2	Pre-Event Day (-1)	Event Day Day (0)	Post-Event Day (+1)
1	0	0	0	0	0
2	1	0	1	0	0
3	***1***	0	0	***1***	0
4	1	0	0	0	1
5	0	0	0	0	0
6	0	1	1	0	0
7	0	***1***	0	***1***	0
8	0	1	0	0	1

Table 2. Independence Tests: Limit Moves and Housing Starts Releases (day of release).

Frequency (percent) [expected][1]	START=0	START=1	**Total**
NO LIMIT	2674 (85.68) [2663]	121 (3.88) [132]	2795 (89.55)
LIMIT	300 (9.61) [311]	26 (0.83) [15]	326 (10.45)
Total	2974 (95.29)	147 (4.71)	3121 (100)
Tests of Independence:	Value:	ASE[2]	P-value
Gamma	0.314	0.101	0.001

[1][expected] is the expected count under the null hypothesis of independence, rounded to the nearest integer. [2]ASE is the asymptotic standard error.

Table 3. Independence Tests: Limit Moves and ESA events (one day before through three days after).

Frequency (percent) [expected][1]	ESA=0	ESA=1	**Total**
NO LIMIT	2744 (87.92) [2741]	51 (1.63) [54]	2795 (89.55)
LIMIT	317 (10.16) [319]	9 (0.29) [6]	326 (10.42)
Total	3061 (98.08)	60 (1.92)	3121 (100)
Tests of Independence:	Value:	ASE[2]	P-value
Gamma	0.209	0.175	0.116

[1][expected] is the expected count under the null hypothesis of independence, rounded to the nearest integer. [2]ASE is the asymptotic standard error.

Table 4. Independence Tests: Limit Moves and TRADE events (day of and two days after event).

Frequency (percent) [expected][1]	TRADE=0	TRADE=1	**Total**
NO LIMIT	2763 (88.53) [2763]	32 (1.03) [32]	2795 (89.55)
LIMIT	322 (10.16) [322]	4 (0.13) [4]	326 (10.45)
Total	3085 (98.85)	36 (1.15)	3121 (100)
Tests of Independence:	Value:	ASE[1]	P-value
Gamma	0.035	0.266	0.447

[1][expected] is the expected count under the null hypothesis of independence, rounded to the nearest integer. [2]ASE is the asymptotic standard error.

Table 5. The impact of individual events on the rate of return on lumber futures contract (estimates for housing starts omitted from table for space considerations).

Dep. Var: $\log(P_t/P_{t-1})$		N=3117, model DF=181		R-square= 0.0953
Variable	Estimate	Std. Error	T-stat.	Prob > |T|
RRCRB	0.3478	0.05108	6.81	<.0001
RRTBILL	-0.1946	0.04033	-4.83	<.0001
RRCAN	-0.1758	0.11175	-1.57	0.116
RRJAPAN	0.0101	0.04612	0.22	0.827
Monday	0.0022	0.00104	2.14	0.032
Tuesday	-0.0005	0.00104	-0.52	0.603
Wednesday	0.0012	0.00104	1.19	0.234
Thursday	0.0036	0.00104	3.41	0.001
Friday	0.0024	0.00103	2.35	0.019
Time	0.0000	9.08E-07	-1.33	0.183
Time squared	1.76E-10	1.95E-10	0.90	0.366
Trade Event #1	-0.0045	0.00876	-0.51	0.609
Trade Event #2	-0.0079	0.00874	-0.90	0.367
Trade Event #3	-0.0089	0.01171	-0.76	0.446
Trade Event #4	-0.0033	0.00873	-0.38	0.702
Trade Event #5	-0.0060	0.00873	-0.69	0.491
Trade Event #6	-0.0031	0.00873	-0.36	0.720
Trade Event #7	0.0226	0.01171	1.93	0.053
Trade Event #8	-0.0096	0.01171	-0.82	0.414
Trade Event #9	-0.0030	0.00873	-0.34	0.734
Trade Event #10	-0.0096	0.01171	-0.82	0.411
Trade Event #11	-0.0272	0.00874	-3.11	0.002
Trade Event #12	-0.0056	0.00873	-0.64	0.525
ESA Event #1	0.0033	0.00756	0.44	0.661
ESA Event #2	-0.0016	0.00791	-0.20	0.841
ESA Event #3	0.0085	0.00677	1.25	0.211
ESA Event #4	0.0059	0.00677	0.87	0.384
ESA Event #5	0.0075	0.01070	0.70	0.485
ESA Event #6	0.0021	0.00677	0.31	0.756
ESA Event #7	0.0009	0.00677	0.13	0.896
ESA Event #8	0.0126	0.00677	1.86	0.063
ESA Event #9	0.0014	0.00677	0.21	0.833
ESA Event #10	-0.0346	0.01069	-3.23	0.001
ESA Event #11	0.0135	0.00677	1.99	0.047
ESA Event #12	-0.0014	0.00757	-0.18	0.857

F-Tests for joint significance of pre- and post-event days DF(den)=2935

	F value:	Prob>F:
ESA Events (DF num = 12)	1.75	0.0501
Trade Events (DF num = 12)	1.47	0.1271
Housing Start Events (DF num = 147) [21 coef. Significant]	1.21	0.0470

Table 6. Regression to generate the residuals used in Table 7.

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	0.0001	0.0003	0.51	0.6120
RRCRB	0.3506	0.0503	6.97	0.0001
RRTBILL	-0.1734	0.0390	-4.44	0.0001
RRCAN	-0.1851	0.1086	-1.71	0.0883
RRJAPAN	0.0126	0.0448	0.28	0.7793

Table 7. The effects of Events on the magnitude of lumber futures price changes using Event Day Relative variables.

Dep. Variable: Absolute value of residuals from table 6.		▪	N=3117	R-square= 0.0593
Variable	Estimate	Std. Err.	T-Statistic	Prob > |T|
Monday	0.010340	0.00064	16.26	<.0001
Tuesday	0.011250	0.00063	17.74	<.0001
Wednesday	0.011050	0.00063	17.42	<.0001
Thursday	0.010230	0.00063	16.16	<.0001
Friday	0.009490	0.00063	14.97	<.0001
time	-0.000001	5.20E-07	-2.17	0.030
Time squared	5.46E-10	1.12E-10	4.88	<.0001
ESA(-1)	0.003730	0.00262	1.42	0.155
ESA(-2)	-0.000849	0.00262	-0.32	0.746
ESA(-3)	-0.001770	0.00262	-0.67	0.501
ESA(-4)	0.003690	0.00262	1.41	0.159
ESA(-5)	0.001160	0.00262	0.44	0.658
ESA Event Day	0.002460	0.00283	0.87	0.385
ESA(+1)	0.003730	0.00261	1.43	0.154
ESA(+2)	0.004220	0.00261	1.62	0.106
ESA(+3)	-0.003390	0.00262	-1.30	0.195
ESA(+4)	0.000888	0.00262	0.34	0.734
ESA(+5)	-0.001680	0.00262	-0.64	0.520
Housing Start(-1)	-0.000293	0.00082	-0.36	0.721
Housing Start(-2)	-0.001470	0.00082	-1.80	0.072
Housing Start(-3)	0.000415	0.00082	0.51	0.612
Housing Start(-4)	0.001350	0.00082	1.66	0.098
Housing Start(-5)	-0.000720	0.00082	-0.88	0.379
Housing Start Event Day	0.002500	0.00082	3.03	0.002
Housing Start(+1)	0.000560	0.00082	0.68	0.494
Housing Start(+2)	0.000030	0.00082	0.04	0.971
Housing Start(+3)	0.001030	0.00082	1.26	0.209
Housing Start(+4)	0.001550	0.00082	1.90	0.058
Housing Start(+5)	-0.000081	0.00082	-0.10	0.921
Trade(-1)	-0.000634	0.00271	-0.23	0.815
Trade(-2)	-0.001360	0.00271	-0.50	0.616
Trade(-3)	-0.002470	0.00272	-0.91	0.362
Trade(-4)	-0.002580	0.00272	-0.95	0.343
Trade(-5)	-0.004150	0.00272	-1.53	0.127
Trade Event Day	0.003230	0.00272	1.19	0.236
Trade(+1)	0.001890	0.00272	0.70	0.486
Trade(+2)	-0.001280	0.00272	-0.47	0.638
Trade(+3)	-0.003380	0.00272	-1.24	0.213
Trade(+4)	-0.003180	0.00271	-1.17	0.241
Trade(+5)	0.001340	0.00271	0.49	0.622

F-Tests for joint significance of pre- and post-event days (DF(num)=5, DF(den)=3077)

	F value:	Prob>F:
ESA(-5) – ESA(-1)	0.92	0.4416
ESA(+1) – ESA(+5)	1.38	0.2292
Housing Start(-5) – (-1)	1.54	0.1731
Housing Start(+1) – (+5)	1.04	0.3918
Trade(-5) – Trade(-1)	0..86	0.5045
Trade (+1) – Trade(+5)	0.56	0.7311

Table 8. The impact of individual events on trading volume (estimates for housing starts are omitted from the table for space considerations).

Dep. Var: trading volume		N=3117, model DF=176		R-square=.4315
Variable	Estimate	Std. Error	T-stat.	Prob > |T|
RRCRB	904.09	1021.30	0.89	0.376
RRTBILL	69.53	806.43	0.09	0.931
RRCAN	1806.85	2234.33	0.81	0.419
RRJAPAN	2104.47	922.08	2.28	0.023
Monday	1118.10	20.89	53.52	<.0001
Tuesday	1173.93	20.71	56.68	<.0001
Wednesday	1187.56	20.76	57.20	<.0001
Thursday	1182.21	20.85	56.70	<.0001
Friday	1162.31	20.68	56.19	<.0001
Time	-6.36E-01	1.82E-02	-35.04	<.0001
Time squared	1.17E-04	3.90E-06	29.94	<.0001
Trade Event #1	-427.63	175.13	-2.44	0.015
Trade Event #2	-74.12	174.80	-0.42	0.672
Trade Event #3	-135.04	234.08	-0.58	0.564
Trade Event #4	-237.44	174.65	-1.36	0.174
Trade Event #5	-5.54	174.56	-0.03	0.975
Trade Event #6	-187.98	174.55	-1.08	0.282
Trade Event #7	212.99	234.09	0.91	0.363
Trade Event #8	337.25	234.10	1.44	0.150
Trade Event #9	-61.23	174.63	-0.35	0.726
Trade Event #10	80.07	234.07	0.34	0.732
Trade Event #11	239.92	174.70	1.37	0.170
Trade Event #12	-175.33	174.61	-1.00	0.315
ESA Event #1	-121.83	151.20	-0.81	0.421
ESA Event #2	357.68	158.16	2.26	0.024
ESA Event #3	-18.64	135.34	-0.14	0.891
ESA Event #4	-88.44	135.34	-0.65	0.514
ESA Event #5	106.83	213.89	0.50	0.618
ESA Event #6	-168.39	135.30	-1.24	0.213
ESA Event #7	-140.24	135.28	-1.04	0.300
ESA Event #8	-12.20	135.33	-0.09	0.928
ESA Event #9	73.72	135.32	0.54	0.586
ESA Event #10	23.30	213.73	0.11	0.913
ESA Event #11	31.96	135.37	0.24	0.813
ESA Event #12	671.37	151.45	4.43	<.0001

F-Tests for joint significance of pre- and post-event days DF(den)=2935

	F value:	Prob>F:
STARTS (DF=147) [26 coeff. significant at 10%]	2.18	0.0000
ESA (DF(num)=12)	2.43	0.0038
TRADE (DF(num)=12)	1.29	0.2156

Table 9. The effects of events on lumber futures contract trading volume using Event Day Relative variables.

Dep. Var.: Trading volume			N=3117	R-square=0.0150
Variable	Estimate	Std. Error	T-stat.	Prob > |T|
Monday	1112.23	21.17	52.54	<.0001
Tuesday	1162.91	21.12	55.07	<.0001
Wednesday	1185.00	21.12	56.12	<.0001
Thursday	1185.20	21.08	56.24	<.0001
Friday	1164.09	21.11	55.15	<.0001
Time	-0.65	0.02	-37.37	<.0001
Time squared	1.19E-04	3.72E-06	31.93	<.0001
ESA(-1)	9.56	87.28	0.11	0.913
ESA(-2)	85.45	87.29	0.98	0.328
ESA(-3)	-12.49	87.29	-0.14	0.886
ESA(-4)	14.97	87.07	0.17	0.864
ESA(-5)	63.80	87.05	0.73	0.464
ESA Event Day	-15.99	94.26	-0.17	0.865
ESA(+1)	49.70	86.92	0.57	0.568
ESA(+2)	38.97	86.88	0.45	0.654
ESA(+3)	65.57	87.09	0.75	0.452
ESA(+4)	18.16	87.08	0.21	0.835
ESA(+5)	-42.05	87.08	-0.48	0.629
Housing Start(-1)	24.25	27.24	0.89	0.373
Housing Start(-2)	-9.58	27.19	-0.35	0.725
Housing Start(-3)	-3.36	27.18	-0.12	0.902
Housing Start(-4)	44.86	27.20	1.65	0.099
Housing Start(-5)	48.54	27.24	1.78	0.075
Housing Start Event Day	90.07	27.44	3.28	0.001
Housing Start(+1)	53.05	27.27	1.95	0.052
Housing Start(+2)	47.27	27.25	1.73	0.083
Housing Start(+3)	35.61	27.27	1.31	0.192
Housing Start(+4)	55.69	27.24	2.04	0.041
Housing Start(+5)	65.05	27.23	2.39	0.017
Trade(-1)	14.00	90.31	0.16	0.877
Trade(-2)	56.39	90.32	0.62	0.533
Trade(-3)	-131.95	90.42	-1.46	0.145
Trade(-4)	-160.96	90.43	-1.78	0.075
Trade(-5)	-118.35	90.44	-1.31	0.191
Trade Event Day	-85.22	90.48	-0.94	0.346
Trade(+1)	-11.77	90.44	-0.13	0.897
Trade(+2)	3.92	90.40	0.04	0.965
Trade(+3)	-18.68	90.37	-0.21	0.836
Trade(+4)	-7.13	90.33	-0.08	0.937
Trade(+5)	64.25	90.36	0.71	0.477

F-Tests for joint significance of pre- and post-event days on trading volume

DF(num):5, DF(den): 3077	F value:	Prob>F:
ESA(-5) – ESA(-1)	0.31	0.9072
ESA(+1) – ESA(+5)	0.27	0.9280
Housing Start(-5) – (-1)	1.28	0.2684
Housing Start (+1) – (+5)	2.8	0.0159
Trade(-5) – Trade(-1)	1.48	0.1925
Trade(+1) – Trade(+5)	0.07	0.9969

Table 10. The impact of individual events on the rate of return on lumber futures contracts, NERM (estimates for housing starts omitted for space considerations).

Dep. Var: $\log(P_t/P_{t-1})$		N=3117, model DF=188		SSE=.6615
Variable	**Estimate**	**Std. Error**	**95% CI, UP.**	**95% CI, LOW.**
σ^2(STARTS)	0.2845	0.0519	0.183	0.386
σ^2(ESA)	20.5841	7.7422	5.403	35.765
σ^2(TRADE)	0.6782	0.2852	0.119	1.237
μ(STARTS)	-0.2103	0.0588	-0.326	-0.095
μ(ESA)	0.1459	0.9424	-1.702	1.994
μ(TRADE)	-0.9439	0.2118	-1.359	-0.529
			T-stat.	**Prob > |T|**
RRCRB	0.3334	0.0509	6.55	0.000
RRTBILL	-0.1997	0.0406	-4.92	0.000
RRCANADA	-0.1916	0.1118	-1.71	0.087
RRJAPAN	0.0121	0.0461	0.26	0.793
Time	-1.22E-6	8.868E-7	-1.38	0.169
Time Squared	1.85E-10	1.91E-10	0.97	0.333
Monday	0.0021	0.0010	2.10	0.036
Tuesday	-0.0004	0.0010	-0.42	0.678
Wednesday	0.0014	0.0010	1.33	0.182
Thursday	0.0035	0.0010	3.41	0.001
Friday	0.0023	0.0010	2.23	0.026
Trade Event #1	-0.0235	0.0260	-0.90	0.366
Trade Event #2	-0.0274	0.0261	-1.05	0.294
Trade Event #3	-0.0171	0.0286	-0.60	0.550
Trade Event #4	-0.0109	0.0258	-0.42	0.673
Trade Event #5	-0.0114	0.0222	-0.51	0.608
Trade Event #6	-0.0189	0.0224	-0.84	0.399
Trade Event #7	0.0503	0.0308	1.63	0.102
Trade Event #8	-0.0325	0.0293	-1.11	0.267
Trade Event #9	0.0032	0.0257	0.12	0.902
Trade Event #10	-0.0569	0.0400	-1.42	0.155
Trade Event #11	-0.0771	0.0283	-2.72	0.006
Trade Event #12	-0.0099	0.0257	-0.38	0.701
ESA Event #1	0.0024	0.0666	0.04	0.972
ESA Event #2	0.0250	0.0654	0.38	0.702
ESA Event #3	0.1303	0.0662	1.97	0.049
ESA Event #4	0.0471	0.0651	0.72	0.469
ESA Event #5	0.0662	0.0693	0.96	0.339
ESA Event #6	0.0251	0.0618	0.41	0.685
ESA Event #7	-0.0310	0.0610	-0.51	0.611
ESA Event #8	-0.0032	0.0703	-0.04	0.964
ESA Event #9	0.0091	0.0687	0.13	0.895
ESA Event #10	-0.2364	0.1095	-2.16	0.031
ESA Event #11	0.1863	0.1099	1.70	0.090
ESA Event #12	0.1036	0.0673	1.54	0.124
# housing starts coefficients significant at < 10% level (out of 147): 33				
Likelihood Ratio Test for joint significance of event sets				
	χ^2 (DF)	Prob>χ^2:		
ESA Events	18.67 (14)	0.178		
Trade Events	21.26 (14)	0.095		
Housing Start Events	214.30 (149)	0.0004		