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QUANTIFYING THE ANNOUNCEMENT EFFECTS IN THE U.S. LUMBER MARKET

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ABSTRACT

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ZARINA ISMAILOVA

The impact of public reports on price fluctuations has been widely investigated in many commodity markets, but little attention has been paid to the lumber market. In this thesis, we examine the impact of two housing market reports, namely the New Residential Construction (Housing Starts) and the New Residential Sales reports, on the U.S. lumber futures market. Our results suggest that the housing starts report does indeed affect lumber market volatility, while the New Residential sales report exerts a minor impact on lumber price volatility. Price volatility is measured by changes future contract prices for lumber. We further find that the effect of the two reports on volatility differs depending on the level of lumber inventory and the nature of the news. When inventory is low, larger-than-expected housing starts have the largest effect on lumber volatility. During periods of abundant inventory, lower-than-expected housing starts increase the volatility most. For the new home sales reports, we find that while lower-than-expected sales do not affect the volatility of lumber prices, larger-than-expected sales do increase the volatility.

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ABBREVIATIONS

ARMA – Autoregressive moving average

ARCH - Autoregressive Conditional Heteroskedasticity

CME – Chicago Mercantile Exchange

EGARCH – Exponential Generalized Autoregressive Conditional Heteroskedasticity

EMH – Efficient Market Hypothesis

ESA – Endangered Species Act

FEA – Forest Economic Advisor

GARCH - Generalized Autoregressive Conditional Heteroskedasticity

HUD - Housing and Urban Development

HS - Housing Starts

NHS – New Home Sales

SLB - Softwood Lumber Board

TARCH - Threshold Autoregressive Conditional Heteroskedasticity

USDA - United States Department of Agriculture

WASDE - World Agricultural Supply and Demand Estimates

Chapter 1: Introduction

Since the seminal paper of Fama et al. (1969) that investigates the effects of stocks splits on firm returns, a large number of studies have examined how prices in the financial and commodity markets react to new information releases. If markets are efficient, then it is expected that the information contained in these reports or news announcements will be quickly incorporated into market prices. This supposition is commonly known as the Efficient Market Hypothesis (EMH), first put forward by Fama (1998). In its weak, semi-strong, and strong forms, the EMH suggests that market prices should reflect all past publicly available information, respond instantaneously to new public information, and reflect all publicly available and private information, respectively.

Public reports play a vital role in disseminating new information, acting to improve market competitiveness and optimizing resource allocation. However, the importance of public reports has been challenged in both the academic literature and the policy arena, often under the lens of the EMH. Sumner and Mueller (1989) argue that public information services are appropriate only if the information is accurate, of interest and "new" to market participants, and to the extent that it influences the economic activity of those yet to make decisions. Binder (1998) similarly contends that a public report is valuable only if its information can alter subsequent market prices.

Due to the high cost of collecting and disseminating commodity supply and demand data, the government has long acted as the primary provider of such information (Mattos and Silveira, 2016). Over the past two decades, however, more private players have participated in generating and disseminating commodity market reports, driven by the rising interest of financial investors in commodities as part of their investment portfolios, as well as the increasing concentration and greater integration of commodity markets over time. Garcia et al. (1997) argue that decreasing government participation in the general economy has also motivated the private sector to increasingly collect and distribute market data. This view is further discussed in Hoffman et al. (2015), who argue that evaluating the net benefits of public data provision is crucial as federal resources are reduced, agencies are downsized, and programs are scrutinized in this new era of declining federal funding.

A number of studies have investigated how commodity prices and volatility respond to public news announcements (e.g., Isengildina-Massa et al. 2008a; Lehecka 2014; Mattos and Silveira 2016; Olga Isengildina-Massa et al. 2008b). These studies often focus on agricultural commodities such as corn, soybeans, wheat, and livestock products (Isengildina-Massa, et al. 2008a; Isengildina, Irwin, and Good 2006; Lehecka 2014; Mattos and Silveira 2016), as well as energy products such as crude oil and natural gas (Halova, Marketa W., Alexander Kurov, and Oleg Kucher, 2013). In general, results suggest that public reports contain valuable information for commodity market participants and improve their decision making. However, the magnitude of the announcement effect differs substantially across markets, and in some instances, the announcement effect has declined in recent years (Lehecka, 2014).

Among all commodities, little attention has been paid to the announcement effect of public reports in the lumber market, the end products of which are some of the most widely used goods in the world, ranging from residential houses and furniture to industrial products such as paper and pulp. There are only three exceptions known within the literature at the time of this study: Rucker et al. (2005), Karali and Thurman (2009), and

Karali (2011). Rucker et al. (2005) investigate the speed of information impoundment of three distinct types of news in lumber prices, namely the monthly housing starts estimates, trade disputes with Canada, and court decisions related to the Endangered Species Act (ESA). They find that of the three types of news, the monthly housing starts estimates are absorbed in lumber prices first, followed by trade disputes and court events on ESA. Karali and Thurman (2009) focus on the reaction of lumber futures prices to monthly housing starts announcements and find that lumber futures return increases with the unanticipated component of housing starts announcement. The effect declines with lumber inventories and the length of contract maturity. Karali (2011) investigates the effect of the U.S.-Canada softwood lumber trade dispute on lumber futures price volatility and finds that daily price volatility was highest in the post-Softwood Lumber Agreement period (1996-2000) and the trade disputes and temporary tariffs (1992-2005). Karali (2011) argues that the time gap between the arrival of news to the markets and the delivery time of futures contracts appear to be the fundamental determinants of the volatility persistence observed in the lumber market. This paucity of literature on the lumber market is surprising given that lumber is used in over 90% of home construction in the United States and that the housing market plays an integral role in the overall economy (Karali, 2011).

Howard's and McKeever's recent report (2017) argues for the critical importance of lumber to the rural community via direct job creation and income generation, as well as indirect employment in downstream industries. As a main input in the manufacturing of trusses, windows, doors, millwork, and wood containers, lumber accounted for 567,567 jobs with annual salaries of $34.93 billion. Additionally, lumber is widely used in the building and construction industry, including residential home construction and the repair or remodeling of homes. Based on information provided by the National Association of Home Builders, an average size home of about 2,400 square feet needs some 14,400 board feet of softwood lumber. Due to the large amount of lumber consumed in the building and construction industry, changes in the lumber prices should also affect housing prices.

Fluctuations in lumber prices could have ripple effects in both the lumber and downstream industries. During the whole process of the distribution chain (from forest, mill, processor wholesaler, retailer to the construction industry or other end-user), lumber prices fluctuations can be a favorable advantage for speculator firms, and disadvantage for the end customer due to the time lag between initial price and final sale price. Based on the statistics of the North American Wholesale Lumber Association, even a 2 percent decrease in lumber price can cause the industry more than $10 million (CME Group, 2009). Thus advanced awareness about price change of the industries involved in lumber production as well as other stakeholders and market participants, will provide advantages in decision-making based on price tendency information, which is reflected in the release of macroeconomic announcements (Roache and Rossi, 2010).

The purpose of this thesis is to investigate the relevance of two government reports on the U.S. lumber market: (1) the New Residential Construction (housing starts), and (2) the New Residential Sales reports. These two monthly reports are jointly released by the U.S. Census Bureau and the Department of Housing and Urban Development (HUD), and contain information on housing market statistics from the previous month. Three metrics are reported in the New Residential Construction reports: the number of new building permits issued, housing starts, and the number of houses completed. Of these three, the housing starts, which reports the number of privately-owned residential constructions started in a month, is of particular relevance since it projects steady lumber demand for the upcoming months. The New Residential Sales report, on the other hand, provides information on the number of sales of newly constructed residential housing units in a given month, and should contain information regarding the demand of newly-constructed houses. Since housing construction is a primary driver of lumber demand in the U.S., these two reports are closely watched by lumber market participants. To isolate the "new" information contained in these two reports, we collect the consensus forecasts (i.e., what experts are predicting the numbers in the forthcoming reports will be) from Bloomberg and measure the surprises from the two reports as the difference between the actual and the forecasted data.

Unlike Rucker et al. (2005) and Karali and Thurman (2009), who investigate the effect of new information on lumber futures prices, the study focuses on the volatility effect of public information releases. Price volatility is measured by changes future contract prices for lumber from 2000 – 2017. Investors closely watch volatility as it affects the cost of capital as well as direct investment, and asset allocation decisions. Here, we use the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models with exogenous variables to estimate the impact of news announcements on lumber market volatility. To estimate the asymmetric effect of news releases, the volatility is allowed to vary depending on the nature of the surprise, i.e., positive and negative news. Additionally, the variance effect of news relating to market volatility with the level of inventory is evaluated. Seasonal effects, as well as day-of-the-week effects, are incorporated in the analysis. Overall results show that the New Residential Construction (housing starts) report significantly affects lumber market volatility, while the New Residential Sales report exerts a minor impact on lumber volatility. Additionally, the effect on volatility is found to differs between positive and negative surprises.

The remainder of the thesis is structured as follows. Chapter two reviews the existing papers and highlight our contributions to the literature. Chapter three presents the data used in this study, focusing on the price and volatility behavior of lumber futures contracts around the announcement date of the two market reports. Empirical strategies and estimation results are presented in chapters four and five, respectively. The last chapter concludes the paper with suggestions for future research.

Chapter 2: Literature Review

2.1. The Economic Value of Lumber

Forests play a vital role in economic development by providing a variety of products and services. According to Dean (2016) , over 1.5 billion people's livelihoods in the world depend on forests. One of the most valuable forest products is lumber, and Dean (2016) estimates that the lumber manufacturing industry accounts for more than $46 billion yearly. Sustainable lumber supply plays an important role in revenue generation, as well as employment support, which is essential for poverty mitigation and public stability.

Ritter, Skog, and Bergman (2011) note that more than 1 million U.S. jobs were directly created based on lumber production, contributing more than $100 billion to the U.S. Gross Domestic Product. Their report further indicates that the economic benefits received from lumber production included more than 350,000 direct jobs and $12.0 billion in payroll in 2009. Job creation and associated payroll are especially important in the economic development of rural forested areas due to fewer job opportunities.

Based on data provided by Forest Economic Advisors (FEA) report, there are 509 sawmills that are currently running in 464 communities across 32 states. These mills offer direct economic impacts, including sales and employment, and the indirect impacts, such as consumption by industry employees. These indirect impacts may also include employee investments in housing.

It is notable that the lumber industry employs more people annually than the oil and gas industries. In 2016, the number of jobs created by lumber production was 208,107 (which nested within the broader category of lumber manufacturing industry), resulting in $11.35 billion in wages. In addition, there are other lumber dependent industry sectors, with their own respective work forces and revenue streams, including the lumber wholesale trade production of windows, doors, trusses, etc. (Software Lumber Board, 2017).

There are two types of lumber, softwood and hardwood. Most of the lumber production consumed in the world is softwood lumber, with the concentration of production being in the Baltic Sea region and North America. The classification of softwood lumber is based on thickness. North America's most common softwood lumber products have a future standardized forward contract dimension of 2 inches thick by 4 inches wide. The softwood lumber is usually 8 to 20 feet in length (CME Group, 2009).

The other type of industry production is hardwood lumber, which is more commonly associated (as compare to softwood) with furniture, flooring, kitchen cabinets, and millwork. According to Luppold et al., (2014) the period of 1990 to 1999 was characterized by an increased consumption of hardwood lumber, and by 1999, its consumption reached 7.7 billion board feet. They find that after 2000, the U.S. hardwood consumption declined by 65%, and in 2009 it was 2.7 billion board feet, due to a number of continuous economic shocks. The biggest decline, in the authors estimation, occurred between 2006 and 2009 and caused a significant fall in the price of hardwood lumber. In the fall of 2012, lumber prices increased again, but still was low compared to the level of the mid-2000s. In the same time, the consumption of hardwood lumber by manufacturers decreased by 75%, and in 2011 about 50% of grade lumber consumption made by US lumber exporters (Luppold et al., 2014).

Increases in population and economic activity in future years will lead to a continuous growth of consumption of most lumber products. For softwoods, it is projected that the consumption will increase from 14.3 billion cubic feet to 17.5 billion cubic feet between 1986 and 2040, and for hardwoods, from 6.2 billion cubic feet to 11.1 billion cubic feet (Haynes, 1990).

2.2 Determinants of lumber prices and volatility

The price and volatility of lumber varies across different species, i.e., hardwood or softwood lumber. Export demand and supply is an influencing factor for both hardwood and softwood lumber prices. Canada is the largest exporter of softwood lumber to the U.S., providing one-third of U.S. consumption. Lumber imports from Canada mostly consist of dressed softwood lumber, which is an aggregate of several different species. There is intense competition between the U.S. and Canadian lumber markets, which leads to lumber trade disputes between the two countries (Nagubadi, Zhang, Prestemon, and Wear, 2004).

According to Zhang and Sun (2001), the most intense dispute regarding softwood lumber imported from Canada to the United States was in 1999. The latest Softwood Lumber Trade Agreement (SLA) between the two countries was made in 1996, together with a tariff-regulated quota system on Canadian softwood lumber imports that regulates the tax-free export limit, tax level and price. The authors mention that price volatility is often caused by the uncertainty associated with different periods of U.S.-Canada softwood lumber trade disputes, and relationships between supply and demand in each period. Thus, price volatility can be explained by certain situations created by SLA when supply cannot respond quickly to changes in demand (Zhang and Sun, 2001) . The construction industry provides the biggest part of the softwood lumber supply (Hseu and Buongiorno, 1993). Due to the quality and safety of the product, more than 90% of the housing market in the U.S. is built with softwood lumber; hence lumber prices are strongly linked to the housing market (Clem, 1985).

A number of studies show the relationship between lumber price, its volatility and housing starts. For instance, Singh and Nautiyal (2007) emphasize that demand for lumber mainly depends on the demand for housing, and there is a significant positive relationship between quantities of lumber exported and price in the export market. They find that the total demand for Canadian lumber is determined more by the housing starts in the United States than in Canada. Thus, the pattern of declining Canadian lumber exports to the U.S., since it’s the peak in 1978, can be partly explained by the decline in U.S. housing starts (Singh and Nautiyal, 2007).

Lumber prices in the U.S. have had some extreme peaks in volatility. Rucker et al. (2005) note that the explanation for these peaks includes domestic supply and demand factors, and trade. The authors compare and analyze the impact of three types of events: housing start announcements, periodic policy decisions related to U.S., Canada lumber trade disputes, and information released in the form of court decisions. Based on the paper results, the regular announcements tend to have more impact on future lumber prices than those without known advance announcement dates.

Karali and Thurman (2010) provide two definitions of volatility: one based on changes in closing price from one day to the next, and the second based on price ranges of intra-day transactions. The authors find that lumber price volatility can change during the course of a year, increasing in months before harvest periods, as volatility increases in line with futures contracts approaching delivery dates (Karali and Thurman, 2010). Streeter and Tomek (1992) reveal that there are nonlinear effects on price volatility of time to delivery and that volatility decreases in the months immediately prior to the expiration time of contracts. The authors also discovered that seasonal volatility effects increase in the summer months. Moreover, lagged volatility has a significant positive effect on price volatility.

Researchers have also examined other factors of price fluctuations. For instance, according to Kyle, (1985) and Andersen and Bollerslev (1997), futures price volatility can change based on related reactions to information flows. While, according to Thurman (1988) and Williams and Wright (1991), the volatility of future prices can be explained by inventory levels, by time to delivery (Samuelson,1965) or by persistence in variability (Kenyon et al., 1987). In addition, Anderson (1985), emphasizes the significant role of seasonality in explaining futures price volatility within grain markets, and that contract maturity is a less significant factor.

2.3 Price risk management in lumber market

There are three main types of commodity trading markets: spot market, forward market, and futures market. The market where buyers and sellers are trading goods at a certain price for immediate delivery is a spot market. A trading market with predetermined price and delivery date is a forward market. And finally, a market working based on an agreement between buyers and sellers to trade standardized contract that has a constant quality, quantity, and point of delivery is a futures market (Bodie and Rosansky, 2017).

Commodity futures trading markets play the role of facilitation and better distribution of commodities over time, which helps smooth price fluctuations (Kawai, 1983).

Stoll and Whaley (1993) explain that fluctuation of prices over time creates risks for firms engaged in producing, processing, marketing, or using lumber and lumber products. This reinforces the earlier claim that futures markets have been commonly used as a tool to manage such price risks. The authors interpret the variety of operations and functions of the futures market, and they assert that one of the key functions of futures market is price discovery.

Availability of derivative contracts allows the market to eliminate pricing errors. Further, according to the authors, when additional information is available about the true price of the underlying security, more instruments can be traded on that security (Stoll and Whaley, 1993). Lumber futures contracts were introduced in 1969 by the Chicago Mercantile Exchange (CME). This was recognized as the first financial tool for price protection of forest products (Karali, 2011).

Each CME lumber futures contract has the same standardized quality for the product. The board foot-length is a trading unit for the CME future lumber contracts, and the price is expressed in the dollar (per thousand board feet). The quantity of each contract is set at 110,000 board feet of random length lumber: 8’ to 20’ (length) x 2” (width) x 4” (depth). Each contract is qualified by grade. This wood is often kiln-dried western spruce-pine-fir (SPF). There are following delivery contracts months: January, March, May, July, September, November and the following January (CME, 2015).

When contracts have matured and expired, the settlement can be done by delivery. According to CME regulations, participating mills must be in the states of Oregon, Washington, Idaho, Wyoming, Montana, Nevada, California, or the Canadian provinces of British Columbia or Alberta (CME, 2015). Nevertheless, CME also has its own rules and regulations regarding delivery offset. To offset the obligated action, traders who have gone short (selling of contracts) can buy back the contracts of the same delivery month. From the other side, traders who have gone long (buying of contracts) must sell a futures contract for the same delivery month. The given trading system is an advantage for the market participants (hedgers and speculators). The futures contracts have an exchangeable nature which allows them to be sold and bought later. In addition, futures quotes are available in real-time due to the negotiability of price. All mentioned factors help traders to have more suitable positions on the lumber futures market (Wong, 2011).

As mentioned earlier, a futures contract is a popular tool for mitigating lumber price risk. Countless contracts have been traded since 1969 by firms involved in producing, processing, marketing and utilizing of lumber and lumber products markets (Wong, 2011). Like other commodities, lumber futures contract prices are under the constant influence of related market supply, demand, and news. That attracts speculators to trade and make profit. More trading contributes to trading volume and improves market liquidity.

Koutmos and Tucker (1996) compare the futures market with its underlying cash market, finding that futures markets have quicker price reaction and lower transaction cost. More specifically, movement in futures markets is predicted to be faster compared to cash markets in response to new information, which can be explained by fewer restrictions in short selling (Martikainen and Perttunen, 1995).

According to Deckard (2000), the future prices respond, and change based on new spot market information and risk expectations. As such, the futures market meets all the required conditions for price risk management.

2.4 The role of public reports on commodity prices and volatility

Commodity price volatility might be associated with unexpected news coming to the market. According to Fama et al. (1969), asset prices quickly adjust to new information. Based on the nature of the news, the prices will increase or decrease. Historically the main source of new information coming from public reports for various commodities is the government. Public reports play a vital role in disseminating the latest market information, acting to improve market competitiveness and optimizing resource allocation (Mattos and Silveria, 2016). In the United States, examples of frequently watched commodity market reports funded by the federal government include, among others, the Energy Information Administration (EIA)'s Weekly Petroleum Status report, the Department of Agriculture (USDA)'s Crop Progress report, and USDA's World Agricultural Supply and Demand Estimates (WASDE) (Mattos and Silveria,2016; Halova, Kurov and Kucher, 2014).

However, the value of public reports has been under scrutiny in both the academic literature and the policy arena. Sumner and Mueller (1989), for instance, argue that the service of providing public information is only justified if the information is of interest to market participants who are yet to make decisions and that the information is accurate and indeed "new" to the market. Hoffman et al. (2015) assert that evaluating the net benefits of providing public data has become more important in an era with federal resources being reduced, agencies being downsized, and programs being scrutinized. Debates regarding the relevance of public data also arise as private sectors increasingly participate in the generation and dissemination of the commodity market.

The basic theoretical model for evaluating the value of public reports or news announcements in asset and commodity markets is called the efficient markets hypothesis (EMH), developed by Samuelson and Fama in the 1960s. Samuelson and Fama have determined three subsets for evaluating public reports or news announcements: the weak form, which states that market prices should reflect all past available public information but also react immediately to new public information. The semi-strong form tests which considers if prices can efficiently adjust to other publicly available information. The strong form test concerns monopolistic access to the information on price formation. The intuition behind the EMH is a concept of informational efficiency and, as a result, profit for many active market participants. Most of the investors are driven by profit opportunities. Thus, an informational advantage can allow investors to absorb the information into the market price and, ultimately, gain a leading trading position (Fama, 1998).

The efficient market hypothesis gained popularity after 1969 when evidence indicates that stock prices respond quickly to new information (Rucker, Thurman and Yoder, 2005). Many studies have followed the idea presented by Fama et al. (1969) regarding information content and economic announcement impact, as well as how fast the price reacts to the new information on the market. According to Ball and Brown (1968), up to 80 percent of the information ‘surprises’ significantly affect the financial market prices. Mandelbrot (1966) talks about consistency of the market price change with the efficient market, which rapidly adjusts to new information.

Numerous studies have empirically investigated the value of public reports on commodity markets based on the EMH emphasizing agriculture commodities and energy products. For example, according to Colling and Irwin (1990); Grunewald, McNulty, and Biere (1993); Garcia et al. (1997); Isengildina-Massa, et al. (2008), livestock futures prices quickly react to the release of USDA Reports. Lehecka (2014) investigates the reactions of corn and soybean futures markets on USDA reports by analyzing post report day variances. Mattos and Silveira (2016) reveal that the impact of reports on corn and soybean prices are generally stronger when crop reports are released in the months before the beginning of harvest season. Halova, Kurov, and Kucher (2013) examine the announcement effect of oil and gas inventory on energy prices.

Most of the above-mentioned empirical studies use a variant of event study methodology. Based on the basic principle of an event study, "the information is valuable to market participants" if prices react to the announcement of public information (Campbell, Lo, and MacKinlay, 1997). The analysis of reports in most of the previous studies however does not allow for a comparison of impacts across relevant reports. Even though most of these earlier research works applied the event study approach, the sample periods and methods differed. Hence, it is difficult to compare results across studies (Isengildina, Irwin and Good, 2006).

Little attention has been paid to the announcement effect of public reports in the lumber market, which are some of the most widely used goods in the world ranging from residential houses and furniture to industrial products, such as paper and pulp. The only exceptions in the research literature, of which is known, are Rucker et al. (2005), Karali and Thurman (2009), and Karali (2011).

Rucker et al. (2005) investigate the speed of information impoundment of three distinct types of news in lumber prices, namely the monthly housing starts estimates, trade disputes with Canada, and court decisions related to the Endangered Species Act (ESA). They find that of the three types of news, the monthly housing starts estimates are absorbed in lumber prices first, followed by trade disputes and court events on ESA. Karali and Thurman (2009), on the other hand, focus on the reaction of lumber futures prices to monthly housing starts announcements, finding that lumber futures returns increase with the unanticipated component of housing starts announcements and that the effects decline with lumber inventories and the length of contract maturity. Karali (2011) focuses on the U.S. and Canada trade softwood lumber trade disputes on lumber futures price volatility and finds that the daily price volatility was the highest in the post-Softwood Lumber Agreement period, 1996 – 2000, and the trade disputes and temporary tariffs from 1992 - 2005. Karali (2011) argues that the time gap between the arrival of news to the markets and the delivery time of futures contracts value appears to be the fundamental determinant of the volatility persistence observed in the lumber market.

2.5 Common Empirical Methods used in Previous Studies

Based on historical evidence, researchers agree upon the fact of the predictability of volatility for various types of commodities. Due to this predictability of variability, there are several different types of approaches presented or suggested.

One methodology is event study, which is the standard method of measuring how commodity prices react to news announcements or events (Binder, 1998). Using this approach, Isengildina-Massa et al. (2008) analyze the impact of WASDE reports on the volatility of corn and soybean markets. The results showed that the announcement of WASDE reports significantly decreased the volatility. The reaction of volatility on the announcement of public information is also described by Lehecka (2014). Based on this research, the volatility is higher on days when reports were released. According to Binder (1998), the main applicability of event study methodology is the ability to measure the reaction of price change compared to public announcements (Binder, 1998).

The event study approach is also used in research studies by Rucker et al. (2005), who observe that the reaction of price depends on event information, noting, that the information on housing starts is absorbed more quickly than trade event information. Belgacem et al. (2015), applying the event study methodology, conclude that the public news has immediate impact on commodity price after their release. Fleming, and Remolona (1999) and Ederington and Lee (1993) find further evidence that commodities prices react to the announcement of new information and assume that price response to the reports is symmetric.

Theoretical interest has developed in "asymmetric" or "leverage" volatility models. The bad and good news in such models are allowed to affect volatility differently. The models, based on the asymmetric effect of news on volatility, have been presented by many researchers. For instance, Black's (1976) results demonstrate that exchange rate behavior is generally influenced by previous information about the exchange rate. This also implies that volatility of the previous day's exchange rate can affect current volatility, and the estimate for asymmetric volatility suggests that positive shocks imply a higher next period conditional variance than negative shocks.

Pagan and Schwert (1990) were the first among researchers who provided a systematic comparison of volatility models. The focus of their paper is on the asymmetric effect of news on volatility using a partially nonparametric model. Using this model, Pagan and Schwert (1990) measure the stock volatility reaction to negative and positive returns using lagged return shocks along with lagged measures volatility.

Due to the importance in the ability to forecast the volatility, many approaches are considered and presented by theoretical literature. The most popular methodology historically is the autoregressive conditional heteroskedasticity (ARCH) model, which was originally introduced by Engle (1982). The ARCH model has been presented in a variety of contexts. For example, Bera and Higgins (1993) introduce it in terms of errors of a dynamic regression model.

Further, Engel (1982) presents an ARCH model as an assumption that the "variance of tomorrow's return is an equally weighted average of the squared residuals from the last 22 days." The model presented by Bollerslev (1986) is a useful generalization of the ARCH model, known as the GARCH parameterization. This model also considers a weighted average of past squared residuals, but when compared to ARCH, it has declining weights that never go completely to zero.

Several empirical studies have analyzed the impact of public information on commodity markets using varying methodologies. For example, Mattos and Silveira (2016) introduce research focusing on the impact of crop reports released by the USDA on futures prices for soybeans and corn using Efficient Market Hypothesis. Since futures prices of agricultural commodities do not generally follow a normal distribution, because of the presence of nonzero skewness and excess kurtosis, authors have chosen a GARCH family model to estimate volatility. In addition, as noted previously, markets react asymmetrically to good and bad news, which is why a Threshold Autoregressive Conditional Heteroskedasticity (TARCH) model has been used (Mattos and Silveira, 2016).

Karali (2012) also addresses the impact of USDA reports on the conditional variances and covariances of returns on corn, lean hogs, soybeans, soybean meal, and soybean oil futures contracts using a market efficiency and multivariate GARCH model. The reaction of corn and soybean futures price to changes in condition information, particularly the informational value of USDA crop progress, was presented and analyzed by Lehecka (2014), who utilizes two event-study methods. First, the differences in close-to-open return variabilities were statistically tested for report-release trading days and pre- and post-report days, and second, the speed and rationality of market prices reaction to new the crop-condition information were examined (Lehecka, 2014).

One limitation of the GARCH model is that it makes the assumption that the impact of positive and negative surprises is symmetric. This limitation has been accounted for by Mattos and Silveira (2016) thru a modification of the standard GARCH equation. Other research (Engle, 2004) suggests that an alternative to the GARCH model could be the EGARCH model. The EGARCH directly allows asymmetric impact of positive and negative price forecast errors on future price volatility.

However, this research will use a GARCH formulation that will directly account for the possibility of asymmetric impact of positive and negative surprises. As explained in Chapter 4, the GARCH model is modified, using the idea of Mattos and Silverira (2016), by introducing dummy variables that capture the different impact of positive and negative report surprises.

There is an additional perspective looking at the volatility of commodity price based on the change in inventory level wherein Halova et al. (2013) describe the effect of oil and gas inventory announcements on energy prices. The approach used in the current study follows traditional event study regressions, as well as Rigobon and Sack's ITC methodology.

The current study contributes to this topic by examining the influence of public information announcements on lumber return volatility. To this end, the following chapter presents data relating to housing reports on lumber trade.

Chapter 3: Data

The previous chapter discussed academic discourse surrounding commodity market behavior, in particular the relation of public announcements on lumber market volatility. This chapter explores data relating to intersections between public announcements and lumber market volatility. We use futures prices to calculate volatility of lumber returns. These futures prices are based on lumber futures contracts traded in the Chicago Mercantile Exchange (CME) with January, March, May, July, September, and November deliveries. Each contract contains 110,000 nominal board feet, with one board foot being a one inch thick, twelve inches by twelve inches board. The pricing unit of the lumber futures contract is dollars per 1,000 board feet. The data of the daily open and closing prices of the nearby lumber futures contracts have been retrieved from Bloomberg over the period from January 2000 to November 2017. The nearby futures prices are the prices of the futures contracts with maturity as a closest for a given day (Chan and Lien, 2003). The roll date used in constructing the nearby series is the first business day of contract delivery month. This price data is based on the trading session that takes place from Monday through Thursday between 9:00 am and 4 pm Central Standard Time (CST), and Friday between 9:00 am and 1:55 pm CST.

Two public reports of relevance to the lumber market were considered: (1) the monthly New Residential Construction (housing starts hereafter), and (2) the New Residential Sales (new home sales hereafter). These reports are released by the US Census Bureau and HUD, respectively. Both reports contain information from the month prior to their release. Housing starts are released around the 17th of the month at 7:30 am CST, hence before the futures trading session begins. New home sales data is typically released at the end of the month. The release time for new housing sales is 9:00 am CST, when the futures trading session begins.

In the context of this study the release time of information is important (not just date), because it has a direct influence on lumber market volatility as mentioned in the previous chapter and will be discussed in chapter four.

To gauge the effect of public reports on the lumber market, this thesis follows the literature and compute daily price changes (returns), as in equation (1):

$$r = \ln\left(\frac{P_t^c}{P_{t-1}^c}\right) \times 100 \qquad (1)$$

where P_t^c is market closing price on date t and P_{t-1}^c is the market closing price on the previous date. The r return series gives the daily price change at close from date $t-1$ to t, and hence reflects market reactions to new information between the end of the trading sessions for two consecutive business days. However, it should be noted that much noise can be introduced to the analysis when r_1 is used since it also reflects market responses to other new information during the trading session. These "measurement errors" in the return sequence should not cause large estimation bias in the regression coefficients, as long as the errors are randomly distributed. However, it does increase the variance of the estimation.

One complication with calculating returns using the nearby data is that the returns on the roll date are computed by taking the price differences of two different contracts. This may introduce large jumps in the return series since the two contracts reflect different delivery dates. For this reason, calculation of the returns on roll date is performed by taking the price differences using the same contract (i.e., the first nearby contract).

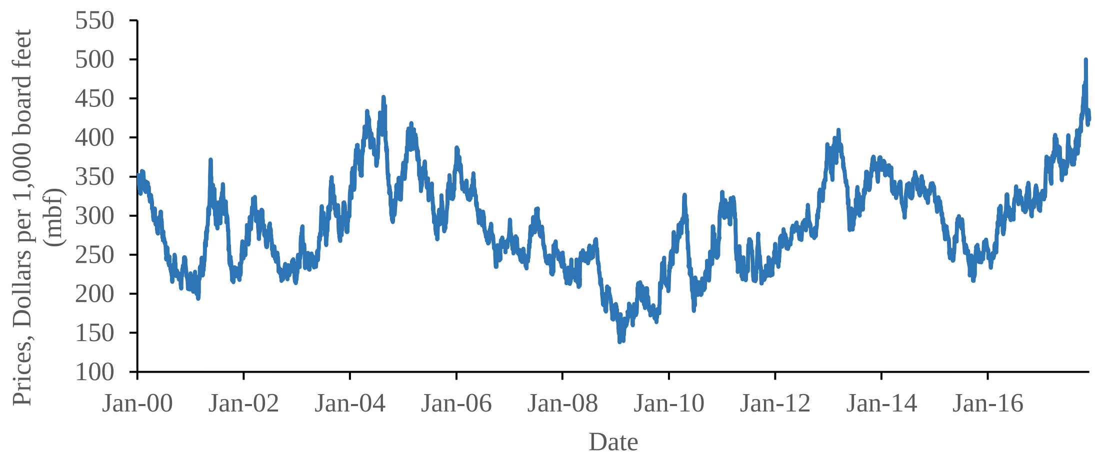

Figure 1: Lumber futures daily closing prices from January 2000 to November 2017

Figure 1 shows the nearby lumber futures contract prices in dollars for per 1000 board feet lumber (mbt) for January 2000-November 2017. As illustrated, the prices are overall rather volatile, ranging between approximately $125/mbt at the end of 2008 to over $500/mbt in October 2017. Large price declines are observed from 2004 to 2009, during which the housing bubble and the financial crisis occurred. Since 2015, the prices have been in general trending upwards, reflecting a strong recovery in the overall economy in the U.S.

Figure 2 shows the daily returns based on lumber futures contract closing prices, as shown in equation (1). As can be seen, there appears to be volatility clustering, i.e., "large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes" (Mandelbrot, 1963). Returns were rather volatile between 2008 and 2012, the period that largely corresponds to the financial crisis and the resulting economic recession in the United States (and the "housing bubble" mentioned earlier).

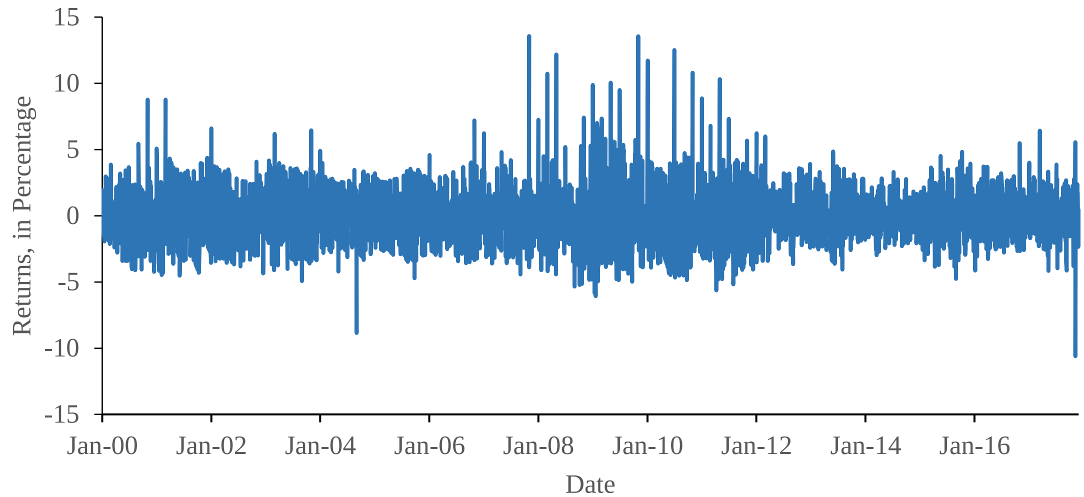

Figure 2: Lumber futures daily log returns of closing prices from January to November 2017

Table 1 presents the summary statistics of the return series. The average daily return is 0.005% during the sample period and is not significantly different from zero. However, there are some extreme cases when the returns are strongly positive or negative. The highest return is 13.6% which occurred in 2007, and the lowest return is -10.6% towards the end of the sample period. The distribution of returns appears to be positively skewed and has positive excess kurtosis that means a fatter tail than a normal distribution, or a higher than normal probability of big positive and negative returns realizations. Fat tails represent a higher than normal probability of big positive and negative returns realizations. The skewness and kurtosis provide evidence that the lumber returns are not normally distributed. To test such an observation statistically, the Jarque-Bera (JB) test for non-normality is utilized. The null hypothesis of the JB test is that the data is normally distributed against the alternative hypothesis of non-normality. As shown in Table 1, a large chi-square with the p-value of less than 1% was found for this test. The results suggest the rejection of the null hypothesis that the lumber returns are normally distributed.

Table 1: Descriptive Statistics of Close-to-Close Percentage Daily Returns for Lumber, 2000-2017

		Test of Autocorrelations	Returns	Returns^2
Mean (%)	0.005			
Maximum (%)	13.566	Ljung-Box (1)	14.384***	25.277***
Minimum (%)	-10.603	Ljung-Box (3)	14.444***	43.662***
Std. deviation (%)	1.967	Ljung-Box (5)	15.373***	50.785***
Skewness	0.653			
Kurtosis	3.155	ADF test	-16.972***	
Jarque-Bera	2195.46***			

Note: *, ** and *** represents a 10%, 5% and 1% level of significance.

The next step involves implementation of the Ljung-Box (LB) test to detect the autocorrelation in different lags (1, 3, and 5 days) for returns series and squared returns series under the null hypothesis that the series exhibits no autocorrelation at given lag period. The market gets information on the prices based on the expectation of the past trades. For such, there should exist the autocorrelation in the series. The p-values of LB tests for returns series of lumber price are less than 1% suggesting rejection the null hypothesis of no autocorrelation in the series. These results suggest that today’s returns can be explained by the past period returns. Further, this study finds that returns (including squared returns), are highly correlated, suggesting the appropriateness of using ARCH/GARCH approaches to model conditional volatility of the return series.

To isolate the “new” information contained in the two reports, the study collects “what economists at major banks and brokerages are predicting those numbers will be” prior to the announcement from Bloomberg and use the median forecasts as the proxy for the market consensus view on the two housing market statistics. Chen, Jiang, and Wang (2013) document the details of how Bloomberg compiles the consensus forecasts and show that the forecasts are slightly more accurate and more consistent with the market consensus view than another widely-used forecast.[1] The Bloomberg forecasts have been widely used in the literature to measure the market consensus view for key macroeconomic statistics. Specifically, we calculate the surprises of the two reports as:

$$E_t^{HS} = HS^{actual} - HS^{forecast} \quad (2)$$

$$E_t^{NHS} = NHS^{actual} - NHS^{forecast} \quad (3)$$

Figures 3 and 4 plot the actual and forecasted housing starts and new home sales data, as well as their percentage differences throughout the sample period. Similar patterns are seen for the two housing market statistics. Both series increased gradually at the beginning of the sample period and peaked in the first half of 2006, after which their values quickly plummeted, before hitting the lowest values in early 2009. The two housing market statistics have since rebounded from the aftermath of the housing bubble and financial crisis, although their values are still significantly lower than the pre-crisis levels. As is also obvious from Figure 4, the market consensus forecasts closely track the actual numbers of housing starts and new home sales. Several large surprises do exist, with the most notable one in March 2009.

[1] The Bloomberg survey on key economic statistics is often distributed to a list of economists and practitioners a month prior to the scheduled announcement date, and the survey subjects can update their estimates as often as they like until the week prior to the announcement. Bloomberg then publishes the median estimates for the upcoming announcement in the week prior to the scheduled release date.

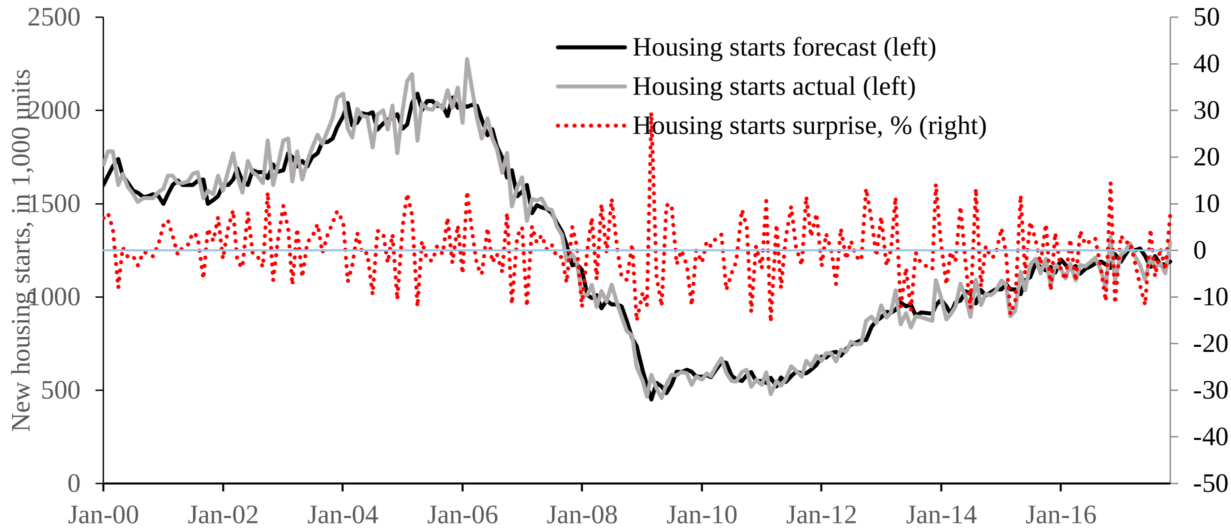

Figure 3: Housing Starts in the U.S.: Forecast vs. Actual Values, 2000-2017

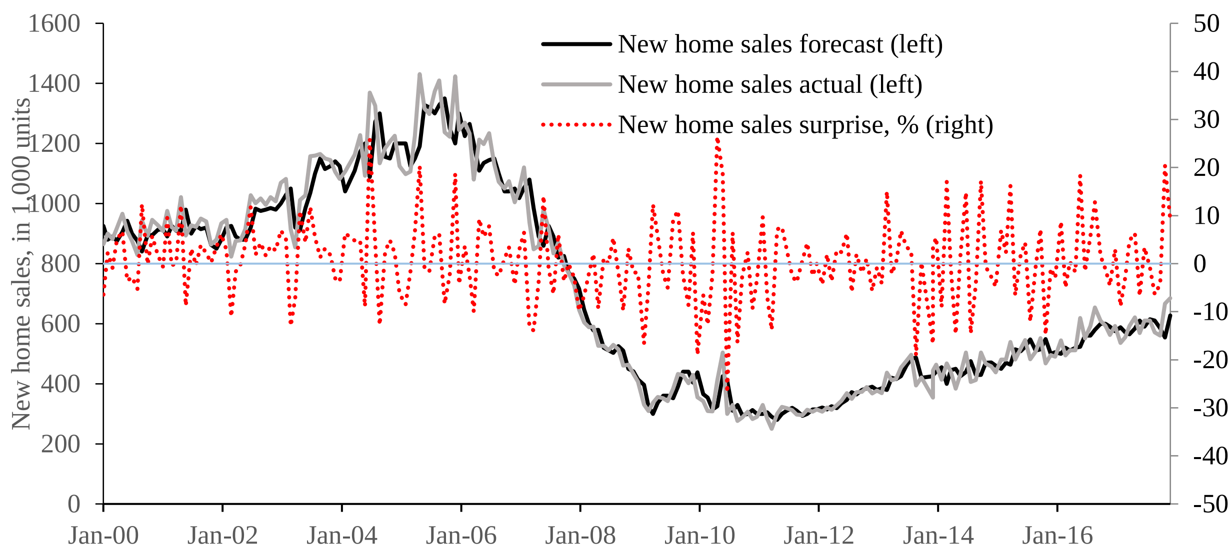

Figure 4: New Home Sales in the U.S.: Forecasted vs. Actual Values, 2000-2017

Table 2 shows the difference in the various mean returns for reporting and non-reporting days. Building further, the Welch t-test[2] which is simply two samples t-test for unequal variance is used. There are 214 instances of reporting day in our sample from Jan 2000 until Nov 2017. Since these reports are not released on the same day, 428 different instances of reporting days are available. The average of daily returns for the housing start announcement is - 0.169% while average daily returns of housing start non-reporting days are 0.013%.

Table 2: Returns on Report and Non-Report Days.

		obs.	Average r	Average of |r|	Average of r-squared
Housing Starts Only					
	Report days	214	-0.169	1.543	3.781
	Non-report days	4303	0.013	1.486	3.884
	T-test statistic for equal mean		1.335 *	-0.679	-.285
New Housing Sales Only					
	Report days	214	-0.081	1.317	2.936
	Non-report days	4303	0.009	1.497	3.926
	T-test statistic for equal mean		0.737	2.324**	2.824
Both reports combined					
	Report days	428	-0.125	1.43	1
	Non-report days	4089	0.018	1.495	0.05
	T-test statistic for equal mean		1.521 *	1.102	-286.706

Note: *, ** and *** represents a 10%, 5% and 1% level of significance.

[2] The ADF test shows the series is stationary therefore, the variance between two sample should be same. Hence the results of Welch t-test is same as the regular t-tests.

Similarly, the average of daily returns for the new home sales announcement is -0.081% while average daily returns of new home sales non-reporting days are 0.009%. The average returns of reporting days (both) are -0.125% while non-reporting days is 0.018%. To pronounce the effect of asymmetric information or volatility clustering absolute daily returns and the square of the daily returns are used. Compared to the former, the later amplifies asymmetric information or volatility clustering. However, the finding shows a t-stat less than the absolute value of 3.0, suggesting these differences in the mean level are statistically insignificant, or statistically zero in 1% significant level.

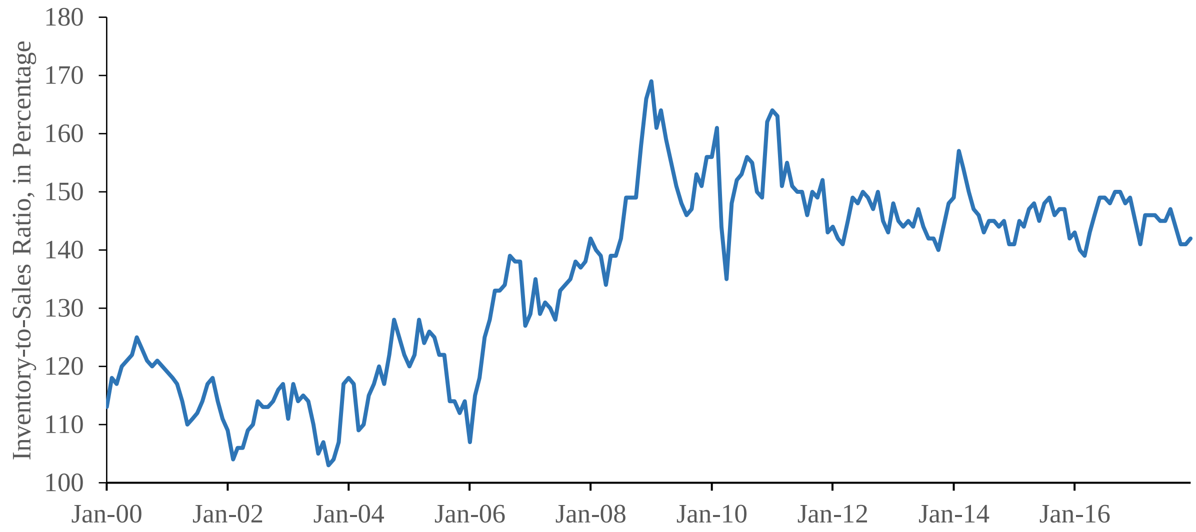

Figure 5: Seasonally Adjusted Sales-to-Inventories Ratio, 2000-2017

A final variable considered in the analysis is the level of inventory, which reflects the current availability of lumber for immediate withdraw and indicates the tightness of the supply and demand balance. Karali and Thurman (2009) use the Lumber, and other construction materials inventory series from the Monthly Wholesale Trade reports published by the U.S. Census Bureau as a measure of lumber inventory. Unlike Karali and Thurman (2009), this study uses the seasonally adjusted inventory-to-sales ratio of Lumber and other construction materials from the same data set. Scaling the inventory with sales provide a normalized measure of inventory. To match the frequency of the return series, t the monthly inventory data is converted to daily data using a cubic spline following Karali and Thurman (2009). The inventory-to-sales ratio is plotted in Figure 5. Note that a level of 100 in Figure 5 indicates that the amount of inventory is equal to the amount of sales for that particular month.

As can be seen in the figure, the ratio was consistently above 100% during the sample period. Starting from 2006, the inventory level had been largely trending upward, most likely due to the decreased demand for lumber from the housing market bubble collapse. In recent years, the inventory ratio has slightly declined. Building on this data, the following chapter will explore empirical strategies.

Chapter 4. Empirical Strategies

Whereas the previous chapter looks at data relating to public announcements and lumber prices, this chapter will evaluate potential and empirical strategies for mapping the asymmetric effect of news to the lumber returns.

Given the high autocorrelation commonly present with financial time series data, which also detected for the lumber market in the previous section, the return of lumber prices is specified as an autoregressive model of order K, as in equation (4):

$$R_t = c + \sum_{k=1}^{K} \varphi_k R_{t-k} + \epsilon_t \qquad (4)$$

where R_t is close-to-close returns, ϵ_t is the error term, φ_k's are the autoregressive coefficients to be estimated, and c is the constant of the regression. The lag order is chosen by minimizing the Akaike information criteria (AIC) while ensuring that the error terms are not autocorrelated.

A common feature of financial time series data is volatility clustering. This salient pattern can be easily seen in Figure 3 for lumber futures price returns, where, substantial changes in prices are observed consecutively around 2008, and relatively small price fluctuations are observed between 2000 and 2002. Generalized Autoregressive Conditional Heteroscedasticity model (GARCH), hence, is used to estimate the conditional volatility equation. Specifically, the error term in Equation (4) can further be written as in Equation (5):

$$\epsilon_t = h_t z_t,$$

$$h_t^2 = \pi + \sum_{p=1}^{P} \gamma_p h_{t-p}^2 + \sum_{q=1}^{Q} \alpha_q \, \epsilon_{t-q}^2 \qquad (5)$$

where z_t follows an identically and independently distributed standard normal process, α_q is the ARCH coefficient indicating the effect of lagged innovation (past news) on conditional volatility, and γ_p indicates the persistence in conditional volatility (GARCH effect). As the sum of γ_p's and α_q's gets closer to one, it takes longer for a shock to dissipate.

Since the primary goal of the present analysis is to determine the value of public reports by investigating how they affect the volatility of lumber prices, the GARCH specification is extended in Equation (5) in two ways. First, if the public report indeed contains information that would change market participants' decisions and alter the prevailing market price, then the conditional volatility should be higher on the report release dates than non-announcement days. Additionally, the theory of storage by Working (1949) posits that for storable commodities, there exists an implied return on holding inventories, i.e., the ability to quickly meet unexpected demand or supply shocks when having the physical commodity in stock. This implied return is often referred to as the convenience yield of stocks (Working, 1949). Previous research often finds that convenience yield is inversely correlated with the level of inventory, and that the relationship is often non-linear (i.e., the Working's curve).

Therefore, the theory of storage suggests that price fluctuations in response to exogenous shocks should vary with the level of inventory, and that during periods of low stocks, large price variations can arise due to an otherwise minor shock. Consequently, interaction terms have been created, between the news announcement variables and inventories. These terms, then, determine the differential effects of the two reports in periods of low and plentiful physical stocks, as in Equation (6):

$$h_t^2 = \pi + \sum_{p=1}^{P} \gamma_p h_{t-p}^2 + \sum_{q=1}^{Q} \alpha_q \, \epsilon_{t-q}^2 + \theta S_t + \beta_1 D_{1t} \\ + \beta_2 D_{2t} + \delta_1 D_{1t} * S_t + \delta_2 D_{2t} * S_t \tag{6}$$

where D_{1t} and D_{2t} are dummy variables equaling one if on date t, the housing starts report or the new home sales reports are released and zero otherwise. S_t indicates the level of inventory in the lumber market on date t. A positive and significant β_1 suggests that the housing starts data indeed increases the conditional volatility in lumber market, while under the null hypothesis ($\beta_1 = 0$) the volatility remains the same for both the announcement and non-announcement dates.

Anecdotal evidence suggests that market prices respond to positive and negative news rather differently (De Goei and Marquering, 2006). To differentiate between the positive and negative news contained in the housing starts report, a second set of dummy variables is defined , i.e., i) $D_{1t}^p = 1$ if $HS^{actual} - HS^{forecast} > 0$ and zero otherwise, and ii) $D_{1t}^n = 1$ if $HS^{actual} - HS^{forecast} < 0$. A similar set of dummy variables (D_{2t}^p and D_{2t}^n) are created for the new home sales data. The second testing equation is specified as:

$$h_t^2 = \pi + \sum_{p=1}^{P} \gamma_p h_{t-p}^2 + \sum_{q=1}^{Q} \alpha_q \epsilon_{t-q}^2 + \theta S_t + \beta_1^p D_{1t}^p + \beta_1^n D_{1t}^n + \beta_2^p D_{2t}^p + \beta_2^n D_{2t}^n$$
$$+\delta_1^p D_{1t}^p * S_t + \delta_1^n D_{1t}^n * S_t + \delta_2^p D_{2t}^p * S_t + \delta_2^n D_{1t}^n * S_t \qquad (7)$$

where the asymmetric market response to positive and negative news is confirmed if $\beta_1^p \neq \beta_1^n$ and $\beta_2^p \neq \beta_2^n$ for the housing starts and new home sales reports, respectively. Additionally, if $\beta_1^n > (<)\ \beta_1^p$ and $\beta_2^n > (<)\ \beta_2^p$, then the negative news from the two housing market reports present a larger (smaller) volatility effect than positive news.

Additionally, to account for the "day-of-the-week" effect reported in previous studies (Isengildina, Irwin, and Good 2006; Berna Karali 2011, 2012; Mattos and Silveira 2016), Friday is used as the base group and four dummy variables are incorporated for Monday through Thursday in all regression models. Given the high seasonal nature of housing construction, quarterly dummies are included to remove the seasonality in the data.

To evaluate the impact of the two housing market reports on prices, estimated coefficients are expressed in Equations (6) and (7) as a proportion of the average standard deviation of the return series. This not only allows to compare the effects across different exogenous shocks, but also provides a direct measure in terms of the percentage price change that would incur due to the two reports and their positive and negative surprises. For Equation (6):

$$\frac{\partial h_t}{\partial D_i} = \frac{\partial h_t}{\partial h_t^2} \times \frac{\partial h_t^2}{\partial D_i} = \frac{\beta_i + \delta_i S_t}{2h_t} \qquad \text{for } i = 1, 2 \qquad (8)$$

For Equation (7), the comparative statics for positive and negative surprises can be written as in Equations (9) and (10), respectively:

$$\frac{\partial h_t}{\partial D_i^p} = \frac{\partial h_t}{\partial h_t^2} \times \frac{\partial h_t^2}{\partial D_i^p} = \frac{\beta_i^p + \delta_i^p S_t}{2h_t} \qquad \text{for } i = 1, 2 \qquad (9)$$

$$\frac{\partial h_t}{\partial D_i^n} = \frac{\partial h_t}{\partial h_t^2} \times \frac{\partial h_t^2}{\partial D_i^n} = \frac{\beta_i^n + \delta_i^n S_t}{2h_t} \qquad (10)$$

Chapter 5: Estimation Results

Employing the empirical strategies reviewed in the previous chapter, the present chapter will contextualize the announcement effect of housing start and housing sales reports on lumber market volatility. Table 3 presents the estimation results based on the mean Equation (6) and the conditional volatility Equations in (6) and (7). Based on AIC, one lag is selected for the model, and the residual from the mean equation are not autocorrelated. For the conditional volatility equation, a GARCH (1,2) has more significant result than ARCH, its specification fits the data best, as it eliminates all the remaining ARCH effect in the residuals.

The left panel of Table 3 shows the estimation results for Equation (6). It appears that the release of housing starts significantly increased the conditional volatility of lumber returns, while the new home sales report does not have any statistically significant impact. Consistent with prior expectations, the effect of housing starts on the conditional volatility decreases with the inventory level, as suggested by the negative coefficient of the interaction term between inventory and housing starts. However, somewhat surprisingly, the effect of inventory by itself is not statistically significant. Volatility also tends to be the highest on Monday, and there is no statistical difference between the volatility on other weekdays. Quarterly dummies are not statistically significant, either.

The right panel of Table 3 shows the estimation results for Equation (7), which differentiates between positive and negative surprises. For housing starts, both positive and negative surprises significantly increase the volatility of lumber futures returns, though the effect of the former is much larger. The release of new home sales reports does not affect lumber market volatility when estimated using Equation (6), but when combined into one variable for both positive and negative surprises, it exerts a positive effect for positive surprises when separated into two variables. For negative new home sales news, however, the effect is statistically non-significant. The impact of news again decreases with the level of inventory, as coefficients associated with the interaction terms between inventory and reports are mostly negative. With the exception of the new home sales negative news, the interaction term is either statistically significant (housing starts positive news) or close to significant (housing starts negative news and new home sales positive).

To obtain a clearer picture of the effect of the two housing market reports on lumber market volatility and how they interact with the level of inventory, the change in the standard deviation is plotted on the report release date at different inventory levels, as shown in following Equations (9) and (10). Since the effect of the new home sales negative surprises is not significant, only the responses for positive and negative housing starts news are plotted, as well as positive new home sales news. As seen in Figure 8, positive housing starts news have the largest impact when the level of inventory is low, while the effect of positive new home sales report is the largest when the level of inventory is high. When the inventory is below 115% of the sales, positive news from the housing start report will increase lumber price by over 20%. This effect gradually decreases as the level of inventory gets larger.[3]

[3] Here, the interaction terms for the housing starts negative news and the new home sales positive surprises are close to being statistically significant. These two interaction terms are accounted for in figure 6.

Table 3: Model Estimation Results

	Coeff	Std Error		Coeff	Std Error
Mean Equation			Mean Equation		
Constant	0.001	0.026	Constant	-0.005	0.025
Lag Return	0.067	0.015	Lag Return	0.065	0.014
Volatility Equation			Volatility Equation		
C	-0.391	0.186	C	-0.357	0.172
ARCH{1}	0.067**	0.016	ARCH{1}	0.066**	0.016
ARCH{2}	-0.052**	0.016	ARCH{2}	-0.053**	0.017
GARCH	0.983***	0.003	GARCH	0.985***	0.004
Housing starts	4.362**	2.060	Housing starts +	5.159**	2.239
New home sales	0.794	2.203	Housing starts -	3.831*	2.274
Inventory	0.001	0.001	New home sales +	3.291	1.949
Inventory*Housing starts	-0.031**	0.015	New home sales -	-0.101	1.919
Inventory*New home sales	0.000	0.016	Inventory	0.002	0.001
Monday	0.333**	0.171	Inventory*Housing starts +	-0.038**	0.016
Tuesday	0.236	0.188	Inventory*Housing starts -	-0.026	0.016
Wednesday	0.244	0.181	Inventory*New home sales +	-0.022	0.014
Thursday	-0.006	0.192	Inventory*New home sales -	0.005	0.014
QTR1	-0.006	0.010	Monday	0.087	0.187
QTR2	-0.007	0.007	Tuesday	0.133	0.202
QTR3	0.005	0.009	Wednesday	0.203	0.181
			Thursday	-0.032	0.201
			QTR1	-0.005	0.009
			QTR2	-0.001	0.007
			QTR3	0.006	0.009
Q for Residual Serial Correlation	6.106		Q for Residual Serial Correlation	6.009	
McLeod-Li for Residual ARCH	7.272		McLeod-Li for Residual ARCH	5.867	

Note: *, ** and *** represents a 10%, 5% and 1% level of significance.

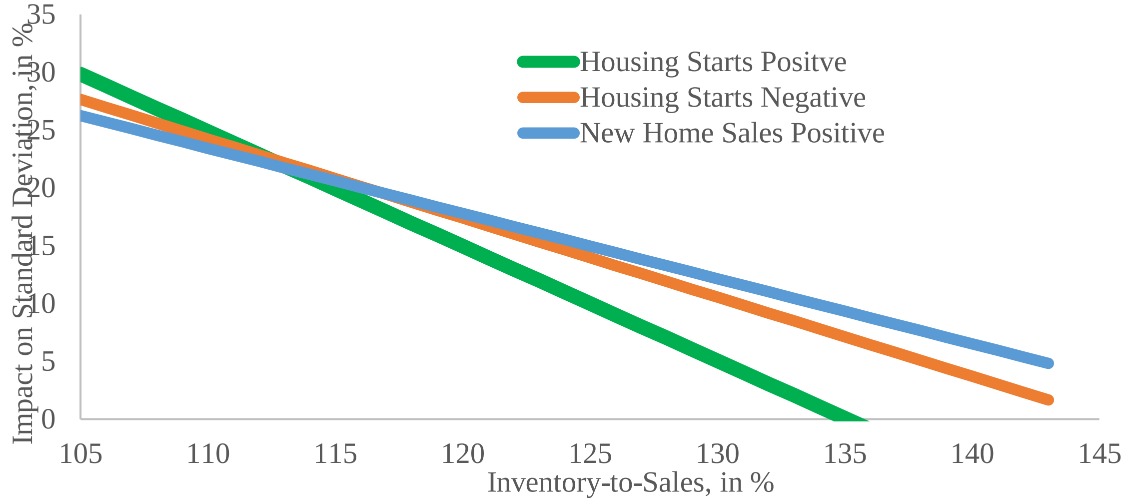

Figure 6: Impact of Positive and Negative Surprises on Lumber Market Standard Deviations, 2000-2017

Chapter 6: Conclusions

This thesis examines the impact of two housing market reports (the New Residential Construction (Housing Starts) and the New Residential Sales) on the U.S. lumber market from January 2000 to November 2017. Results suggest a high degree of volatility persistence in the lumber futures market and volatility clusters which showed the presence of ARCH process. Estimation results further suggest that the housing starts report indeed significantly affect lumber market volatility. In addition, forecast underestimation and overestimation of housing starts have different influences on lumber contract price returns. Thus, there is evidence of the asymmetric effect of volatility shocks in the lumber market, with positive shocks having a bigger impact on conditional variance. This confirms the initial research finding presented by Black (1976); Pagan and Schwert (1990).

Results show that the New Residential sales report exerts a minor impact on lumber price volatility. The effects of the two reports on volatility differs depending on the nature of the news, i.e., whether the news is positive or negative. Additionally, it was found that the impact also varies with the level of inventory. When the level of inventory is low, positive housing starts news has the largest effect on lumber volatility. Conversely, the effect of positive new home sales report has the largest when the level of inventory is high. When the inventory is below 115% of the sales, positive news from the housing start report will increase lumber price by over 20%. This effect gradually decreases as the level of inventory gets larger. Similar results were found by Karali and Thurman (2009). These findings are particular interest of commodity traders and lumber industry stakeholders because it provides the framework for maximizing benefits, while also minimizing risks.

A key insight gained from this research is the ability to understand relative importance of the different public data reports. In this research, New Residential Construction (Housing Starts) was found to have more influence on the price of lumber than the New Residential Sales. Policy makers will stand to benefit from knowing the importance of the two reports under different circumstances. As shown in Figure 6, the Housing Starts report impacts lumber price volatility if there is a positive or a negative surprise. Also, the impact on volatility changes depending upon the inventory to sales ratio. The New Home Sales report impacts lumber price volatility only if there is a positive surprise and is also impacted by the inventory to sales ratio. These results allow policy makers to have a more nuanced interpretation of the reports and also show that the inventory to sales ratio is important. The obtained results have important implications for variety of public and private market participants as announcements of public reports have direct and indirect impacts on commodity prices and returns. Potential investors in lumber market should be able to measure the immediate impact of public information releases and be aware of the risk coming from volatility in the market. Based on the empirical evidence mentioned in the literature review, commodity prices and returns have a tendency of fast reaction to public information announcements. Thus, investors and other market actors can be availed upon by investment opportunities and be able to hedge the pertinent market risks.

Looking further in research perspectives the findings and analysis of the current study provides additional insights to be considered as potential research interests. One such interest is to estimate the effect of public information for different sub-periods. This research treated the lumber price data from 2000-2017 as a single period. Future research could consider breaking this data into two periods before and after 2008 given the presence of the great recession starting in that year. In addition, it might be useful to observe the results using EGARCH instead of GARCH which considered as a good model for defining conditional variance. The comparison of parameters in both models could potentially provide information on how much either past conditional variances, or previous return values, affect future values—and show which of those values have a larger impact on future volatility.

References

Andersen, T. G., and T. Bollerslev (1997). “Intraday Periodicity and Volatility Persistence in Financial Markets.” *Journal of Empirical Finance*, 4, 115–158.

Anderson, R. W. (1985). Some determinants of the volatility of futures prices. *Journal of Futures Markets*, *5*(3), 331-348.

Anson, M. J. (2003). *Handbook of Alternate Assets* (Vol. 120). John Wiley & Sons.

Antonovitz, F., & Roe, T. (1986). Effects of expected cash and futures prices on hedging and production. *Journal of Futures Markets*, *6*(2), 187-205.

Ball, R., & Brown, P. (1968). An empirical evaluation of accounting income numbers. *Journal of Accounting Research,* 159-178.

Beechey, M., Gruen, D., & Vickery, J. (2000). *The efficient market hypothesis: a survey*. Sydney: Reserve Bank of Australia, Economic Research Department.

Belgacem, A., Creti, A., Guesmi, K., & Lahiani, A. (2015). Volatility spillovers and macroeconomic announcements: evidence from crude oil markets. *Applied Economics, 47*(28), 2974-2984.

Bera, A. K., & Higgins, M. L. (1993). ARCH models: properties, estimation, and testing. *Journal of Economic Surveys*, *7*(4), 305-366.

Binder, J. (1998). The event study methodology since 1969. *Review of quantitative Finance and Accounting*, *11*(2), 111-137.

Black, F. (1976). Studies in Stock Price Volatility Changes," Proceedings of the American Statistical Association, Business and Economic Statistics Section, 177-181.
(1986). *Noise," Journal of Finance*, *41*, 529-543.

Bodie, Z., & Rosansky, V. I. (1980). Risk and return in commodity futures. *Financial Analysts Journal*, 27-39.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, *31*(3), 307-327.

Buongiorno, J., & Balsiger, J. W. (1977). Quantitative analysis and forecasting of monthly prices of lumber and flooring products. *Agricultural Systems*, *2*(3), 165-181.

Carter, C. A. (1999). Commodity futures markets: a survey. *Australian Journal of Agricultural and Resource Economics*, *43*(2), 209-247.

Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997). *The Econometrics of Financial Markets* (Vol. 2, pp. 149-180). Princeton, NJ: Princeton University Press.

Chen, L. H., Jiang, G. J., & Wang, Q. (2013). Market Reaction to Information Shocks—Does the Bloomberg and Briefing. com Survey Matter?. *Journal of Futures Markets*, *33*(10), 939-964.

Chan, L., & Lien, D. (2003). Using high, low, open, and closing prices to estimate the effects of cash settlement on futures prices. *International Review of Financial Analysis*, *12*(1), 35-47.

Christie, A. A. (1982). The stochastic behavior of common stock variances: Value, leverage and interest rate effects. *Journal of Financial Economics*, *10*(4), 407-432.

Clem, A. (1985). Commodity price volatility: trends during 1975-84. *Monthly Labor Review*, *108*, 17.

Colling, P. L., & Irwin, S. H. (1990). The reaction of live hog futures prices to USDA hogs and pigs reports. *American Journal of Agricultural Economics*, *72*(1), 84-94.

CME Group (2009). *An Introductory Guide to Random Length Lumber Futures and Options*. retrieved from: https://www.cmegroup.com/trading/agricultural/files/AC-243_RanLenLumberBrochure.pdf

Deneckere, R., Buongiorno, J., & Bark, S. I. (1986). Optimal hedging in lumber futures markets. *Forest Science*, *32*(3), 634-642.

Dean, C.(2016). *100% Sustainable Timber Markets: The Economic and Business Case.* World Wildlife Fund retrieved from: http://assets.wwf.org.uk/downloads/wwf_business_and_economic_case_report.pdf

De Goeij, P., & Marquering, W. (2006). Macroeconomic announcements and asymmetric volatility in bond returns. *Journal of Banking & Finance*, *30*(10), 2659-2680.

Ederington, L. H., & Lee, J. H. (1993). How markets process information: News releases and volatility. *The Journal of Finance*, *48*(4), 1161-1191.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, 987-1007.

Engle, R. F., & Ng, V. K. (1993). Measuring and testing the impact of news on volatility. *The Journal of Finance*, *48*(5), 1749-1778.

Engle, R. (2004). Risk and volatility: Econometric models and financial practice. *American economic review*, *94*(3), 405-420.

Erb, C. B., & Harvey, C. R. (2006). The strategic and tactical value of commodity futures. *Financial Analysts Journal*, *62*(2), 69-97

Fama, E. F., Fisher, L., Jensen, M. C., & Roll, R. (1969). The adjustment of stock prices to new information. *International economic review*, *10*(1), 1-21. retrieved from: http://www.jstor.org/stable/2525569?origin=crossref.

Fama, E. F. (1998). Market efficiency, long-term returns, and behavioral finance1. *Journal of Financial Economics*, *49*(3), 283-306.

Fleming, M. J., & Remolona, E. M. (1999). Price formation and liquidity in the US Treasury market: The response to public information. *The journal of Finance,* 54(5), 1901-1915.

Garcia, P., Irwin, S. H., Leuthold, R. M., & Yang, L. (1997). The value of public information in commodity futures markets. *Journal of Economic Behavior & Organization*, *32*(4), 559-570.

Grunewald, O., M.S. McNulty, and A.W. Biere. (1993). Live cattle futures response to cattle on feed reports. *American Journal of Agricultural Economics*, 75, 131-137.

Halova, M. W., Kurov, A., & Kucher, O. (2014). Noisy inventory announcements and energy prices. *Journal of Futures Markets*, *34*(10), 911-933.

Hoffman, L. A., Etienne, X. L., Irwin, S. H., Colino, E. V., & Toasa, J. I. (2015). Forecast performance of WASDE price projections for US corn. *Agricultural economics*, *46*(S1), 157-171.

Hood, H. B., & Dorfman, J. H. (2015). Examining dynamically changing timber market linkages. *American Journal of Agricultural Economics*, 97(5), 1451-1463.

Howard, J. L., & McKeever, D. B. (2017). US forest products annual market review and prospects, 2013–2017. *USDA Forest Service, Forest Products Laboratory*. retrieved from: *https://www.fpl.fs.fed.us/documnts/fplrn/fpl_rn348.pdf*

Hseu, J. S., & Buongiorno, J. (1993). Price elasticities of substitution between species in the demand of US softwood lumber imports from Canada. *Canadian Journal of Forest Research*, *23*(4), 591-597.

Isengildina, O., Irwin, S. H., & Good, D. L. (2006). The value of USDA situation and outlook information in hog and cattle markets. *Journal of Agricultural and Resource Economics*, 262-282.

Isengildina-Massa, O., Irwin, S. H., Good, D. L., & Gomez, J. K. (2008a). The impact of situation and outlook information in corn and soybean futures markets: Evidence from WASDE reports. *Journal of Agricultural and Applied Economics*, *40*(1), 89-103.

Isengildina-Massa, O., Irwin, S. H., Good, D. L., & Gomez, J. K. (2008b). Impact of WASDE reports on implied volatility in corn and soybean markets. *Agribusiness: An International Journal*, *24*(4), 473-490.

Karali, B. (2007). Information and price response in storable commodity futures markets: An application to lumber contracts. retrieved from: https://repository.lib.ncsu.edu/handle/1840.16/4215

Karali, B., & Thurman, W. N. (2009). Announcement effects and the theory of storage: an empirical study of lumber futures. *Agricultural Economics*, *40*(4), 421-436.

Karali, B., & Thurman, W. N. (2010). Components of grain futures price volatility. *Journal of Agricultural and Resource Economics*, 167-182.

Karali, B. (2011). What Drives Daily Volatility in Lumber Futures Markets? *Forest Science*, *57*(5), 379-392.

Karali, B. (2012). Do USDA announcements affect comovements across commodity futures returns? *Journal of Agricultural and Resource Economics*, 77-97.

Kawai, M. (1983). Price volatility of storable commodities under rational expectations in spot and futures markets. *International Economic Review*, 435-459.

Kenyon, D., Kling, K., Jordan, J., Seale, W., & McCabe, N. (1987). Factors affecting agricultural futures price variance. *Journal of Futures Markets*, *7*(1), 73-91.

Koutmos, G., & Tucker, M. (1996). Temporal relationships and dynamic interactions between spot and futures stock markets. *Journal of Futures Markets: Futures, Options, and Other Derivative Products*, *16*(1), 55-69.

Kyle, A. S. (1985) “Continuous Auctions and Insider Trading.” *Econometrica* 53:1315–1336(Carter 1999).

Lehecka, G. V. (2014). The value of USDA crop progress and condition information: Reactions of corn and soybean futures markets. *Journal of Agricultural and Resource Economics*, 88-105.

Lewandrowski, J. K., Wohlgenant, M. K., & Grennes, T. J. (1994). Finished product inventories and price expectations in the softwood lumber industry. *American Journal of Agricultural Economics*, *76*(1), 83-93.

Lo, A. W. (2007). Efficient markets hypothesis. In L. Blume and S. Durlauf, editors, *The New Palgrave: A Dictionary of Economics*, Second Edition, 2007. New York: Palgrave McMillan.

Luppold, W., Bumgardner, M., & McConnell, T. E. (2014). Impacts of changing hardwood lumber consumption and price on stumpage and sawlog prices in Ohio. *Forest Science*, *60*(5), 994-999.

Luppold, W. G., & Prestemon, J. P. (2003). Tests for long-run relationships in hardwood lumber prices. *Forest Science*, *49*(6), 918-927.

Magill, M. J. (1984). Understanding futures markets. *Empirical*, *11*(2), 125-145.

Mandelbrot, B. (1966). Forecasts of future prices, unbiased markets, and" martingale" models. *Journal of Business*, 39(1), 242-255.

Mandelbrot, B. B. (1997). The variation of certain speculative prices. In *Fractals and scaling in finance* (pp. 371-418). Springer, New York, NY.

Martikainen, T., Perttunen, J., & Puttonen, V. (1995). On the dynamics of stock index futures and individual stock returns. *Journal of Business Finance & Accounting*, *22*(1), 87-100.

Mattos, F. L., & Silveira, R. L. (2016). Futures price response to crop reports in grain markets. *Journal of Futures Markets*, *36*(10), 923-942.

McDonald, J. G., & Fisher, A. K. (1972). New-issue stock price behavior. *Journal of Finance*, 27(1), 97-102.

Milonas, N. T. (1986) "Price Variability and the Maturity Effect in Futures Markets." *Journal of Futures Markets*, 6(1986):443– 460.

Miller, S. (1979). The response of futures prices to new market information: The case of live hogs. *Journal of Agricultural and Applied Economics*, *11*(1), 67-70.

Nagubadi, R. V., Zhang, D., Prestemon, J. P., & Wear, D. N. (2004). Softwood lumber products in the United States: substitutes, complements, or unrelated?. *Forest Science*, *50*(4), 416-426.

Pagan, A. R., & Schwert, G. W. (1990). Alternative models for conditional stock volatility. *Journal of Econometrics*, *45*(1-2), 267-290.

Ritter, M. A., Skog, K., & Bergman, R. (2011). Science supporting the economic and environmental benefits of using wood and wood products in green building construction. *General technical report FPL-GTR-206. Madison, WI: US Dept. of Agriculture, Forest Service, Forest Products Laboratory, 2011: 9 p., 206*.

Roache, S. K., & Rossi, M. (2010). The effects of economic news on commodity prices. *The Quarterly Review of Economics and Finance*, *50*(3), 377-385.

Robenstein, R. G., & Thurman, W. N. (1996). Health risk and the demand for red meat: evidence from futures markets. *Review of Agricultural Economics*, *18*(4), 629-641.

Rucker, R. R., Thurman, W. N., & Yoder, J. K. (2005). Estimating the structure of market reaction to the news: Information events and lumber futures prices. *American Journal of Agricultural Economics*, 87(2), 482-500.

Rutten, L. (1998). *The feasibility of an international tropical plywood futures contract* (No. 0301001). UNCTAD. retrieved: https://econwpa.ub.uni-muenchen.de/econ-wp/ri/papers/0301/0301001.pdf)

Samuelson, P. A. (1965). Proof that properly anticipated prices fluctuate randomly. *Industrial Management Review*, *6*(2).

Sandor, R. L. (1973). Innovation by an exchange: A case study of the development of the plywood futures contract. *Journal of Law and Economics*, *16*(1), 119-136.

Singh, B. K., & Nautiyal, J. C. (2007). An econometric analysis of markets for Canadian lumber. *Wood and Fiber Science*, *18*(3), 382-396.

Softwood Lumber Board (2017). New Report Asserts Softwood Lumber's Economic Impacts. retrieved from: https://www.softwoodlumberboard.org/wp-content/uploads/2018/02/2017_SLB_annual_report_FINAL_web_spreads.pdf

Stoll, H.R., and Whaley R.E. (1993). *Futures and Options: Theory and Applications.* Cincinnati, OH: South-Western Publishing.

Streeter, D. H., and W. G. Tomek (1992). "Variability in Soybean Futures Prices: An Integrated Framework." *Journal of Futures Marekets.,*. 12:705–728.

Summer, D. A., & Mueller, R. A. (1989). Are harvest forecasts news? USDA announcements and futures market reactions. *American Journal of Agricultural Economics*, *71*(1), 1-8. retrieved from: http://www.jstor.org/stable/1241769.

Tang, K., & Xiong, W. (2012). Index Investment and Financialization of Commodities. *Financial Analysts Journal*, 68(6), 54-74.

Thurman, W. N. (1988). "Speculative Carryover: An Empirical Examination of the U.S. Refined Copper Market." *RAND Journal of Economics,* 19(3), 420–437.

Timmermann, A., & Granger, C. W. (2004). Efficient market hypothesis and forecasting. *International Journal of Forecasting*, *20*(1), 15-27.

Tomek, W. G., & Gray, R. W. (1970). Temporal relationships among prices on commodity futures markets: Their allocative and stabilizing roles. *American Journal of Agricultural Economics*, *52*(3), 372-380.

Williams, J. C., and B. D. Wright (1991). *Storage and Commodity Markets*. London/New York: Cambridge University Press.

Wong, J. (2011). The role of lumber futures markets for forest products firms: do forest products firms take positions in lumber futures market. University of British Columbia, UBC Undergraduate Research. retrieved from: https://open.library.ubc.ca/cIRcle/collections/undergraduateresearch/52966/items/1.0075526

Working, H. (1949). The theory of price of storage. *The American Economic Review, 39*(6), 1254-1262.