Optimal Hedging Horizon for a Hog Feeding Spread (Crush) Margin

A Thesis

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Science

with a

Major in Applied Economics in the College of Graduate Studies

University of Idaho

by

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August 2017

Authorization to Submit Thesis

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Abstract

The goals of this thesis are to a) develop a graphical and mathematical analysis of an optimal hedging horizon for lean hog feeding spread, b) develop a mathematical model depicting an ideal hedging horizon for a lean hog feeding spread, and c) derive implications of the model for improving lean hog spread hedging effectiveness.

Chapter one encompasses previous research and a thesis overview.

Chapter two creates the framework for creating a lean hog input spread and examines optimal horizons for each input.

Chapter three utilizes the framework in chapter two and develops an extensive model that compares the hedging effectiveness of different horizon lengths.

Chapter four analyzes possible implications of the model on hedging effectiveness following a shock to hedging inputs.

Chapter five summarizes the results and discusses the implications of the model on hedging effectiveness.

Acknowledgements

It is with the utmost pride and gratitude that I have the opportunity to acknowledge the contributions that my committee have so graciously bestowed upon me. First and foremost I would like to thank Dr. Ekaterina Vorotnikova for being my Major Professor. I owe the completion of this thesis to her belief in me and unwavering motivation throughout my graduate studies. Ekaterina created numerous opportunities for me to extend my education and experience outside of the classroom such as competing in national case study events, attending economic research conferences, and competing in international commodity trade competitions. Ekaterina always found time to encourage me, provide insight to potential careers and opportunities, and to help build my resume throughout my time as a graduate student.

I would also like to thank Dr. Marin Bozic for allowing me to work on his research grant. This thesis would not have been possible without the contributions of Marin's research and time. Marin was always available to assist me with any research problems and his passion for his work inspired me to pursue a career in commodity analytics. I am extremely fortunate to have had the industry leader in dairy economics assist in my research.

I am also grateful for Dr. Stephen Devadoss. Dr. Devadoss began preparing me for grad school during my undergraduate studies. It was under his direction that I completed a degree in mathematics that ultimately prepared me for my success in my graduate studies, research, and finding a career. Dr. Devadoss inspired me to embark on a Master's in

Agricultural Economics and I am deeply grateful to have had the opportunity to work alongside him and witness his incredible work ethic.

Lastly, I am thankful to all the faculty in the Agricultural Economics and Rural Sociology department for being willing to provide their opinions, insight, and advice on my research as it progressed.

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Chapter 1: Introduction and Thesis Overview

1.1 Introduction to Hedging and Hedge Ratios

As many commodity prices have been testing multi-year lows at the end of 2016, the practice of hedging is as important as ever. Hedge effectiveness is generally measured by the agent's ability to offset (as closely as possible) the adverse price movements in the commodities' cash markets (produced or purchased as an input) by the changes in the futures or options contracts' prices of the those same (or closely related) commodities' by establishing positions in the futures or options markets, opposite of those in the cash markets. Previous literature assessed hedging effectiveness mostly in light of the correlation between the cash and futures market prices, which mostly relates to the basis risk.

In search for optimality in hedging, much of the existing literature analyzed price risk management procedure through the prism of the optimal hedge ratios (Rao 2002, Lien and Tse 2002, Moschinia and Myers 2002, Chan et al. 2003, Moosa 2003, Chavas and Klemme 2003, 2004, Garcia and Leuthold 2004). Some studies focused specifically on the hedge ratios for the hog industry (Kenyon and Clay 1987, Liu 2005) and some examined hedge ratio by analyzing its performance in a two-time framed scenarios: longer and shorter horizons (Ditsch and Leuthold 1996, Geppert 1995, Malliaris and Urrutia 1991). However, given that price shocks occur at various times during the production cycle, the timing of the hedge is as critical as the hedge ratio.

1.2 Hedging Horizons

Hedging horizon was usually planned (if at all) with respect to the production cycle, but since price shocks occur unexpectedly, it is important to consider the market shock dynamics when planning a hedging horizon as well. For example, if a hedge for a hog producer is placed by establishing a short position in the lean hog futures contract after a downward price shock has already occurred, the short position will not yield enough value in the price differential to offset the value lost in the cash price since the hedge is purchased already at a lower price level than if it was purchased before the downward price shock. High amplitude price shocks can happen for many reasons such as dislocations in the supply and demand dynamics, shipping and transportation challenges, changes in the market structures, currency and interest rate movements.

In addition to price shocks, another challenge producers face is when their input prices increase while their output prices decreases, which squeezes their profit margin. For example, prior to January 2010 U.S. hog industry has registered a 29 consecutive month period during which profit margins were consistently negative. The question we poise in this paper is how many months ahead of the marketing time should a hedge be placed in a hog operation in order for the hedge effectiveness not be diluted by the market shocks.

Bozic et al. (2012) have demonstrated that shocks to milk prices dissipate slowly, approximately over a period of 9 months. Which would suggest that the ideal hedging horizon for class III milk is 9 months. The implications of this study show that having shorter hedging horizons following a shock to milk prices may be inadequate to preserve short-term profitability. However, the study looks at the output price shocks only, while profit margin (crush margin) in both dairy and hog production consists of the output (milk and hog, respectively) and input prices such as corn and soybean meal.

Bozic et al. (2014) have shown that hedging horizons plays an important role in the ability of LGM-Dairy to smooth farm income over feed cost margins over time. Bozic et al. (2016) have found that the optimal hedging horizon depends on the speed of mean reversion and the critical margin threshold chosen by the producer that marks how much below the margin mean the producer is willing to accept. Both of those papers focused on the optimal horizon empirics for the profit margin itself. This paper differs from others by developing the optimal hedge horizon for each commodity involved in the hog crush, namely, corn, soybeans, and hogs as to maximize hog-crush margin by widening the difference between the inputs value and the sold finished hog value, referred to as gross feeding margin (GFM).

Bessembinder et al. (1995) analyzed the terms of futures prices and found that futures in many asset classes, especially in commodities, are mean reverting. Following his methodology, we first test whether optimal hedging horizons of the each component are mean reverting and then we test whether the optimal hedging horizons of those components are GFM improving.

1.3 Thesis Overview

The paper contributes to the literature by calculating forward hog crush margins by utilizing the independent optimal hedge horizons for corn, soybean meal, and hog hedges in a wean-to-finish hog operation. By analyzing the forward crush margins using optimal hedging horizons for each component of the crush equation, the model may be beneficial to help mitigate risk following shocks to the market price.

Another contributions of the paper is that we assess the effect of the insurance programs (Livestock Gross Margin - Swine) for the hog producers enacted by the Agricultural Act of 2014. The LGM- insurance for Swine provides swine producer with margin protection by hedging the price of corn, soybeans, and lean hogs. That is, the producers are paid coverage when the hog crush margin has decreased beyond their coverage level (UNL 2017). This study observes the effect on the optimal hedge horizons by comparing the prices and recovery of forward crush margins and each of its component: lean hogs, corn, and soybeans before and after the LGM policy was enacted.

Chapter 2 Lean Hog Spread

2.1 Gross Feeding Margin

Bozic et all (2012) analyzed the term structure of forward margins for Income Over Feed Cost Margins (IOFC) for dairy. The term structure for forward margins is the series of forward margins over consecutive months observed on a single trading day. For example a 3 month the crush margin forward term structure observed on June 24, 2015 would consist of consecutive forward prices in the days following June 24, 2015 through September 24, 2015. The forward crush margin is made up of the market's expectations for the crush components. Since the forward crush margin is composed of market expectations, then an optimal hedging horizon would be the result of the expected rate at which the market expects prices to recover from short term shocks.

We model the forward Gross Feeding Margin (GFM) for a given month prior to its realization. The Gross Feeding Margin is comprised of the value of the ween pig, soybean meal, and corn subtracted from the value of the hog at the time of marketing (Schulz 2012). We consider wean to finish hog operation where young pigs (10-50 pound) are raised to a grown live weight of 240-270 pound animals for slaughter or a lean weight of approximately 200 pounds.

The pigs require about 4 pounds of feed to gain 1 pound of mass A typical ratio for hog feed is 1 part soybean meal to 3 parts corn. Therefore, a weened hog would need to consume about 900 pounds of feed prior to being market ready or 225 pounds of soybean meal and 675 pounds of corn. Given 1 soybean meal contract is approximately 200,000 pounds and 1 contract of corn is 254,000 pounds. 1 contract of soybean meal would hedge the soybean meal input cost for about 888 hogs and 1 contract of corn would hedge the input cost of corn for 376 hogs, respectively. For simplicity the model utilizes the number of bushels of corn and weight of soybean meal in tons per hog. That is, 10 bushels of corn and .075 tons of soybean meal per hog (ISU 2012).

$$GFM = \left(2 * LHF_{T+n_1}\right) - WP_{t+5} - \left(10 * CF_{t+n_2}\right) - (.075 * SBMF_{t+n_3})$$

GFM is the gross feeding margin LHF_{T+n_1} is the futures price for lean hogs cwt. with a hedging horizon length of n_1 at the time of marketing T. LHF_{T+n_1} is multiplied by 2 to hedge a 200 pound carcass. WP_{T-5} is the estimated price of the weaned pig price at the time of marketing T. The estimated price of a weaned pig is approximately half of the futures price 5 months in advance or .5LHF_T (Schulz, 2012). CF_{t+n_2} is the price of corn per bushel at time $t + n_2$, where n_2 is the length of the hedging horizon for corn and t is the time of purchase 5 months prior to marketing, T. $SBMF_{t+n_3}$ is the price of soybean meal futures per ton at time $t + n_3$. Where n_3 is the length of the hedging horizon for soybean meal. By utilizing hedging horizons for each input and output of the crush margin, the model represents a forward crush margin for lean hogs.

2.2 Model Overview

An optimal length of hedging horizons n_1, n_2, and n_3 should be long enough for price shocks to dissipate, but short enough that any significant shift in price due to macroeconomic market conditions wouldn't be a factor in hedging at time T and t. In order for optimal horizons of length n_1, n_2, and n_3 to exist, there must be an observable rate at which spot prices revert to their mean.

Bessembinder et al (1995) analyzed margins of commodities that can leverage storage to arbitrage between cash and futures markets. When spot prices are high the slope of the term structure is negative, when the prices are low the term structure increases. That is, the regression coefficients must be uniformly negative and significant. This implies that we would expect a decrease in the slope following a price shock resulting in an increase of the price of a commodity.

To find the expected rate of mean reversion we take the daily data for corn, soybean meal, and lean hog contracts' prices for the years 2001- 2016. The data is collected from Chicago Board of Trade (CBOT) and Chicago Mercantile Exchange (CME). Basis information for lean hogs, cost of production, and feed composition are obtained from Iowa State University's Extension and Outreach (ISU Livestock Crush Margins). IMF (2012) defined a price swing as 1 standard deviation from the annual regression. Our model graphically compares each shock greater than or equal to one standard deviation between 2011 – 2017 over a 12 month hedging horizon. Since macroeconomic factors can fundamentally shift market prices, we compare each hedging horizon to its respective 3 year average.

2.3 Lean Hog Hedging Horizons

The lean hog price shocks were calculated by indexing all historical values of lean hogs that were 1 standard deviation above or below the relative 3 year average as shown in figure 1. Since historical price shocks occur in a series that may or may not revert back to the mean, each shock in the model is separated by at least 6 months of historical prices within the 1 standard deviation range as to reduce redundancies.

The 3 year average for years 2015- 2017 was 73.73 cwt. The shocks that occurred between these years are shown in blue. The model includes all shocks greater than 1 standard deviation over the 2015 – 2017. The shocks that were less than or equal to 67.91 cwt, or one standard deviation above and below the average with values of 79.54 cwt and 67.92 respectively.

Similarly the 3 year average for years 2011- 2014 was 92 cwt. The shocks that occurred between these years are shown in red. The model includes all shocks greater than 99 or 1 standard deviation over the 2011 – 2014 .The shocks that were less than or equal to 85 cwt. or one standard deviation below the 2011 – 2014 average. Figure 1 shows that most shocks to lean hogs prices dissipate within 100 days. Therefore, the optimal length of n_1 used in the model will be about 3 months such that,

$$LHF_{T+n_1} = LHF_{T+3}$$

2.4 Soybean Meal Horizons

The soybean meal horizons were calculated by indexing all historical values of corn that were 1 standard deviation above or below the relative 3 year average as shown in figure 1. Similar to the corn shocks, historical price shocks occur in a series that may or may not revert back to the mean, each shock in the model is separated by at least 6 months of historical prices within the 1 standard deviation range as to reduce redundancies.

The 3 year average for years 2015- 2017 was 338.506 per ton. The shocks that occurred between these years are shown in blue. The model includes all shocks greater than or equal to 1 standard deviation above, 387.50, and 1 standard deviation below, 289.84, the mean between years 2015 – 2017.

Similarly the 3 year average for years 2011- 2014 was $390.02 per ton. The model includes all shocks greater than or equal to 1 standard deviation above, $439 per ton, and 1 standard deviation below, 340, the mean between years 2015 – 2017. The 3 year average for years 2011 2014 was considerably higher than years 2015 – 2017.

Figure 2 shows that most shocks to soybeans dissipate within 150 days. Therefore, the optimal length of n_2 used in the model will be about 4 months such that,

$$SBMF_{t+n_3} = SBMF_{t+4}.$$

This may be indicative that an effective hedging horizon for feed input, soybean meal, is approximately 4 months A 4 month horizon is used in the final model for an optimal hedging horizon for a hog crush spread.

2.5 Corn Hedging Horizon

The shocks to corn prices were calculated by indexing all historical values of corn that were 1 standard deviation above or below the relative 3 year average as shown in figure 1. Similar to the soybean meal shocks, historical price shocks occur in a series that may or may not revert back to the mean. Each shock in the model is separated by at least 6 months of historical prices within 1 standard deviation of the mean as to reduce redundancies.

The 3 year average for years 2015- 2017 was 338.506 per contract. The shocks that occurred between these years are shown in blue. The model includes all shocks greater than or equal to 1 standard deviation above, 387.50, and 1 standard deviation below, 289.84, the mean between years 2015 – 2017.

Similarly the 3 year average for years 2011- 2014 was $390.02 per 5,000 bushels. The model includes all shocks greater than or equal to 1 standard deviation above, $439.92

per 5,000 bushels, and 1 standard deviation below, 340.12, the mean between years 2015 – 2017. The 3 year average for years 2011- 2014 was considerably higher than years 2015 – 2017.

Figure 3 shows that most shocks to corn dissipate within 120 days. Therefore, the optimal length of n_2 used in the model will be about 4 months such that,

$$CF_{t+n_2} = CF_{t+4}$$

This may be indicative that an effective hedging horizon for feed input, Corn, is approximately 4 months. A 4 month horizon is used in the final model for an optimal hedging horizon for a hog crush spread.

Chapter 3: Hog Crush Margin Using Optimal Hedging Horizons for Input

3.1 Hog Crush Margin Explained

The Hog Crush Margin is developed using the optimal hedging horizons found in Chapter 2 for each component of the Crush margin such that,

$$GFM = \left(2 * LHF_{T+n_1}\right) - WP_{t+5} - \left(13 * CF_{t+n_2}\right) - (.075 * SBMF_{t+n_3})$$

Where n1 = 3 , n2 = 4 , and n3 = 4. The robustness of the model was tested by comparing the margins of different horizon lengths post shock. Since shocks occur at different times per commodity, we will hold all commodity variables constant, except for the variable that has incurred a shock.

3.2 Comparing Horizon Lengths of Soybean on GFM Margins

We compare GFMs of different soybean horizon lengths following a shock on soybeans that occurred on June 2, 2014. During this shock, soybean prices were at a 3 year high. Figure 6 shows the GFM margin given a horizon length of 1 month, 3 months, 5 months, 8 months, greater than or equal to 9 months, and no hedging horizon.

The greatest margins were those that were 8 months or greater. Figure 6 exemplifies a direct relationship between horizon length and the GFM. Where no hedging horizon had the smallest GFM margin, followed by 1 month, 3 months etc. There was little difference between no hedging horizon and a hedging horizon of 8 months or greater. This could be because soybean prices have a relatively small effect on the GMF margin. Similarly corn had a relatively small effect on GFM margins with the longest horizons having the greatest GFMs. Figure 6 shows that utilizing optimal hedging horizons for soybeans, although marginal, could be beneficial when in a post-shock market.

3.3 Comparing Horizon Lengths of Lean Hog Shock Incurred on December 2015 Shock to GFM Margins

We compare GFMs of different lean hog horizon lengths following a shock on soybeans that occurred in December 2015. During this shock, lean hog prices were 2 standard deviations below its 3 year average price. Figure 6 shows the varying horizon lengths of Lean hogs following the shock in December 2015. GFM margin given a horizon length of 2 month, 4 months, 6 months, greater than or equal to 7 months, and no hedging horizon.

The model displays that there is little difference between the GFM of no hedging horizon and a 2 month hedging horizon. The 4 month hedging horizon is considerably larger in magnitude than both the no hedging horizon and 2 month hedging horizon. The 4 month hedging horizon is nearly 1.5 times greater on average over the 30 days following the shock. The 6 month hedging horizon is about 2 times greater than having no hedging horizon on average for 30 days following the shock. After 6 months there doesn't appear to be a consistent increase in GFM given longer horizon lengths. This could be because there may be greater uncertainty in the markets following the time frame of when the market expects the shock to dissipate.

We observed in Chapter 2 that hog prices appeared to recover from price shocks around 6 months following a shock. This trend is also exemplified in figure 7. The model shows that the spread between no hedging horizon and a 6 month hedging horizon is nearly double. There appears to be more uncertainty in the market place following the 6 month period. This could be because the market expects the price to recover within 6 months but is unsure about pricing following the shock recovery. Also, the longer the horizon following 6 months the lower the GFM margin as seen by the hedging horizon of length 12 months at lower levels than the no hedging horizon line.

3.4 Comparing Horizon Lengths of Lean Hog Shock Incurred on December 2016 Shock to GFM Margins

We compare GFMs of different lean hog horizon lengths following a shock on soybeans that occurred in December 2016. During this shock, lean hog prices were 2 standard deviations below its 3 year average price. Figure 6 shows the varying horizon lengths of Lean hogs following the shock in December 2016. GFM margin given a horizon length of 2 month, 4 months, 6 months, greater than or equal to 7 months, and no hedging horizon.

Figure 7 displays that there is a considerable difference between the GFM of no hedging horizon and a 2 month hedging horizon. The 2 month hedging horizon increases by about 30% over the course of the 30 days following the shock. The 4 month hedging horizon is considerably larger in magnitude than both the no hedging horizon and 2 month hedging horizon. The 4 month hedging horizon is nearly 1.5 times greater on average over the 30 days following the shock. The 6 month hedging horizon is about 2 times greater on average than having no hedging horizon on over the course of the 30 days following the shock.

After 6 months there doesn't appear to be a consistent increase in GFM given longer horizon lengths. Hedging horizons of 7 months and 8 months track closely with the 6 month hedging horizon. Hedging horizons of 10 months and 12 decrease to GFM levels similar to those observed in the 2 month hedging horizon and the 4 month hedging horizon lengths. This could be because there may be greater uncertainty in the markets following the time frame of when the market expects the shock to dissipate. It could also be that the market expects the prices to decrease again in one year time, in which case the shock would be a seasonality trend.

3.5 Comparing Horizon Lengths of Lean Hog Shock Incurred on January 2015 Shock to GFM Margins

We compare GFMs of different lean hog horizon lengths following a shock on soybeans that occurred in January 2015. During this shock, lean hog prices were 2 standard deviations below its 3 year average price. Figure 6 shows the varying horizon lengths of Lean hogs following the shock in January 2015. GFM margin given a horizon length of 2 month, 4 months, 6 months, greater than or equal to 7 months, and no hedging horizon.

Figure 8 displays that there is a considerable difference between the GFM of no hedging horizon and a 2 month hedging horizon. The 2 month hedging horizon remained relatively steady over the course of the 30 days following the shock. The 4 month hedging horizon is considerably larger in magnitude than both the no hedging horizon and 2 month hedging horizon. The 4 month hedging horizon is nearly 1.5 times greater on average over the 30 days following the shock. The 6 month hedging horizon is also about 1.5 times greater on average than having no hedging horizon on over the course of the 30 days following the shock. The GFM margins for hedging horizon of 4 months and 6 months are similar, with the 6 month hedging horizon having a slightly higher margin.

After 6 months there is not an increase in GFM given longer horizon lengths. Hedging horizons of length 7 months or greater had GFMs that were lower than that of the 4 month an 6 month horizon. The hedging horizons that were of length 7 months or appear to have relatively low volatility. These hedging horizons remain fairly constant over the 30 day period following the shock that incurred in January 2015 and have similar patterns given the spot prices over the 30 days following the shock.

This could be because there may be greater uncertainty in the markets following the time frame of when the market expects the shock to dissipate. It could also be that the market following this particular shock expected the shock to dissipate within 4 months but were uncertain about the behavior of lean hog prices following the recovery. The hedging horizon of length 6 months in Figure 8 has the highest GFM among the varying horizon lengths. This is consistent with the shocks incurred on December 2015 and December 2016.

Chapter 4 Examining Optimal Hedging Horizons for Shock Incurred Prior to LGM 2014.

4.1 Comparing Horizon Lengths of Lean Hog Shock Incurred on June 2011 Shock to GFM Margins

We compare GFMs of different lean hog horizon lengths following a shock on soybeans that occurred in June 2015. During this shock, lean hog prices were 2 standard deviations below its 3 year average price. Figure 6 shows the varying horizon lengths of Lean hogs following the shock in June 2015. GFM margin given a horizon length of 2 month, 4 months, 6 months, greater than or equal to 7 months, and no hedging horizon.

Figure 9 shows that there is a considerable difference between the GFM of no hedging horizon and a 2 month hedging horizon. Unlike the Figure 6, Figure 7, and Figure 8 where the GFMs observed increase as the length of the hedging horizons neared 6 months, Figure 9 shows a decline in GFM given hedging horizons of length 4 months and of length 6 months. Hedging horizons of length 7 months or greater are slightly higher than that of no hedging horizon. The 2 month hedging horizon has similar GFM margins within the first 10 days following the shock but increases to have the highest GFM towards the end of the month. The 2 month hedging horizon is considerably larger in magnitude than the no hedging horizon

The GFMs for horizon length 4 months and of length 6 months could be lower than no hedging horizon for several reasons. The months of October and December have seasonally low prices. Figure 9 shows that the market expectations following a shock 4 months and 6 months prior to the seasonally low month of October and December may be abnormally pessimistic about the recovery of the shock. Furthermore, the market may expect the price of lean hog in October and December to be lower than the seasonal average given a shock in price 6 months prior to the end of the year.

4.2 Comparing Horizon Lengths of Lean Hog Shock Incurred on September 2012 Shock to GFM Margins

We compare GFMs of different lean hog horizon lengths following a shock on soybeans that occurred in September 2012. During this shock, lean hog prices were 2 standard deviations below its 3 year average price. Figure 10 shows the varying horizon lengths of Lean hogs following the shock in September 2012. GFM margin given a horizon length of 2 month, 4 months, 6 months, greater than or equal to 7 months, and no hedging horizon.

Figure 10 displays that there is a relative small difference between the GFM of no hedging horizon and a 2 month hedging horizon. The 2 month hedging horizon displays a similar pattern in GFMs to the no hedging horizon. The 2 month hedging horizon begins to have a slightly greater GFM than the no hedging horizon the last 15 days over the course of the 30 days following the shock. The 4 month hedging horizon is about slightly larger in magnitude than both the no hedging horizon and 2 month hedging horizon. The 4 month hedging horizon is about 20% greater on average over the 30 days following the shock than the 2 month hedging horizon. The 6 month hedging horizon is about 2 times greater on average than having no hedging horizon over the course of the 30 days following the shock.

After 6 months there doesn’t appear to be a consistent increase in GFM given longer horizon lengths. Hedging horizons of 7 months and 8 months track closely with the 6 month hedging horizon. Hedging horizon of length 11 months is below the hedging horizon of length 6. This could be because there may be greater uncertainty in the markets following the time frame of when the market expects the shock to dissipate. It could also be that the market expects the prices to decrease again in a year's time, in which case the shock would be a seasonality trend.

Chapter 5 Results and Conclusion

Chapter 5.1 Summary of Hedging Horizon Effectiveness in Lean Hogs

Given individual hedging horizons for the hog crush components, we find that GFM converges to a long term mean after about 6 months. This time frame is just about a month longer than the production cycle for hogs. That is, the rate of mean reversion is greatest within a 6 month hedging horizon before GFM pricing levels off. This could indicate that market expectations for price recovery following a shock is about 6 months.

We found that using optimal hedging horizons for all GFM components consistently produces the highest forward GFM margin within a year. We also found that the volatility of the model using optimal hedging horizons had the lowest volatility among all hedging horizons within a year. This could be indicative that the market expects the price to recover back to its mean within 6 months and uncertainty is greater after recovery. Locking in higher GFM margins with lower volatility has several risk management benefits.

We notice that mean reversion in hog production occur quicker than those in other live-stock production such as cattle or dairy industries. We believe it is directly related to the shorter production cycle. The shorter production cycle could be advantageous to the market in its recovery to price shocks as the producers are able to more quickly adapt.

The results of this paper show that utilizing the forward hedging horizons of the GFM components may lower hedging costs, improve hedging effectiveness, and, thus, enhance profit margin for hog producers. Our results show that the insurance programs (Livestock Gross Margin – Swine) may have decreased the volatility in forward GFM post shocks. The LGM-Swine policy may have also had a marginal effect on the anticipated price recovery of Lean Hogs post shock. This could be a result of increased perceived stability by the market place for producers, translating to a smoother recovery post shock.

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Figure 1

Lean Hog Recovery Post Shock Actual

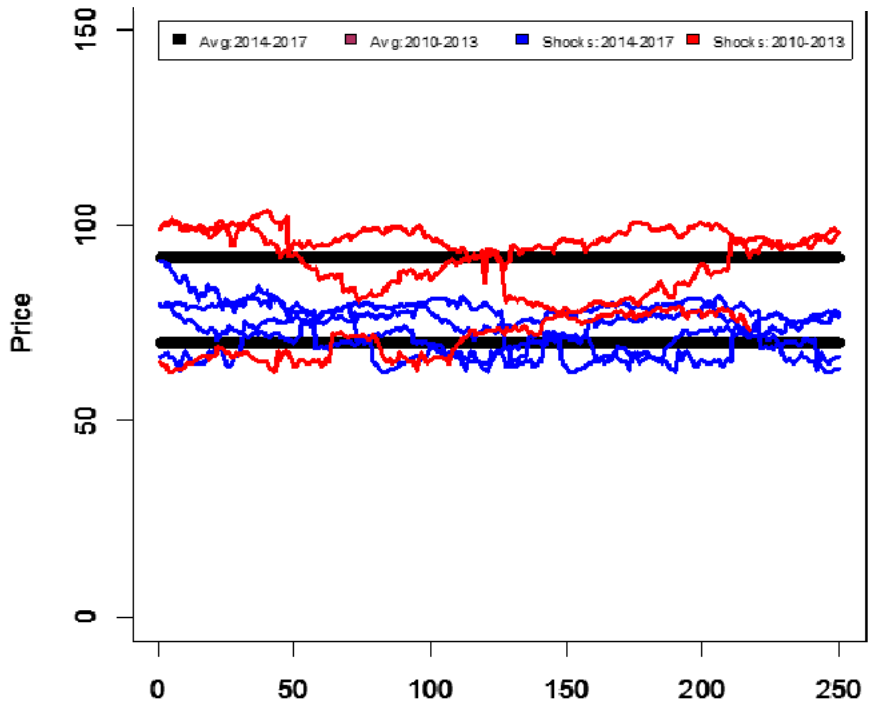

Figure 2

Soybean Price Recovery Post Shock Actual

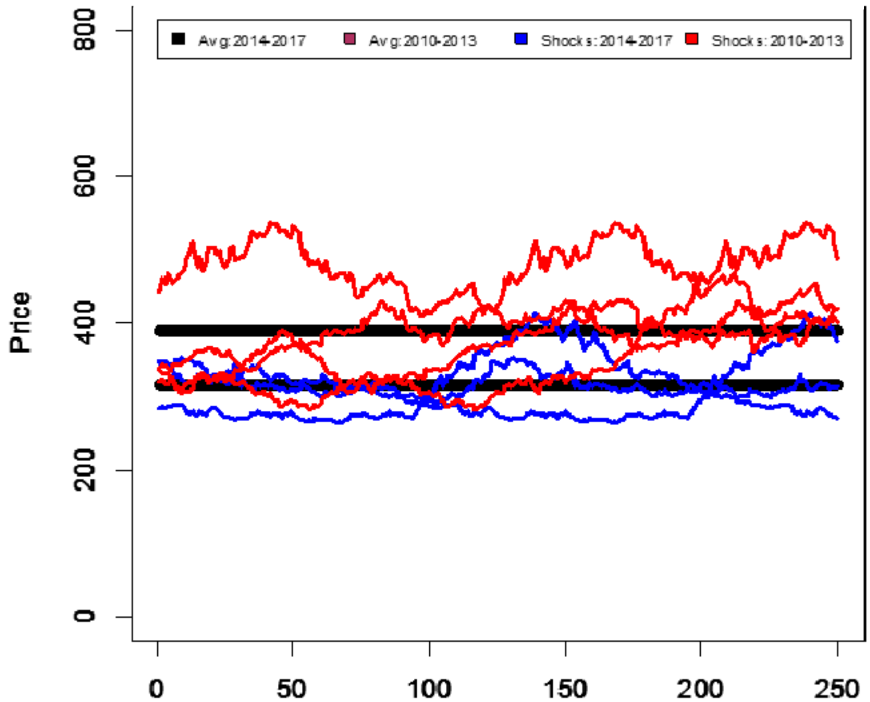

Figure 3

Price Recovery Post Shock Actual

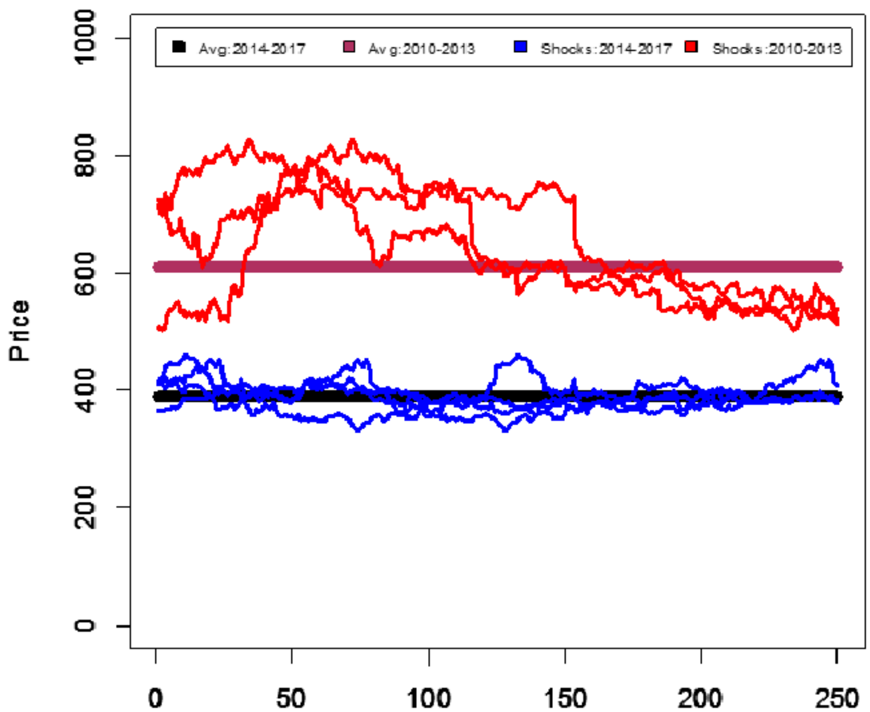

Figure 4

Price vs. Horizon Length Following Shock: Lean Hogs

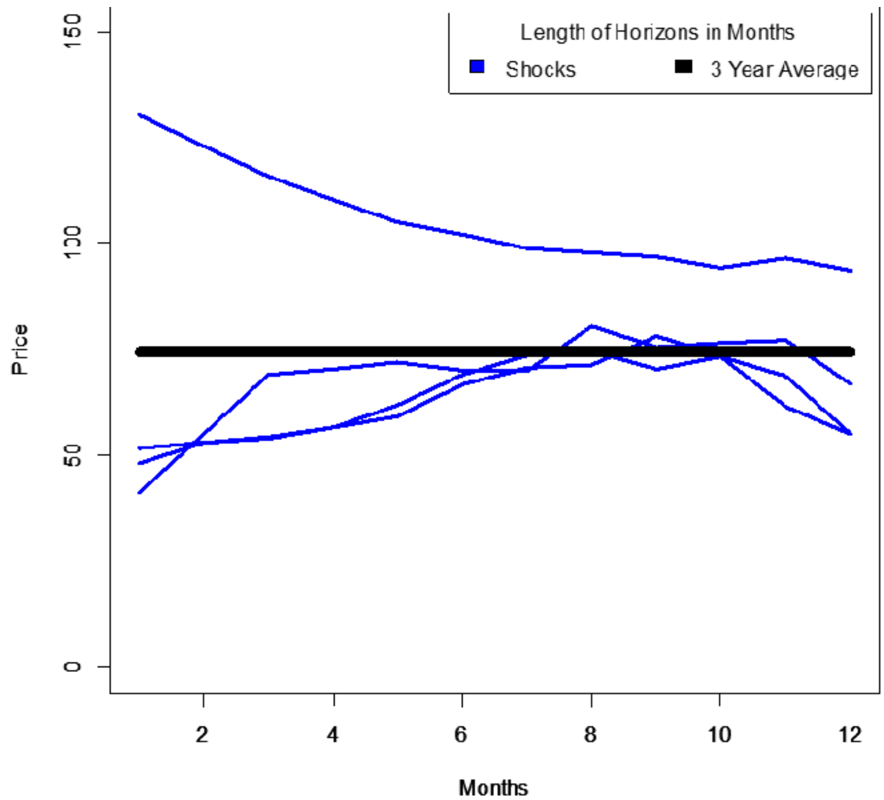

Figure 5

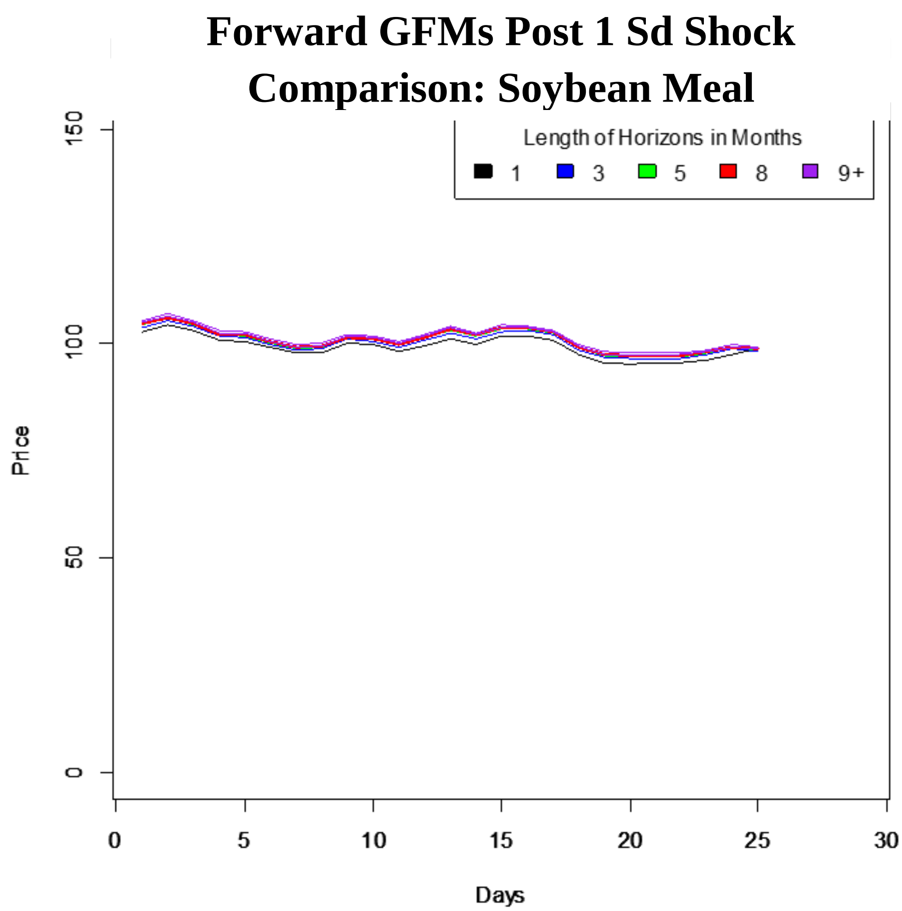
Forward GFMs Post 1 Sd Shock
Comparison: Soybean Meal
Length of Horizons in Months
1
3
5
8
9+
Price
150
100
50
0
0
5
10
15
20
25
30
Days

Figure 6

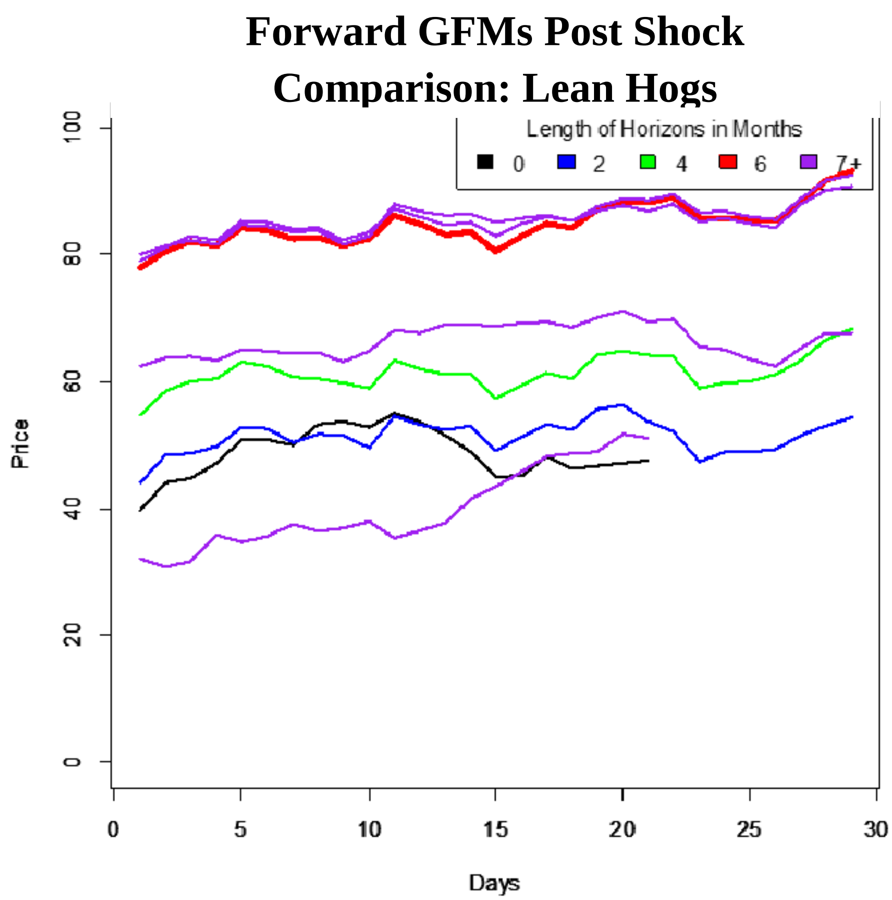
Forward GFMs Post Shock
Comparison: Lean Hogs
Length of Horizons in Months
0
2
4
6
7+
Price
Days
0
20
40
60
80
100
0
5
10
15
20
25
30

Figure 7

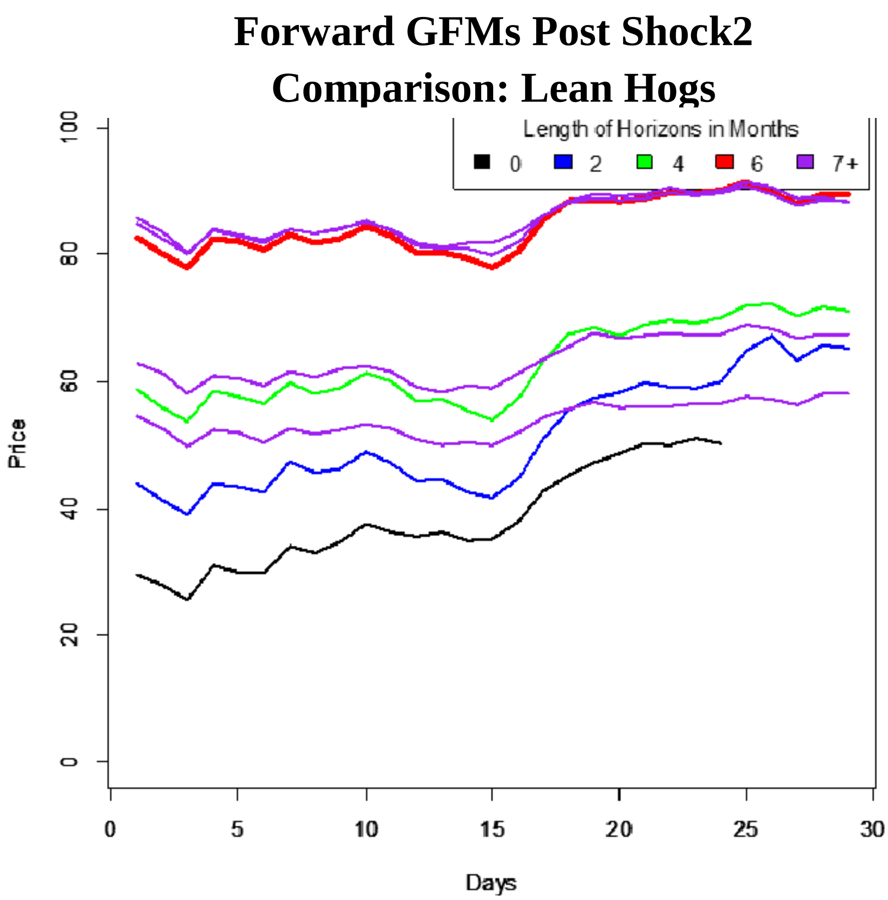
Forward GFMs Post Shock2
Comparison: Lean Hogs
Length of Horizons in Months
0
2
4
6
7+
Price
Days
0
20
40
60
80
100
0
5
10
15
20
25
30

Figure 8

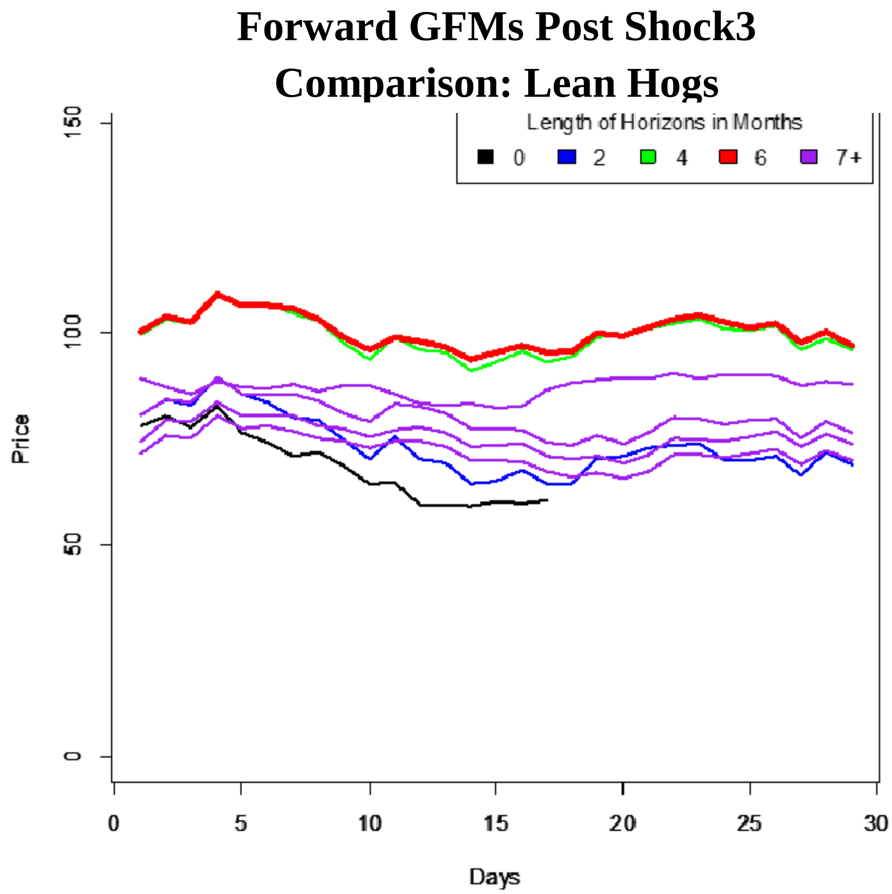
Forward GFMs Post Shock3
Comparison: Lean Hogs
Length of Horizons in Months
0
2
4
6
7+
Price
Days
0
50
100
150
0
5
10
15
20
25
30

Figure 9

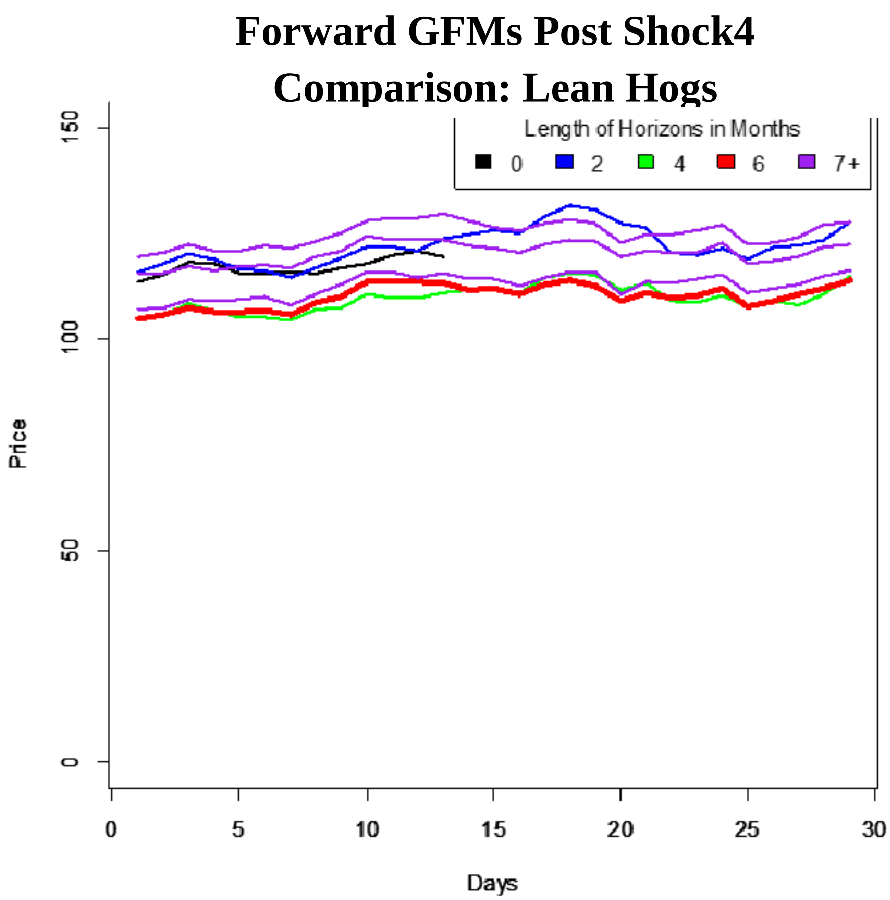
Forward GFMs Post Shock4
Comparison: Lean Hogs
Length of Horizons in Months
0
2
4
6
7+
150
100
50
0
Price
0
5
10
15
20
25
30
Days

Figure 10

Forward GFMs Post Shock5 Comparison: Lean Hogs

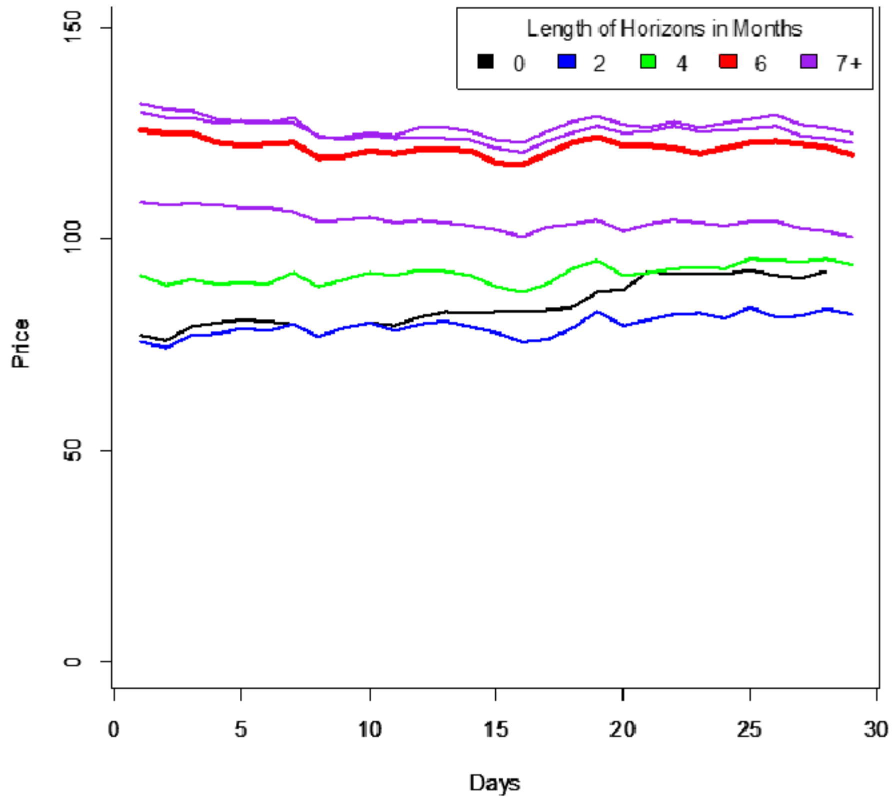

Figure 11

ANOVA

ANOVA				
Df	Sum Sq	Mean Sq	F value	Pr(>F)
Groups: 5	3944.8	788.95	3.6308	0.007255 **
Residuals: 48	10430.2	217.30		

Figure 12

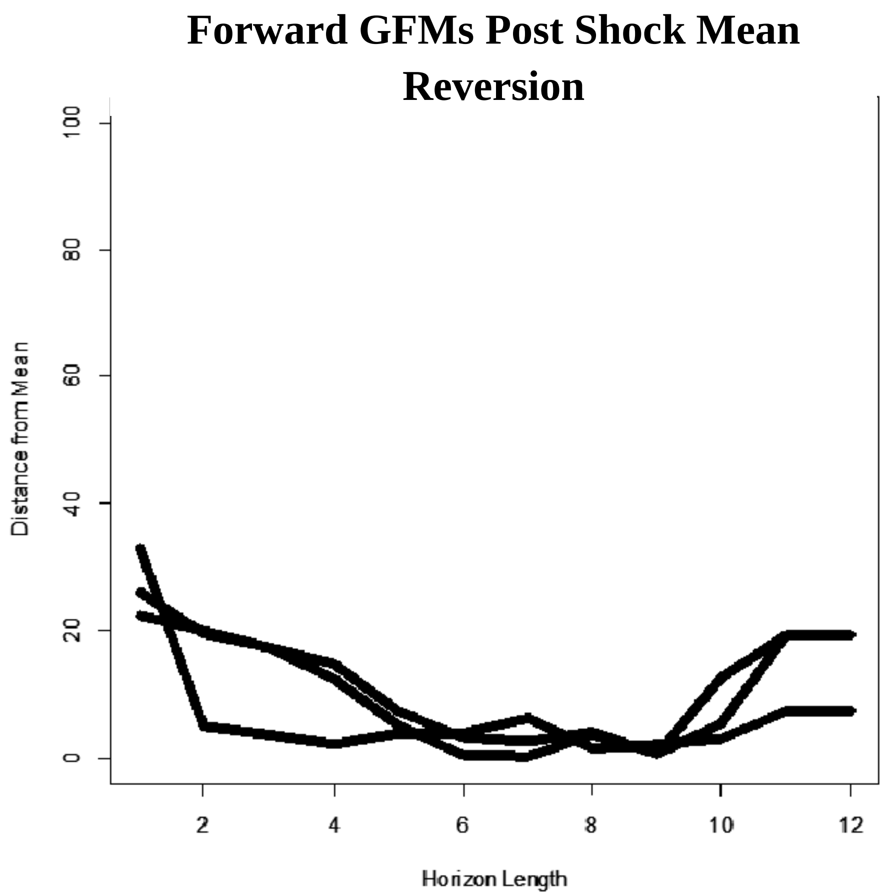
Forward GFMs Post Shock Mean
Reversion
Distance from Mean
0
20
40
60
80
100
2
4
6
8
10
12
Horizon Length

Figure 13

Analysis of Variance Post Shock 1

Horizon Length in Months	Mean Variance	mean S.D.
0	44.71	6.686554
2	45.35	6.734241
4	22.98	4.793746
6	15.03	3.876854
8	11.54	3.397058
10	11.34	3.367492
12	21.67	4.655105

Figure 14

Analysis of Variance Post Shock 2

Horizon Length in Months	Mean Variance	mean S.D.
0	44.71	6.686554
2	45.35	6.734241
4	22.98	4.793746
6	15.03	3.876854
8	11.54	3.397058
10	11.34	3.367492
12	21.67	4.655105

Figure 15

Bartlett's Test Post Shock 1

Bartlett's Test	K-Squared	df	P-Value	Chi Square
All Forward Contract Months	62.84	8	1.288e-10	15.507
≥ 6 Month Horizon	2.8283	4	.587	9.487

Figure 16

Bartlett's Test Post Shock 2

Bartlett's Test	K-Squared	df	P-Value	Chi Square
All Forward Contract Months	47.684	9	1.135 e-07	16.918
≥ 6 Month Horizon	.79945	4	.9385	9.487