A Case Study on Risk Management: Lessons from the Collapse of Amaranth Advisors L.L.C.

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The speculative activities of hedge funds are a hot topic among market agents and authorities. In September 2006, the activities of Amaranth Advisors, a large-sized Connecticut hedge fund sent menacing ripples through the natural gas market. By September 21, 2006, Amaranth had lost roughly $4.942 billion over a 3-week period or one half of its assets primarily due to its activities in natural gas futures and options in September. On September 14 alone, the fund lost $681 million from its natural gas exposures. Shortly thereafter, Amaranth funds were being liquidated. This paper uses data obtained by the Senate Subcommittee on Investigations through their subpoena of Amaranth, the New York Mercantile Exchange (NYMEX), the Intercontinental Exchange (ICE), and other sources to analyze exactly what caused this spectacular hedge fund failure. The paper also analyzes Amaranth's trading activities within a standard risk management framework to understand to what degree reasonable measures of risk measurement could have captured the potential for the dramatic declines that occurred in September. Even by very liberal measures, Amaranth was engaging in highly risky trades which (in addition to high levels of market risk) involved significant exposure to liquidity risk – a risk factor that is notoriously difficult to manage.

I. Introduction

In September, 2006, a large-sized hedge fund named Amaranth Advisors LLC lost $4.942 billion in natural gas futures trading and was forced to close their hedge fund.[1] Although Amaranth Advisors was not exclusively an energy trading fund, the energy portion of their portfolio had slowly grown to represent 80% of the performance attribution of the fund (Source: Senate Subcommittee Exhibit #12). Their collapse was not entirely unforeseeable or unavoidable. Amaranth had amassed very large positions on both the New York Mercantile Exchange (NYMEX) and the Intercontinental Exchange (ICE) in natural gas futures, swaps, and options. The trades consisted mainly of buying and selling natural gas futures contracts with a variety of maturity dates. Their trades

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[1]These losses are computed as the actual change in net asset value of the Amaranth funds, including the Amaranth LLC fund, Amaranth Partners fund, and Amaranth Global Equities Master fund from Exhibit #12 of the Senate Subcommittee documents. The value of these funds was $10,228,192,000 on August 31, 2008 and $5,286,050,000 on September 21, 2006. These total net asset values do not include the Amaranth Securities LLC, which had a smaller amount of around $30-50 Million since the data was not available.

were very risky from both a market risk perspective and a liquidity perspective.

Since the collapse of Amaranth, several authors have attempted to understand what positions and risk levels Amaranth was engaged in to cause such a dramatic collapse (Chincarini, (2006) and Till, (2006). Chincarini (2006) used the information from newspapers, CEO statements, and actual natural gas futures data to quantify the nature of the most likely trades that were made at Amaranth. That paper hypothesized that Amaranth had engaged in a short summer, long winter natural gas trade primarily using natural gas futures. Based on these backward-engineered positions, the paper examined both the market and liquidity risk of Amaranth's positions prior to its collapse.

On June 25, 2007 the Committee of Homeland Security and Government Affairs released a document containing a detailed investigation of the Amaranth scandal entitled "Excessive Speculation in the Natural Gas Markets." The U.S. Senate Permanent Subcommittee on Investigations used its subpoena power to analyze the trading records at the NYMEX, the ICE, as well as the trades of Amaranth and other traders. It also conducted numerous interviews with natural gas market participants, including natural gas traders, producers, suppliers, and hedge fund managers, as well as exchange officials, regulators, and energy market experts.

In this paper, we make extensive use of the Amaranth trading positions derived from the actual Amaranth trading data. This data was obtained under subpoena by the Senate Subcommittee. We also discuss the risks associated with the trades Amaranth made and what risk managers should do to avoid these risks in the future. The rest of the paper is as follows: Section II discusses the background of the firm Amaranth Advisors L L C; Section III discusses the natural gas futures market and details the basics of typical spread trades to help the reader appreciate the more complicated Amaranth trading strategies; Section IV discusses Amaranth's actual trading positions on August 31, 2006 and in other periods; Section V analyzes the market and liquidity risks inherent in Amaranth's natural gas positions; Section VI discusses lessons for regulators and risk managers, and Section VII provides a conclusion.

II. Background

A. Amaranth Advisors, L.L.C.

Amaranth Advisors L.L.C. was a hedge fund operating in Greenwich, Connecticut.[2] The hedge fund was launched in 2000 as a multi-strategy hedge fund, but had by 2005-2006 generated over 80% of their profits from energy trading (Source: Senate Subcommittee Exhibit #12). This section provides a very brief summary of Amaranth. (For additional information, please see a more detailed version of this section on the *Journal of Applied Finance*, JAF, website: www.fma.org/jaf.htm).

1. The Management

The management consisted of several seasoned professionals. The most relevant to the natural gas futures disaster was Mr. Brian Hunter. Hunter joined Amaranth in 2004.[3] He was hired by Mr. Maounis and Mr. Arora, a former Enron trader who had established Amaranth's energy and commodities trading desk. Prior to this, he had worked at TransCanada Corporation, a Calgary pipeline company, where he began getting a name for himself in energy trading. While there, he was able to find mispricing in energy options, which helped the firm make profits. After this, Hunter moved to Wall Street to work for Deutsche Bank on the energy desk. While there, his positions in natural gas futures caused large fluctuations in profit and loss.

In the summer of 2005, Hunter threatened to leave Amaranth, partly because he disliked his compensation structure and did not wish to report to Arora. Maounis reacted by allowing Hunter to trade a book separate from Arora. Also, his share of the operating profits eventually were increased from 7.5% to 15%. Hunter made a name for himself on Wall Street when he helped Amaranth make $1 billion in profits in 2005. Due to his trading success in 2005, Hunter was rumored to have been compensated between $75 million and $100 million. Late in 2005, Hunter was also allowed to return to his hometown of Calgary and trade from there. Eventually, his four other natural gas traders migrated from Greenwich to Calgary.[4]

2. The Strategies and Fund Structure

Amaranth began as a multi-strategy hedge fund, but by 2006 had become dominated by its energy portfolio. The principal fund, with $8.394 billion of capital at the end of August 2006, was the Amaranth L.L.C. fund. The multi-strategy portfolio consisted of trades in the following areas: Energy Arbitrage and Other Commodities, Convertible Bond Arbitrage, Merger Arbitrage, Credit Arbitrage, Volatility Arbitrage, Long/Short Equity, and Statistical Arbitrage. Amaranth's exposure to these

[2] Many thanks to Dan Berkovitz for providing the information upon which much of this section is based. This section draws heavily from Exhibit #12 of the Senate Subcommittee Investigations. In addition to their Greenwich office, Amaranth had been working on expanding their operations and had offices in London, Singapore, Houston and Toronto.

[3] Most of this discussion is based upon an article in the Wall Street Journal entitled "How Giant Bets on Natural Gas Sank Brash Trader." and FERC Docket No. IN07-26-000.

[4] These other natural gas traders on his team were Mr. Matthew Donohoe, Mr. Matthew Calhoun, Mr. Shane Lee, and Mr. Brad Basarowich.

various strategies changed dramatically over the years prior to September 2006. For example, at Amaranth's inception, 60% was devoted to convertible arbitrage, whereas by September 2006 only 2% was devoted to this strategy. Over 86% of their performance in 2006 was due to energy and commodity related trades. In addition to this, Amaranth had no stop limits and no concentration limits, which allowed the fund to concentrate more towards energy by the end of August 2006. There were no leverage restrictions within the firm. Style drift was evident with this multi-strategy fund.[5]

A combination of liquidity and funding risk ultimately caused Amaranth's collapse.

Amaranth's capital came from a variety of investors: About 60% came from fund-of-funds, about 7% from insurance companies, 6% from retirement and benefit programs, 6% from high net worth individuals, 5% from financial institutions, 2% from endowments, and 3% was insider capital.

Minimum investments in Amaranth were $5 million. The management fee was 1.5% and the incentive fee was 20%. A high water mark was also employed.[6]

3. Risk Management and Liquidity Management

The Chief Risk Officer of Amaranth had a goal of building a robust risk management system. Amaranth was unusual in terms of risk management in that it had a risk manager for each trading book that would sit with the risk takers on the trading desk. This was believed to be more effective at understanding and managing risk.[7] Most of these risk officers had advanced degrees.

The risk group produced daily position and profit and loss (P&L) information, greek sensitivites (i.e. delta, gamma, vega, and rho), leverage reports, concentrations, premium at risk, and industry exposures. The daily risk report also contained the following:

1. Daily value-at-risk (VaR) and Stress reports. The VaR contained various confidence levels, including one standard deviation (SD) at 68% and 4 SD at 99.99% over a 20 day period. The stress reports included scenarios of increasing credit spreads by 50%, contracting volatility by 30% over one month and 15% for three months, 7% for six months, and 3% for twelve months, interest rate changes of 1.1 times the current yield curve. Each strategy was stressed separately, although they intended to build a more general stress test that would consolidate all positions.

2. All long and short positions were broken down. In particular, the risk report listed the top 5 and top 10 long and short positions.

3. A liquidity report that contained positions and their respective volumes for each strategy was used to constrain the size of each strategy.

The risk managers also calculated expected losses for the individual positions. The firm had no formal stop-losses or concentration limits. Amaranth took several steps to ensure adequate liquidity for their positions. These steps are listed on the more detailed version of this section on the FMA website.

B. Events in September

The price movements of natural gas futures in September 2006 were quite different than in past years. Figure 1 shows a timeline of the events in September and leading up to September. Historically, a spread trade strategy in natural gas futures had done quite well. Figure 2 shows the average returns of different maturity futures contracts in the month of September from 1990 through 2005. The x-axis plots the contract months forward. Thus, in this particular graph, "1" represents the returns for the nearest October futures during September, "2" represents the returns for the nearest November contract in September, and so on. One can see that generally, winter month returns are higher than non-winter month returns and that natural gas prices have tended to rise on average in September for the first 36 months out. Some of the near contracts had returns as high as 5.73% on average in September.

In September 2006, the natural gas futures market behaved entirely differently than it had historically. Figure 3 shows the behavior of natural gas futures returns in September 2006. One can see, from this figure, the dramatic negative returns in September, which were as low as -27% for front-month

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[5] Style drift refers to a change in a hedge fund's strategy over time which may or may not reflect a formal change in policy, hence the "drift". An example would be a Large-Cap hedge fund manager that suddenly has huge small-cap exposure. Most of the time style drift happens inadvertently, but in Amaranth's case, they were clearly increasing energy exposure.

[6] A high water mark is a common feature of most hedge funds. It is a level of the fund's net asset value (NAV) at which incentive fees begin to accrue. Typically, the high water mark is the highest NAV received by the client over their investment period. The purpose of the high water mark is to prevent a double counting of incentive fees. For example, if the fund went from 100 to 200 NAV, the hedge fund would obtain a percentage of that appreciation as an incentive fee. However, if the fund dropped to 150 the following year, they would not receive an incentive fee for bringing it from 150 to 200. Their incentive fees would only begin again for gains above 200.

[7] One might ask whether this system is indeed optimal. It could perhaps cause risk managers to become more integrated in the trading style and not be as objective in assessing risk. Regardless of one's beliefs in such a system, Amaranth actually strayed from their system in the case of Brian Hunter. When Brian Hunter and his traders moved their trading operations to Calgary, Canada, there was no risk management team on the premises to monitor their actions.

Figure 1. Timeline of the Amaranth Collapse

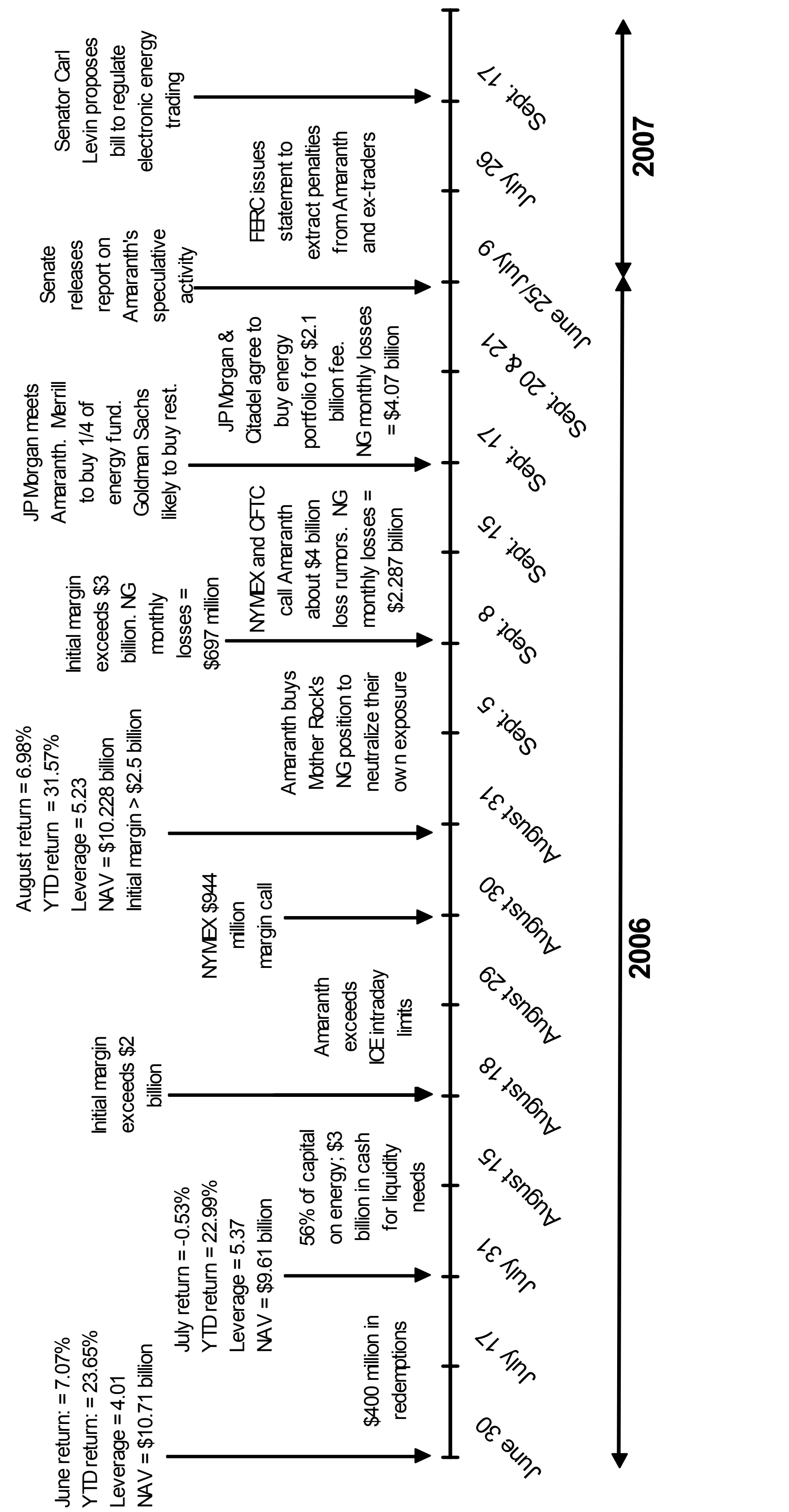


Figure 2. Historical Average Returns of Natural Gas by Contract in September (1990-2005).

Note: Since these returns are for historical contracts, the numbers represent the average return for the 1st contract out, 2nd contract out, and so on. Thus, '1' represents the nearest October contract, while '2' represents the nearest November contract, and so on up to 73 months forward. In some of the earlier years, contracts did not exist 73 months forward, in this case they were not included in the averages.

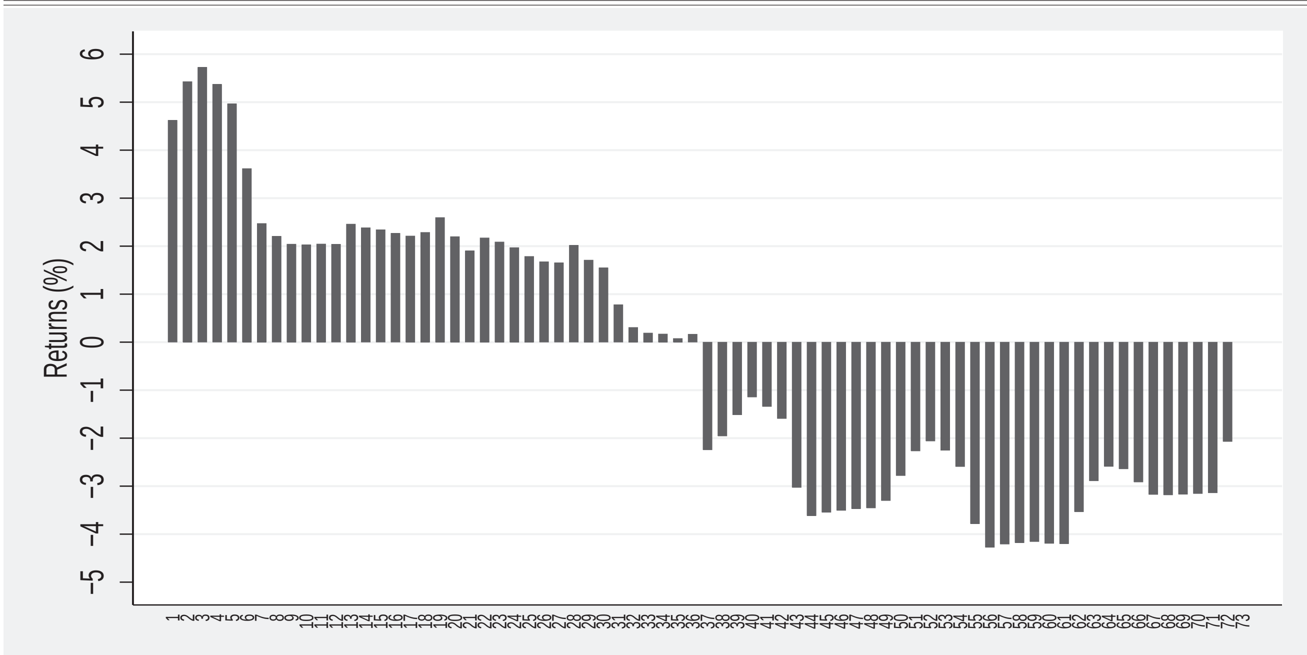
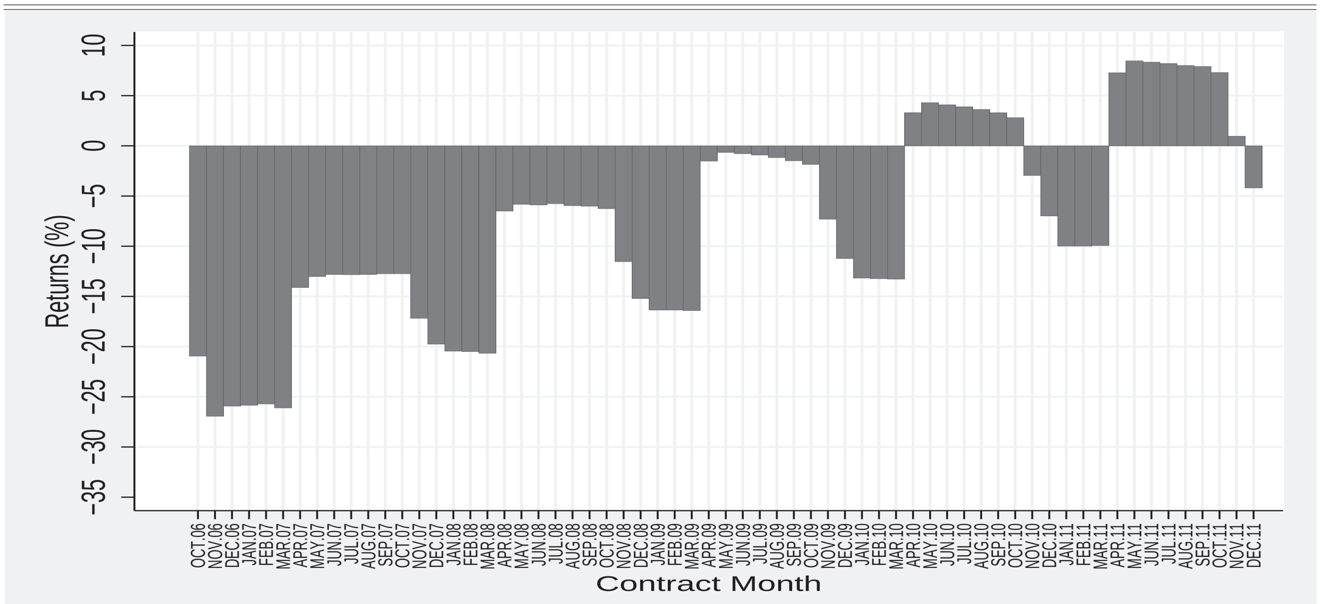


Figure 3. Natural Gas Futures Returns by Contract from August 31, 2006 - September 21, 2006



contracts.[8] One can also see that the negative returns were less for non-winter months. That is, although returns were severely negative for most natural gas futures contracts, they were worse for winter months through the maturity spectrum. For example, for the first year out the contract months 2 through 6 did poorly, representing the contracts for November 2006 through March 2007, while in months 7 through 13 the negative returns are less severe for the months April 2007 through October 2007. This pattern is seen for contracts in future years as well. This pattern would not bode well for a strategy that is long winter and short non-winter months.

Figure 4 shows the profit and loss (P/L) of Amaranth's natural gas futures equivalent positions on a daily basis in September 2006. Figure 4A shows the daily P/L , while Figure 4B shows the cumulative P/L starting at zero on August 31, 2006. The daily P/L is computed using Amaranth's actual daily positions from August 31, 2006 through September 15, 2006. After September 15, 2006, no data on their positions was available and the daily P/L was computed assuming Amaranth maintained their September 15, 2006 natural gas positions.

As shown in Figure 4B, from August 31, 2006 to September 7, 2006, Amaranth had lost about $696.9 million on their natural gas positions. This soon deteriorated very quickly. By the close of business on September 20, they had lost about $4.071 billion on their natural gas futures positions. Margin calls on these losses eventually led Amaranth to sell the energy portfolio to Citadel and J.P. Morgan with the final transfer occurring on September 21, 2006.

If one computes the losses of Amaranth's natural gas positions from August 31, 2006 through September 21, 2006, assuming the positions were not altered during the period, the losses amount to about $3.295 billion. The actual losses computed in Figure 4 total $4.433 billion.[9] This difference between the losses indicates that the trades that Amaranth executed between August 31, 2006 and September 15, 2006 served to increase their losses by an additional $1.138 billion. In fact, these additional losses were probably not accidental or random. That is, given the losses up to September 7, 2007, the Amaranth energy traders may have exercised their "free option" of limited downside liability if things went wrong by increasing the bets in response to troubled times. Correspondence from an Amaranth trader to Brian Hunter indicates a line of reasoning along this path:

Tell me if I am wrong, but we have 3 choices here.

(1) shut down and start energy fund, lose 0.3 to 1.0 getting out, and have great future potential. However, if we lose that, who is going to want in on the energy fund? If h/j drops to 1.50 or worse, the deferred positions are all going to get obliterated too.[10]

(2) jump back in and help this market out. Risk losing some investors due to risk profile, but manage along until we get the proper catalyst to exit positions. Start energy fund when we can later. Without the market's ability to absorb some xh or even some back length right now this market in a world of trouble.[11] *2 days ago things were fine, but it feels like it just tipped overboard on risk. There is comfort selling spreads, and comfort selling price right now. If you were a cash trader caught long hub gas right now, would you buy or sell January?*

(3) Sit and wait. Let market take its course, find natural fixed price demand.

There is not catalyst right now. That's the problem. You exit this size without one (without exiting every positions in your book), and we got a big problem. Things were fine when we were holding the risk for the market, b/c we could handle it. That risk in 30 other hands is a much more dangerous proposition.

Calhoun think #2

Rummy thinks #3

And I haven't decided yet. All I know is I am personally 1 more bad day away from stopping out...can't afford to drop below 30 for my family.—Amaranth Trader Shane Lee to Brian Hunter, September 7, 2006 16:54 (Source: Senate Subcommittee, Exhibit #9).

One of the suggested choices in this email correspondence is to increase their positions (choice #2), which some were suggesting. In fact, after this email correspondence, Amaranth modified their natural gas future positions over the next few days. Although it is difficult to quantify in a single number exactly what they did, the total number of absolute NYMEX natural gas equivalent contracts did increase from around 462,992 on September 7, 2006 to 508,923 on September 13, 2006. Thus, the additional losses of Amaranth in these days were partly due to increasing the actual exposure to natural gas futures contracts, partly due to modifying the positions

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[8] Front-month refers to futures contracts with the nearest month to expiration.

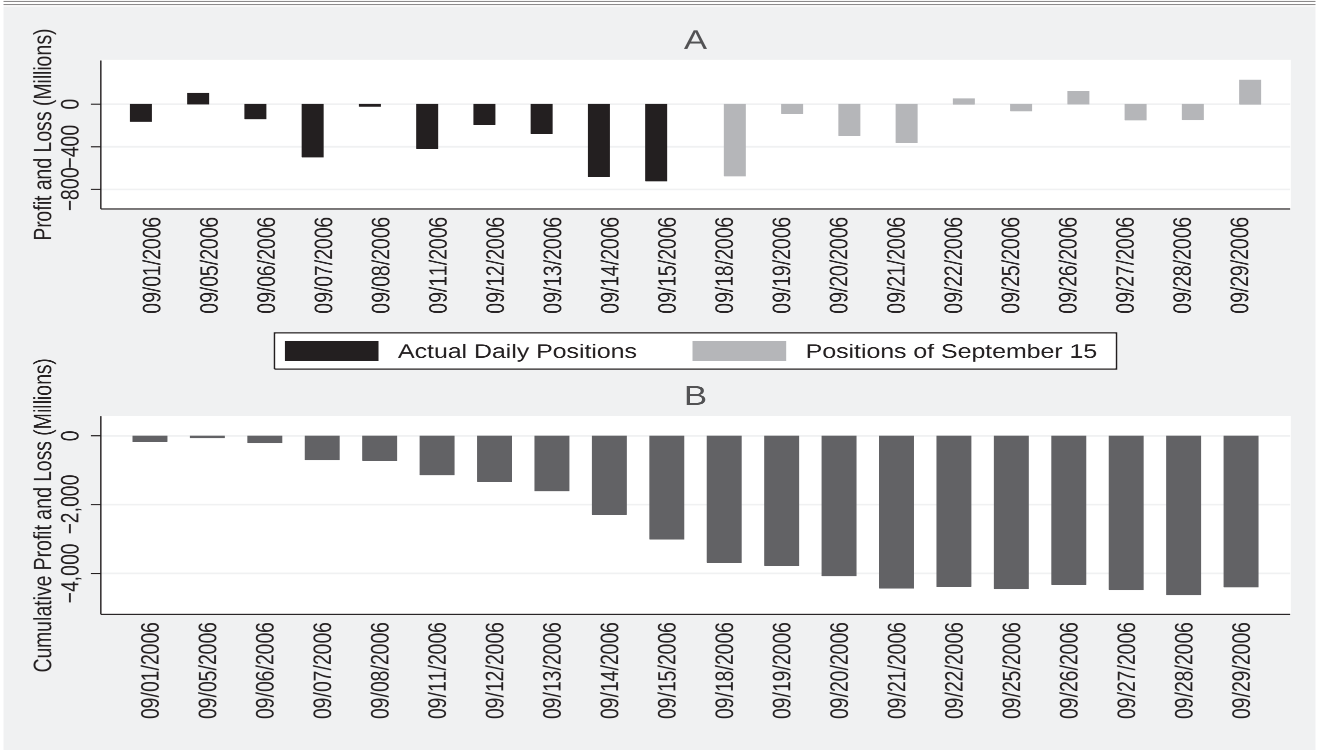
[9] The reader is reminded that these are losses computed from the Amaranth natural gas futures equivalent positions. The actual change in net asset value of the main Amaranth funds was $4.942 billion. The discrepancy is due to losses from other types of positions not related to natural gas futures trading and slightly due to the discrepancies between the natural gas future equivalent positions and the actual positions.

[10] Natural gas futures contracts are denoted by letter symbols on the NYMEX; F=January, G=February, H=March, J=April, K=May, M=June, N=July, Q=August, U=September, V=October, X=November, and Z=December. Thus, the h/j comment is referring to the March-April spread. At the close of business on September 7, 2006, the March contract (H) was trading at $10.073, while the April contract (J) was trading at $8.153. Thus, the h/j spread was $1.92. In this conversation, the trader is worried that the spread may decline to $1.50 which would cause a position short April and long March to lose money.

[11] In this discussion, *xh* refers to the November and March natural gas futures contracts. See the preceding footnote for more information about contract symbols.

Figure 4. The Profit and Loss of Amaranth's Natural Gas Positions in September.

Note: Losses each day are computed based upon the actual positions Amaranth had at the close of the prior day. From September 18, 2006 onwards, the positions of Amaranth were not available, thus the returns are computed assuming Amaranth maintained the positions they had at the close of business on September 15, 2006.



across the maturity spectrum and partly due to the movement of the options and other positions in the Amaranth portfolio.[12]

C. Natural Gas Spread Trades

Amaranth's collapse was mainly due to losses in the trading of natural gas. To understand the Amaranth collapse, one needs to understand the mechanics of trading natural gas futures, options, and swaps.

1. Trading Natural Gas

In this section, some basic features of trading natural gas futures on the NYMEX and ICE exchanges are discussed. Traders in natural gas futures have several options. The largest exchange for trading natural gas futures is the NYMEX, which has futures contracts of consecutive delivery months up to five years out. They also have options on all of the futures contracts, as well as spread options which pay off on the difference between futures contract prices of two different months. The initial margin requirement on futures contracts vary by type of trader (non-member customer, member customer, and clearing member and customer) and also vary by time to maturity of the contract. Contracts closer to delivery have stricter margin requirements. To give a flavor of the margin differences as a percentage of notional value, on August 31, 2006, \$12,150 was required for each October 2006 contract (Tier 1), which had a futures value of \$60,480, thus, representing about 20% of the futures notional position. The March 2007 contract had a margin requirement of \$7,425 (Tier 5) with a notional value of \$104,830 or 7.08%. The expiration of the contracts is usually a few days before the end of the prior month and there are conventions for the last trading day of each contract which can be obtained from NYMEX.

In addition to NYMEX, traders can use the ICE, which is a virtually unregulated exchange but performs very similar functions. ICE is the leading exchange for the trading of energy

[12]As described in (2) of the correspondence, Amaranth may have increased positions to drive up the spread or "manipulate" the price spread so as to temporarily remove the possibility for further margin calls on the existing spread position.

commodity swaps in natural gas and electricity. “The ICE natural gas swap and the NYMEX natural gas futures contract perform the same economic functions. The ICE swap contract even provides that its final settlement price will equal the final settlement price of NYMEX futures contract for the same month, which means that the final price for the two financial instruments will always be identical.” (Senate Report, p. 29) Traders also can use the ICE trading screen to enter into bilateral, non-cleared transactions rather than cleared transactions (i.e., Over-the-counter, OTC, transactions with other parties to buy or sell natural gas). One major difference between NYMEX and ICE is that ICE has “...no legal obligation to monitor trading, no legal obligation to prevent manipulation or price distortion, and no legal obligation to ensure that trading is fair and orderly...” (Senate Report, p. 41) due to its status as an electronic trading facility. In addition, the Commodity Futures Trading Commission (CFTC) has no authority or obligation to monitor trading on ICE.

2. The Natural Gas Futures Spread Trade

A popular type of trade in natural gas futures is to short one contract, while going long another contract. This type of trade has several attractive features. First, the trade as a whole will have less risk to the direction of natural gas futures prices - in a sense, “hedge-like” in nature. Second, by shorting one contract and being long another contract, an entity will reduce their overall net position and hence may allow for greater positions on the exchange without causing a trader to hit position limits.[13] NYMEX’s control system will investigate any position with a size greater than the position limit in that contract. However, if the entity is questioned by NYMEX about the position, an offsetting position in another contract may be an acceptable reason for NYMEX to allow the trade in excess of the position limit. Third, if the trade is done as a spread position, then the actual margin requirements from NYMEX are lower allowing greater leverage possibilities. Even if position limits are reached, by being short one contract and long another contract, the entity will have a better story of why they have such large positions (i.e. the position is naturally hedged) and may be allowed to engage in such positions on the exchange. Fourth, spread positions allow for more sophisticated hedge fund-like trades.

A simple example of a spread position may illustrate the point: Suppose on July 31, 2006 a trader wished to short one contract and go long another contract. Suppose the trader chose to short the March 2007 contract and go long the April 2007 contract. The closing prices on July 31, 2006 for the March and April contract were $11.461 and $8.851 respectively. The notional value of this position would equal $114,610 short and $88,510 long.[14] The position is “hedged” in the sense that if natural gas futures prices rise or fall, one position’s loss will be partly offset by the other’s gain. However, the position is focusing on a spread bet. That is, a bet that the March futures contracts will have a lower return than the April futures contracts. In the month of August 2006, this was actually the case. By August 31, 2006 the price for March and April 2007 futures contracts was $10.483 and $8.343 respectively. Thus, if the position were closed out on August 31, 2006 by buying March 2007 futures (covering the short position) and selling back (offsetting the long position) April 2007 futures, the net profit would have been $4,700 on this simple spread position (See Supplemental Table 1 on the *JAF* website). The return of these positions will depend on the leverage employed. Notice that even though natural gas prices dropped, the spread position still made profits.

On July 31, 2006, these natural gas futures contracts represented the Tier 5 futures contracts on the NYMEX for margin calculation.[15] For a non-member customer, this would require an initial margin on each of the March and April contracts of $7,425. Thus, for an initial capital outlay of $14,850, the return on this investment would have been 31.6% ($\frac{4,700}{14,850}$). This is one of the advantages of leverage; big returns for little initial capital outlay.

3. The Natural Gas Spread Trade with Options

The previous section discussed one way a natural gas futures trader can engage in a calendar spread trade using natural gas futures contracts on the NYMEX. In addition to this, a trader could use NYMEX natural gas options, which are options whose value depends on the underlying natural gas futures contract. There are both call and put options and they are available for selling or purchasing.[16] Thus, the trader could also make a calendar spread trade using options.

In addition to straight call and put options, the NYMEX also has calendar spread options available for trading. These are options on the difference in price between two natural gas

[13] That is NYMEX looks not only at individual contract position limits to decide about a particular entity, they also consider net exposure limits. Thus, if a trader is long 10,000 contracts in one contract and short 10,000 contracts in another contract, the net position is 0. This makes the position more feasible with respect to NYMEX acceptability of such a position.

[14] Each contract of natural gas is worth 10,000 MMBtu. Natural gas futures prices are quoted in terms of 1MMBtu. Thus, each contract in natural gas futures represents a notional value of $1 \times P \times 10,000$, where P represents the price of that natural gas futures contract.

[15] For more details, see www.nymex.com for margin requirements. Tier 5 represents the 6th through the 16th nearby month. On July 31, 2006, March and April contracts were the 8th and 9th month respectively.

[16] Margin is required for short positions or writing options. However, for purchasing options, only the premium is required.

futures contracts of different months. For example, an IBK07 call option is a call option on the price differential between the May 2007 natural gas futures contract and the July 2007 natural gas futures contract.

4. Natural Gas Swaps

Finally, using the NYMEX Clearport trading platform, traders can transact in natural gas swaps and natural gas penultimate swaps which are based upon the final price of the natural gas futures contracts, but are one-fourth the size.

A trader could also do such a spread trade using the ICE. The ICE allows for trading of natural gas swaps that are based on the settlement prices of the NYMEX natural gas futures contracts.[17] The ICE swaps are, for all practical purposes, identical in behavior and risk to the NYMEX natural gas futures contracts. For more details about these swaps, the reader is referred to the detailed version of this section on the JAF website.

All of the positions and types of trades we discussed in this and the preceding sections were employed by Amaranth. In fact, Amaranth's collapse was due to a large variety of these type of trades that they made on NYMEX and ICE in both futures, swaps, and options. In the next section, we focus on the Amaranth trades in detail.

> **It is difficult to classify a large group of trades into one simplified strategy, but for the most part, the complex combination of instruments and spread trades could be summarized as a general bet that winter natural gas prices would rise, while non-winter natural gas prices would increase to a lesser degree, referred to as the long winter, short non-winter spread trade.**

III. Amaranth's Trading Strategy

A. The Basic Strategy

The Senate's Permanent Subcommittee on Investigations report (2007a) provided a detailed account of Amaranth's natural gas positions on a daily basis throughout 2006. Amaranth's positions in natural gas involved trades in various types of contracts, including futures, swaps, and options. Their trades also amounted to a collection of many spread trades whose return depended on the movement of natural gas futures price all the way out until 2011. It is difficult to classify a large group of trades into one simplified strategy, but for the most part, the complex combination of instruments and spread trades could be summarized as a general bet that winter natural gas prices would rise relative to non-winter natural gas prices, referred to as the long winter, short non-winter spread trade (Chincarini (2006, 2007a, 2007b)).

Amaranth's positions in natural gas consisted of a variety of actual instruments. The vast majority of positions were traded on the NYMEX and ICE. On the NYMEX, Amaranth held positions in outright natural gas futures contracts from October 2006 maturity to December 2011 maturity. Amaranth also had a significant amount of positions in call and put options on the underlying natural gas futures contracts with NYMEX. They also had natural gas swap contracts through the Clearport system of NYMEX. They had a combination of regular swaps and penultimate swaps, the latter which expire one day prior to the former, but are otherwise identical.[18] The rest of their positions consisted of natural gas swap contracts on ICE, some of which were electronically traded and cleared positions on ICE, while others were off-exchange contracts, but later cleared through ICE. Among the trades entered on ICE, some of the swap contracts were in individual contract months (e.g. October, 2006), while others were in calendar strips (e.g. November through March). Due to the difficulty of understanding Amaranth's positions when divided amongst so many types of securities, it is useful to convert all of the securities into the NYMEX futures equivalent value (NYMEX FEQ). For the swap contracts, this is quite easy to do, since the swaps are essentially the same as the NYMEX natural gas futures contract, but one-fourth the size. Thus, one swap contract is worth one-fourth of a NYMEX natural gas futures contract. The option contracts are more complicated, but can be translated by adjusting the position for the delta of the option.[19] Once these conversions have been made, we can aggregate the entire Amaranth position in terms of NYMEX natural gas futures equivalents.[20] Table I shows the positions of Amaranth

[17]Although the ICE calls these instruments "swaps", they are similar to futures contracts.

[18]These were created to allow traders access to an instrument that would expire one day before option expiration on natural gas futures contracts.

[19]For more on this type of concept, one is referred to any options book or any book on value-at-risk. For example, see Hull (2006), Jorion (2006), or Dowd (1999).

[20]The conversion of these positions was done by the NYMEX and the Senate Subcommittee.

Table I: Natural Gas Positions of Amaranth on August 31, 2006

Note: On the NYMEX, Amaranth held positions in outright natural gas futures contracts from October 2006 maturity to December 2011 maturity. Amaranth also had a significant amount of positions in call and put options on the underlying natural gas futures contracts with NYMEX. They also had natural gas swap contracts through the Clearport system of NYMEX. They had a combination of regular swaps and penultimate swaps, the latter which expire one day prior to the former, but are otherwise identical. The rest of their positions consisted of natural gas swap contracts on ICE, some of which were electronically traded and cleared positions on ICE, while others were off-exchange contracts, but later cleared through ICE. Among the trades entered on ICE, some of the swap contracts were in individual contract months (e.g. October, 2006), while others were in calendar strips (e.g. November through March). All of these different types of instruments were converted to NYMEX futures equivalent value (NYMEX FEQ).

Contract		NYMEX Contracts			ICE Contracts			Total
		Futures	Options	Swaps (NN)	Swaps (NP)	ICE Swaps	ICE Off-Exchange	
Oct-06								
	FEQ	-64711	43523	-21703	-5307	-87625	41381	-94441
	Percent	24.49	16.47	8.21	2.01	33.16	15.66	100
Nov-06								
	FEQ	-336	6431	17451	-442	85597	-49453	59247
	Percent	0.21	4.03	10.93	0.28	53.60	30.96	100
Dec-06								
	FEQ	-7308	-2430	-8154	-449	28711	-38127	-27757
	Percent	8.58	2.85	9.57	0.53	33.71	44.76	100
Average	Percent	28.40	14.82	32.61	2.00	10.21	11.96	100

in the various instruments as NYMEX natural gas futures equivalents on August 31, 2006.

For example, on August 31, 2006, Amaranth had a net position of October 2006 NYMEX natural gas futures equivalent contracts of -94,441. That is, the combined position of NYMEX natural gas futures, options, and swaps and ICE swaps was equivalent to a short position in 94,441 NYMEX natural gas futures contracts. In fact, many of the outright positions on the October 2006 were short (i.e. 64,711 NYMEX natural gas futures contracts, 21,703 and 5,307 NYMEX swap contracts, and 87,625 ICE swaps), but some positions had a long exposure (i.e. 43,523 NYMEX options and 41,381 off-exchange ICE swaps). For October, ICE swap contracts represented the largest component of the trade at 33.16% of the position.

For the entire period, looking at all contract months in which they had positions, the averages are shown in the last row of Table I. On average, 28.40% of the monthly exposures were through NYMEX natural gas futures contracts, 14.82% in NYMEX options, 34.61% in NYMEX swaps, 10.21% in ICE swaps, and the remaining 11.96% in ICE off-exchange swaps.

Amaranth's actual positions in natural gas future equivalents on August 31, 2006 are depicted in Figure 5 and Table II. This graph is identical to the graph produced in the appendix of the Senate Subcommittee's report. It contains the Amaranth positions on each contract month in NYMEX natural gas futures equivalents. Before the data on Amaranth's positions were publicly available, Chincarini (2006, 2007b) postulated that Amaranth's position was a long winter, short non-winter position. Although the figure seems to indicate this, it is worth examining the issue further.[21] For the purposes of this analysis, we follow Chincarini (2007a) and define winter contract months to be November, December, January, February, and March. All other months will be considered non-winter months.

Table III presents additional measures of the August 31, 2006 positions of Amaranth in natural gas. The total dollar value of natural gas futures positions by Amaranth in winter months equalled $23,489,626,234. That is, the notional value of all winter contract months was almost $23 billion across all exchanges and instruments. The total dollar value of non-winter positions was -$15.863 billion. This is consistent with a long winter, short non-winter position.

Another way to measure whether Amaranth's strategy was long winter and short non-winter is to find the percentage of winter months in which they had long positions versus short positions. Of all the contract months out until December, 2011, 35 of those months are non-winter months, while 27 are winter months. For winter months, Amaranth had a long position 63% of the time, while for non-winter months, Amaranth had a short position 69.44% of the time. This is again consistent with a long winter, short non-winter strategy. And within the winter months, they had an equivalent of $28.812 billion long

[21]Although some winter months are actually shorted, the overall positions are smaller.

Figure 5. Amaranth NYMEX FEQ Positions on August 31, 2006

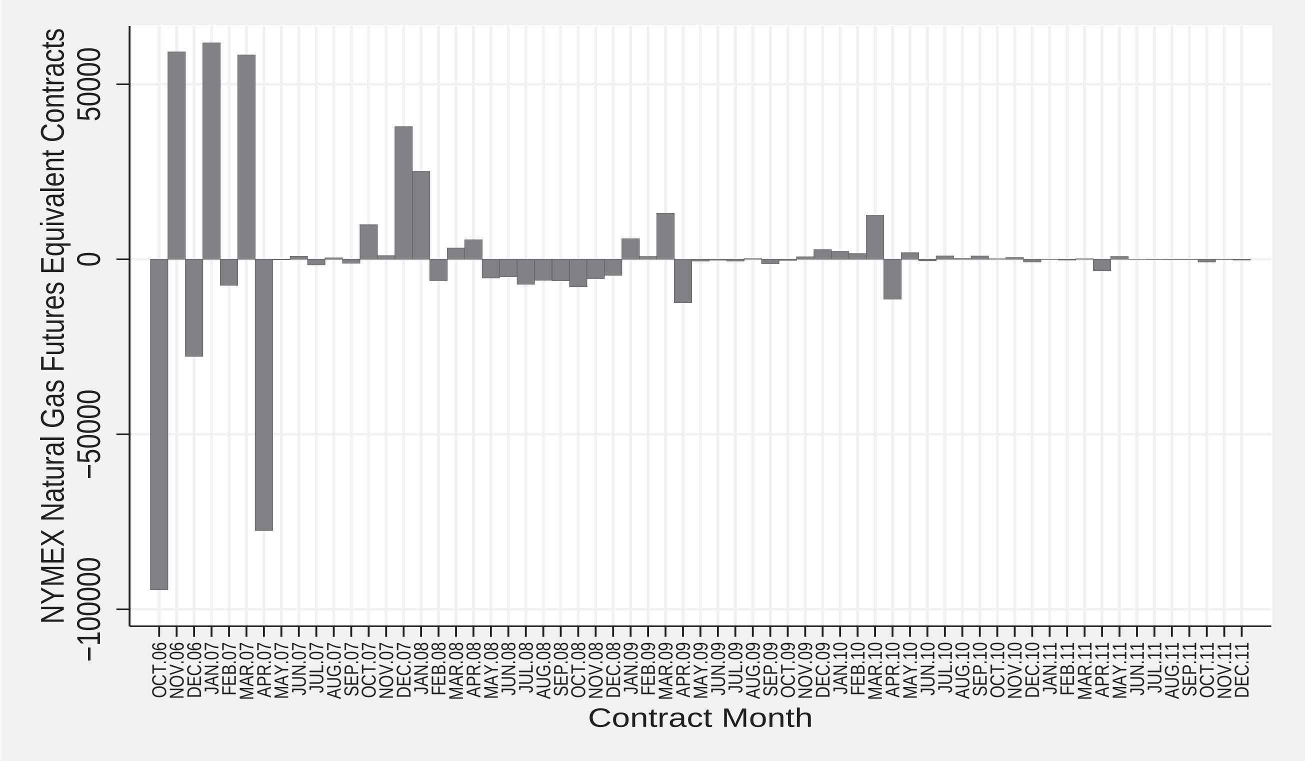


Table II. NYMEX Futures Equivalent Values of Positions for Amaranth on August 31, 2006

Note: NYMEX FEQ refers to NYMEX futures equivalent values of positions. Only the positions for contracts out to September 2007 are listed in this table. For a table of all of their positions in natural gas on August 31, 2006, see the expanded version of this table on the *JAF* website. Weight represents the weight of Amaranth's exposure in that particular contract as a percentage of the total absolute dollar volume of all contracts. That is, for each contract, the absolute value of Amaranth's positions are multiplied by the price for that contract on August 31, 2006 and 10,000. The percentage for each contract of each contract is the total dollar value of their position in that contract divided by the sum of the total dollar value of all of the contracts. The Dollar P/L represents the profit and loss of Amaranth in each position assuming no changes were made to the holdings. That is, it is simply Dollar P/L = NYMEX FEQ $\times (P_{t+1} - P_t)$, where P_t is the contracts price on August 31, 2006 and P_{t+1} is the contract's price on September 21, 2006.

Contract Month	NYMEX FEQ	Weight	Percent of NYMEX Open Interest	Dollar P/L (August 31, 2006 - September 21, 2006)
OCT.06	-94441	0.1068	-80.8	$1,196,571,821
NOV.06	59247	0.0911	84.1	$(1,313,512,297)
DEC.06	-27757	0.0518	-54.3	$718,082,127
JAN.07	61825	0.1228	125.5	$(1,698,345,675)
FEB.07	-7464	0.0149	-24.1	$204,658,602
MAR.07	58365	0.1144	73.2	$(1,597,458,370)
APR.07	-77527	0.1209	-123.9	$912,497,139
MAY.07	-140	0.0002	-0.6	$1,491,906
JUN.07	869	0.0013	5.7	$(9,226,529)
JUL.07	-1612	0.0025	-13.9	$17,362,443
AUG.07	406	0.0006	3.1	$(4,408,604)
SEP.07	-1128	0.0018	-9.6	$12,318,357

Table III: Amaranth Positions in Winter and Non-Winter Months

Note: For this table, winter months are defined to be November, December, January, February, and March. Non-Winter months are all other months. For each day listed, Winter-Longs represented the total dollar value of the long positions in winter months, Winter-Shorts represent the total dollar value of the short positions in winter months, W. Total represents the sum of the two, Non-Winter-Longs represents total dollar value of the long positions in non-winter months, Non-Winter-Shorts represents the total dollar value of the short positions in non-winter months, and N.W. Total represents the sum of the two. Correct Sign (%) represents the number of Winter (Non-Winter) months in which the position is long (short) regardless of size.

	Total Dollar Value						Correct Sign (%)	
Trade Date	Winter-Longs	Winter-Shorts	W. Total (Net)	Non-Winter-Longs	Non-Winter-Shorts	N.W. Total (Net)	Winter	Non-Winter
31-Jan-06	4,258,305,934	(4,207,665,123)	50,640,811	1,435,236,076	(2,186,529,127)	(751,293,051)	64.29	50.00
28-Feb-06	6,747,057,844	(2,581,042,631)	4,166,015,213	1,107,062,004	(4,459,247,449)	(3,352,185,445)	77.78	50.00
31-Mar-06	8,139,116,076	(1,823,491,062)	6,315,625,014	1,414,829,338	(5,252,719,674)	(3,837,890,336)	70.37	51.22
28-Apr-06	11,676,812,614	(3,236,275,580)	8,440,537,034	1,927,180,168	(6,202,124,031)	(4,274,943,863)	70.37	57.50
31-May-06	17,101,267,975	(4,524,524,915)	12,576,743,060	2,782,321,098	(11,225,510,296)	(8,443,189,198)	70.37	48.72
30-Jun-06	20,229,114,833	(5,357,498,215)	14,871,616,618	3,222,527,838	(11,998,686,079)	(8,776,158,242)	66.67	47.37
31-Jul-06	28,568,081,397	(2,432,009,020)	26,136,072,377	1,198,034,025	(19,426,414,857)	(18,228,380,831)	62.96	56.76
31-Aug-06	28,812,493,335	(5,322,867,101)	23,489,626,234	1,762,963,323	(17,626,398,609)	(15,863,435,286)	62.96	69.44

and $5.322 billion equivalent short positions. For the non-winter months, they had an equivalent $17.626 billion of short positions and $1.762 billion of long positions.

Thus, although not every winter contract was held long and not every non-winter month was held short, the Amaranth actual positions on August 31, 2006 seemed to be consistent with a long winter and short non-winter spread trade in natural gas using a combination of NYMEX futures, swaps, and options, as well as ICE natural gas swaps.

It's clear that on August 31, 2006, Amaranth was engaged in a natural gas futures position that was long winter and short non-winter. Next we examine whether or not they had a similar trade in prior months. In order to examine the general position of Amaranth, we look at their position three months prior to August 31, 2006. The NYMEX natural gas futures equivalents of Amaranth's natural gas positions on May 31, 2006 are depicted in the supplemental figure on the JAF website and Table III. The total absolute dollar value of winter month contracts was $12.577 billion, while the non-winter months was $8.443 billion. Of the winter month contracts, 48.7% were held long, while 70.4% of the non-winter months were held short. The total value of long positions in winter months was $17.101 billion, while short positions were $4.525 billion; for non-winter it was $2.782 billion and $11.226 billion respectively. Although not a perfectly consistent winter/non-winter spread trade, the general position of the trade is long winter and short non-winter on May 31, 2006 as well.

The natural gas positions of Amaranth on other days during the summer are of a similar nature to those on May 31, 2006 and August 31, 2006 (see Table III). Thus, even months prior to August 31, 2006, Amaranth had engaged in a long winter, short non-winter spread trade in natural gas.

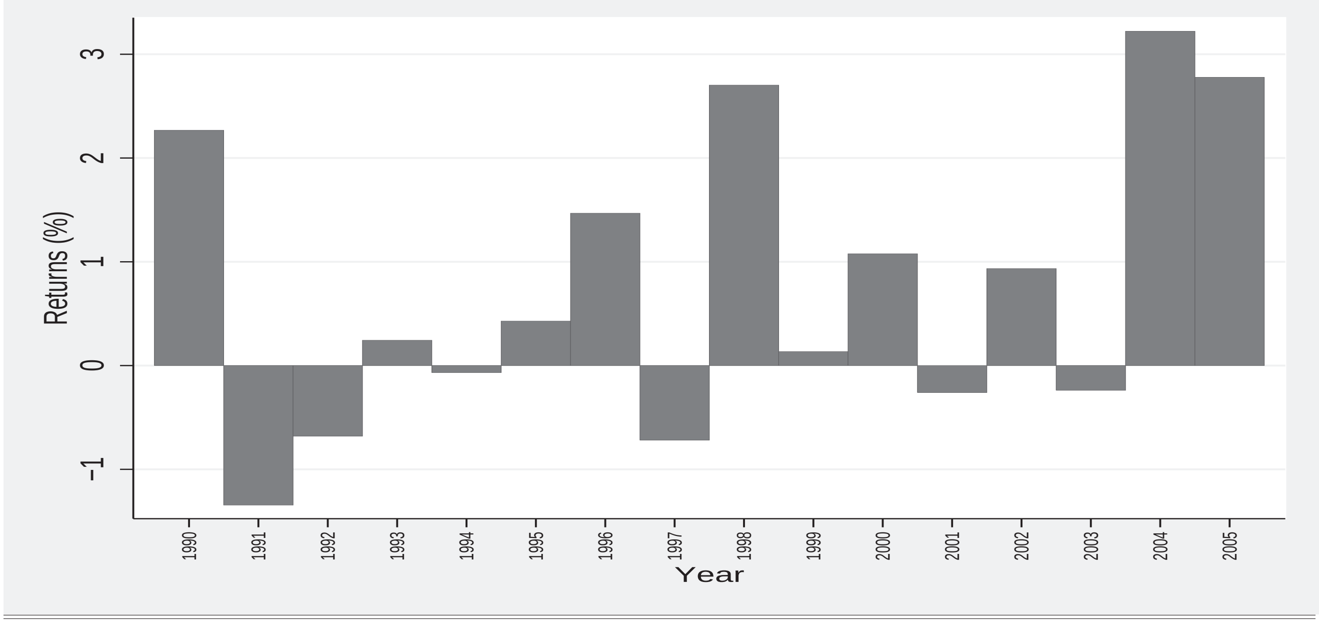
B. The Rationale for the Strategy

In the previous section, we concluded that Amaranth's primary trading strategy consisted of a spread trade that was primarily long winter natural gas contract months and short non-winter natural gas contract months. Chincarini (2007a, 2007b) noted that such a spread trade had performed well on average since 1990. That is, a long winter, short non-winter spread trade in proportion to the open interest on NYMEX tended to do very well in September. It is not clear whether the Amaranth natural gas traders actually backtested the strategy or whether they used experience combined with their own trader instinct.[22] If one backtests the Amaranth strategy of August 31, 2006 on past years, one finds that the strategy produced a significantly positive average return of 0.74% per month or 8.96% on an annualized basis with relatively small losses in down years (See Figure 6).

One might naturally ask if there is some potential reason explaining this historical pattern. More specifically, one might ask if there is a justifiable reason for a trade that is long winter and short non-winter to earn an excess return. Natural gas is one of the main sources of energy for the United States, fueling

[22] Backtesting a strategy refers to the process of testing a trading strategy on prior time periods. In other words, a trader can do a simulation of his or her trading strategy on relevant past data in order to gauge the effectiveness.

Figure 6. Historical September Returns (1990-2006) from Positions Similar to Amaranth's Position on August 31, 2006



nearly one-quarter of the nation's energy consumption. Natural gas is used by individual households, small businesses, and large industries. The total domestic demand for natural gas is highly seasonal, this is mainly because natural gas is the primary heating fuel for homes in the winter months.[23] "During summer months, when supply exceeds demand, natural gas prices fall, and the excess supply is placed into underground storage reservoirs. During the winter, when demand for natural gas exceeds production and prices increase, natural gas is removed from underground storage." (Senate Report, p. 17). In many commodity markets, the storage costs of a commodity are priced into futures contracts. Theoretically, the price of a futures contract is given as $F_t = S_t e^{(c+r)(T-t)}$, where S is the spot price of the commodity, c is the continuously compounded storage costs of the commodity, r is the opportunity cost of money or the interest rate, and $T-t$ is the time until the futures contract matures.

Thus, a storage operator might use natural gas futures to *hedge* his or her exposure. That is, by selling natural gas winter contracts and buying non-winter months, the storage operator will lock-in his or her profit for storage, which in a perfectly competitive market should cover interest and storage costs.[24]

On the other side of this trade would be the *speculator* who buys winter contracts and shorts non-winter contracts providing liquidity to the natural hedgers. In exchange for taking on this risk, the speculator should receive compensation on average. This might explain the positive average return to this strategy over time. Thus, the excess returns from a long winter, short non-winter trade in September might be a compensation to speculators for supplying liquidity to natural hedgers, which consist of storage operators and natural gas producers.[25]

A quantitative type of trader would have probably backtested the winter-summer spread strategy and found that it produced significant excess returns historically and might have used this as a basis to make such a trade going forward. However, it is difficult to determine if Amaranth's traders had based their strategy on a similar motivation. It is somewhat reassuring to find that the Amaranth strategy generated positive average returns historically. However, in my opinion, the traders were not relying on statistical techniques, but rather were using their instincts and experience in natural gas futures which was conditioned by this historical pattern. Their view was also influenced by their beliefs about the demand and supply of natural gas in 2006. Interviews with Amaranth traders revealed that they believed that winter natural gas prices would rise

[23]A 2001 EIA survey found that 54% of all U.S. household use natural gas as the main heating fuel (Source: Senate Report).

[24] Even though this is an overly simplistic description of the real behavior of storage operators, it may help explain some of the reasons why a speculator might choose this side of the trade. Natural gas producers might accentuate the need for speculators as they might continuously short natural gas as a hedge which might require more liquidity for winter contracts.

[25]The forward curve for natural gas futures looks like a sine wave with natural gas futures prices high in winter months and low in non-winter months. Another reason is that there is lower demand for natural gas in summer months and higher demand in winter months.

throughout 2006. They believed that with increasing domestic demand for natural gas, they expected supply shortages, delivery bottlenecks, and weather-related disruptions to develop during the winter and boost prices. From early 2006, they believed that the fundamentals of supply and demand justified much higher spreads between the natural gas winter and summer prices (Senate Report, p. 56).

In addition to this, a lot of their trading around the main position seemed to be driven by typical trader instinct, sentiment, and weather conditions, rather than some well-designed trading strategy. Many of the instant message and email conversations between Brian Hunter and other traders seemed to reveal this.[26] For example, in one email, an Amaranth employee writes to Brian Hunter:

I think you should sell 15,000 red March April and buy 15,000 (or more) front Mar/Apr. My rationale is not that you should short the reds, just that you're moving risk...not increasing it. Leveraging it to the part of the curve that is undervalued and lightening up on the one that is perhaps fair value.[27]—Amaranth Employee, Email to Brian Hunter, July 28, 2007 (Source: Senate Subcommittee, Exhibit #9)

IV. The Risks of Amaranth's Strategies

As was described in Section II.D, Amaranth had an apparently sophisticated risk management operation with 12 dedicated risk managers supporting each desk, including a Chief Risk Officer. They used daily VaR and stress reports, so one might naturally ask how they did not foresee the risks they were taking on August 31, 2006. In fact, the CEO of Amaranth stated in a conference call to investors that:

Although the size of our natural gas positions was large, we believed, based on input from both our trading desk and the stress-testing performed by our energy risk team that the amount of risk capital ascribed to the natural gas portfolio was sufficient. In September 2006, a series of unusual and unpredictable events caused the Funds' natural gas positions (including spreads) to incur dramatic losses while the market provided no economically viable measure of exiting these positions.—Nick Maounis, Conference Call to Investors, September 22, 2007

It could be that historical measures of natural gas volatility were insufficient to identify the types of events that occurred in September, 2006, or it could be that Amaranth simply ignored the warning signs from risk measurement systems. Or, it might be that market risk was not the principal risk of the positions, but it was rather liquidity risk. In this section, we take the actual Amaranth positions in natural gas and attempt to construct both market risk and liquidity risk measures using only data up to August 31, 2006 to examine whether or not the risks of the Amaranth portfolio could have been obtained from basic risk measurement tools. In particular, we examine three sources of risk for Amaranth: market risk, liquidity risk, and funding risk. Market risk is the risk that occurs from the volatility of investment returns. Liquidity risk measures the degree of difficulty in exiting a given trading position. Funding risk measures the extent to which they were able to meet margin calls on their natural gas positions.

A. Market Risk

In order to evaluate Amaranth's market risk on August 31, 2006, simple historical VaR (value-at-risk) measures are constructed for their actual positions. We consider three ways to measure this VaR. The first method is computed by recreating the August 31, 2006 natural gas exposures of Amaranth in other years from 1990-2005 (See Table II). Table II shows the weight of Amaranth's exposure to each contract month of natural gas futures. This weight is computed by taking the absolute value of the notional value of each contract and dividing it by the sum of the absolute notional value of all other contracts. For example, for the October contract month, this was equal to 10.68%. For prior years, the weight scheme was kept similar. That is, in each prior year, the weight of the October current year contract was kept at 10.68%. The corresponding returns of these positions were computed in every year from the last trading day in August to the last trading day in September. These 16 years of September returns were then used to calculate a sample average and standard deviation of the strategy in September to be used to estimate a VaR for the strategy in September.[28]

[26]These documents were obtained by subpoena from the Senate Subcommittee and used in the public presentation of the Amaranth case. In particular, they were taken from Exhibit #9 of the Senate Subcommittee Investigation documents.

[27] In natural gas trading, colors are used to distinguish between contracts of different years. "Front" refers to the contract month closest to the current date. For instance, on July 28, 2007, the "front March" contract would be the March 2008 contract. "Red" refers to the next contract year. Thus, in this case, "red March" contract would refer to the March 2009 contract. "Blue" is also used to denote the contract 2 years out. Thus, if someone referred to the "blue March" contract on this date, it would refer to the March 2010 contract. These colors help traders communicate more easily.

[28]The return calculation for the strategy is given by $r_t = \sum_{i=1}^{N} w_{i,t-1} r_{i,t} \phi_{i,t-1}$, where $w_{i,t-1}$ is the weight of contract i on the last trading day of August in any given year, $r_{i,t}$ is the return of natural gas futures contract i from the last trading day in August to the last trading day in September in any given year, and ϕ_i is an indicator variable that equals 1 if Amaranth was long in that particular futures contract and equals -1 if Amaranth was short that particular contract month, and N represents the total number of contract months (e.g. 63 from October 2006 to December 2011). In some years, especially in the early 1990s, there were not as many natural gas futures positions and thus the weights were renormalized so as to be relatively the same between any two contracts. For example, on August 31, 1990 there were only 12 contracts from October 1990 to September 1991. Thus, the weight for October 1990 was -0.1697 and the weight for November 1990 was 0.14483. The relative weight was still -1.172 as in other years.

The VaR was computed as

$$VaR_t = V_t(\mu - k(\alpha)\sigma) \quad (1)$$

where μ represents the average historical return of the strategy in September, σ represents the standard deviation of the historical September returns, V_t represents the notional value of the portfolio positions, and $k(\alpha)$ represents the critical value from the normal distribution for a confidence level $(1-\alpha)$ [i.e. $k(0.025) = 1.96$ for a 97.5% confidence interval].

The second method is a modification of the first method to account for non-normally distributed returns. It is the Cornish-Fischer expansion VaR ((Cornish and Fisher (1937), Ord and Stuart (1994), and Favre and Galeano (2002)). This method adjusts the VaR calculation taking into account the skewness and kurtosis of the distribution of returns.[29]

The third method is to measure the most recent volatility in natural gas futures over the three months prior to August 31, 2006. Ideally, one would like to recreate the same type of positions in the past as what Amaranth had on August 31, 2006, but there is no obvious way to do this, since a whole host of different contract months are introduced. Instead, the actual positions of Amaranth from May 31, 2006 to August 31, 2006 are used and the daily returns calculated. The VaR for September on August 31, 2006 is then computed as follows:

$$\text{VaR}_t = V_t(\mu_d T - k(\alpha)\sigma_d \sqrt{T}) \quad (2)$$

where μ_d represents the daily return of the strategy over the past three months, σ_d represents the standard deviation of daily returns over the last three months, and T represents the number of trading days that Amaranth used for VaR (i.e. 20 days). The confidence levels were chosen to conform closely with the risk reports that Amaranth produced internally on a daily basis (see Section II).

Table IV shows the potential VaR from the spread positions and different confidence intervals. Suppose we take the 99% confidence interval for use with our Method 1 VaR calculation at the end of August 2006. A notional position in the spread trade of $10.228 billion would give us a VaR calculation of $254.95 million.[30] The actual leveraged position of Amaranth had an estimated VaR of $1.33 billion. This is a sizeable amount of VaR, however it is not the actual amount they lost in September. The actual amount they lost from August 31, 2006 to September 21, 2006 *had the positions been held constant* was around $3.295 billion which is listed under the column "Actual" in the table.

Prior to that year, the worst lost in September of any year with the same sized position since the opening of natural gas trading in 1990 would have been -$719.7 million. The average return of the spread position over the prior 16 years was 0.7466% with a sample standard deviation of 1.3902 in September. Thus, if Amaranth used a simple risk measurement system as used here, they would have been chasing an average return of $399.6 million (0.7466)×($53,524,979,536) with a potential 99.95% VaR of -$2.048 billion.

Thus, they were chasing a 4.13% return in September for a "worst-case" scenario of a loss of 21.2%.[31] This is, in itself, quite risky, but perhaps part of their philosophy. It should also be noted by looking at Figure 3 that the historical returns of such a spread trade seemed to look favorable. The strategy provided mainly positive returns with a positively skewed distribution. The largest negative return of the trade was 1.34% in 1991 on an unlevered basis.

The other methods show similar results. The Cornish-Fisher VaR is actually smaller reflecting the negative kurtosis of the sample distribution and very slight skewness.[32] The VaR based upon the last three months of Amaranth positions reflected a lower VaR than the historical calculation, but basically near the same magnitude.

It is clear from this exercise, the losses of September were not entirely explained by VaR calculations. The further losses may have come from another source of risk which they failed to manage as well: liquidity risk.

B. Liquidity Risk

Liquidity is defined as the ability to sell a quantity of a security without adversely changing the price in response to your orders. Models for liquidity risk are not as common place as models for market risk. One simple precautionary measure that practitioners use to control liquidity risk is to measure the size of their trades versus the average daily trading volume of a security. A rule-of-thumb is to not own positions greater than 1/10 to 1/3 of the average daily trading volume over some specified time interval, for example, the last 30-days of trading.

Figure 7 shows Amaranth's August 31 positions as multiples of the trailing 30-day average daily trading volume in each contract for the spread position. For example, Amaranth's exposure in terms of NYMEX natural gas futures equivalents in July 2008 futures contracts represented 253 days of the average daily trading volume. Even though many of the Amaranth positions were not with NYMEX, and instead with ICE, these positions were extremely large relative to the average daily trading volume of the largest natural gas futures

[29] The actual calculation of the Cornish-Fisher VaR is contained in the detailed version of this section on the JAF website.

[30] This net asset value differs from that in Chincarini (2007b) due to a typo in the earlier paper.

[31] This downside percentage is for the 99.99% confidence level VaR. It would be much less for the 99% VaR at -13.8%.

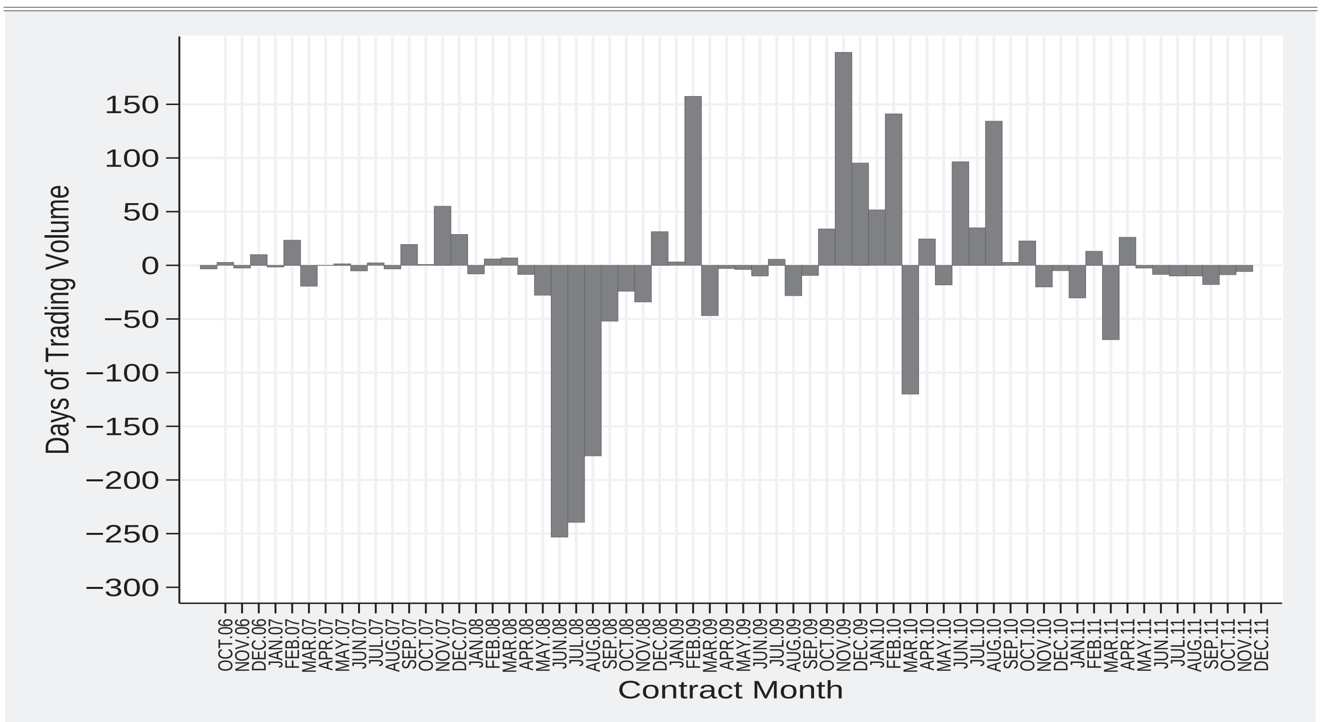
[32] It should be noted that the Cornish-Fisher VaR critical values began to decrease when the critical values where extended to a 99.99% confidence interval.

Table IV: Measures of VaR of Amaranth's Natural Gas Position on August 31, 2006

Note: [a] Actual losses represent the losses had Amaranth maintained the positions of August 31, 2006 through the end of trading on September 21, 2006. [b] No leverage computes the VaR based on an investment in natural gas futures equal to the value of the total assets under management by Amaranth on August 31, 2006 of $10.228B. The Leverage row represents the VaR with Amaranth's actual leverage of 5.23 on August 31, 2006. For Methods 1 and 2, the numbers for each confidence level in the table represent the VaR estimates in millions of dollars using the historical mean and volatility of the winter / non-winter spread trade of 0.7466% and 1.3902% respectively. For Method 3, the VaR estimates are based on the daily mean and standard deviation of Amaranth's natural gas positions for the prior three months. These daily values were 0.0172% and 0.2435% respectively. The "Worst" column represents the losses of the respective size fund if one uses the worst historical September loss of the spread trade using NYMEX data from 1990-2005. The "Actual" column represents the actual loss that occurred for Amaranth from August 31, 2006 to September 21, 2006 assuming no changes were made to the positions held on August 31, 2006.

	Position Size	Confidence Interval 68%	99%	99.95%	Worst	Actual[a]
Method 1 (VaR)						
No Leverage[b]	$10.228B	-65.83	-254.95	-391.53	-137.53	-629.97
Leverage	$53.523B	-344.50	-1334.18	-2048.92	-719.71	-3295.50
Method 2 (Cornish-Fisher VaR)						
No Leverage	$10.228B	-126.44	-246.31	-225.14	-137.53	-629.97
Leverage	$53.523B	-661.67	-1288.97	-1178.16	-719.71	-3295.50
Method 3 (Recent Historical VaR)						
No Leverage	$10.228B	-76.27	-224.43	-331.42	-137.53	-629.97
Leverage	$53.523B	-399.12	-1174.44	-1734.37	-719.71	-3295.50

Figure 7. Amaranth's August 31, 2006 Positions as a Ratio to 30-Day Average Daily Trading Volume



exchange. In some cases, the positions are hundreds of times the 30-day average daily trading volume. It is quite clear that Amaranth was taking immense risk with respect to liquidity.

Another way of depicting Amaranth's natural gas positions is to compare them to the open interest of NYMEX natural gas futures contracts (abbreviated as NYMEX NGFOI). Figure 8 compares the actual Amaranth positions to the open interest of NYMEX natural gas futures. Figure 8A shows all the Amaranth positions (including ICE positions as well) as a percentage of the NYMEX NGFOI. In many contract months, this is greater than 100%.[33] Figure 8B shows only the positions on NYMEX as a percentage of NYMEX NGFOI. It is still very high and, in some contracts, greater than 100% as well. Figure 8C shows only Amaranth's position in NYMEX natural gas futures as a percentage of NYMEX NGFOI. Even by this very direct measure of Amaranth's positions on the NYMEX exchange, their positions were excessive representing more than 50% of the open interest in many contracts and almost 100% in some contracts. In some contracts, Amaranth had positions of nearly 100,000 contracts, which represents roughly 1 trillion cubic feet of natural gas, 23% of the amount of natural gas consumed by residential users in 2006, and 5% of the total amount of natural gas consumed in the United States in 2006 (Senate Report, p. 64).

Thus, while market risk measures such as VaR indicate that Amaranth may have had a VaR of about -$2.048 billion, their liquidity risk was also very high. Thus, Amaranth was certainly being imprudent with respect to its natural gas futures positions in terms of the size versus the market size. This may have resulted in the extra $1.247 billion losses not accounted for by simple VaR measures.[34]

In addition to these measures showing Amaranth's excessive positions in natural gas, Amaranth was continuously reprimanded by NYMEX for violating trading standards and position limits on NYMEX. The Senate Subcommittee report discusses these violations in detail (See Senate Report, pp. 90-99). On April 26, 2006 for example, Amaranth violated trading rules on the May 2006 futures contract resulting in a letter from NYMEX and a CFTC investigation. In addition to this, Amaranth exceeded NYMEX position limits virtually every month in 2006 triggering reviews of Amaranth's positions.

Of particular note was an August 8, 2006 complaint by NYMEX officials that Amaranth's position in the September 2006 contract (near-month contract) was too high at 44% of the open interest on NYMEX. Figure 9 shows that Amaranth reduced this short position by the day's close by 5,379 contracts (see the change in NYMEX contracts from the close of August 7 to the close of August 8), but they also increased their similar exposure short position on ICE by 7,778 contracts. Thus, ironically, the request by NYMEX to reduce Amaranth's positions led Amaranth to actually increase their overall September 2006 position. At the same time, they also increased their exposure to the October 2006 contract; a contract that is a close substitute to the September 2006 contract. In particular, they had increased their October 2006 position in NYMEX natural gas futures by 7,655 contracts and their equivalent position on ICE October 2006 contracts by 4,984.

On August 9, 2006 the NYMEX called Amaranth with continued concern about the September 2006 contract and warned that October 2006 was large as well and they should not simply reduce the September exposure by shifting contracts to the October contract. In fact, by the close of business that day, Amaranth increased their October 2006 position by 17,560 contacts and their ICE positions by 105.75. For September 2006, Amaranth did follow NYMEX instructions by reducing NYMEX natural gas positions by a further 24,310, but increased September ICE positions by 4,155.

On August 10, 2006 another call from NYMEX urged Amaranth to reduce the October 2006 position since it represented 63.47% of the NYMEX open interest. In response to this call, Amaranth reduced the October 2006 position by 9,216 contracts, but increased their similar October 2006 ICE position by 18,804 contracts.

By the end of this three-day session of calls from the NYMEX warning Amaranth of its position size in September and October contracts, Amaranth had actually increased their overall positions from August 7, 2007 to August 11, 2006 in those two contracts by 16,484 (a decrease in September 2006 positions by 23,143 and an increase in October positions by 39,627).

The Senate Report highlighted that one of the problems with the current system is that electronic exchanges like ICE are not regulated. Thus, Amaranth was able to shift their exposure and actually increase it by using ICE without the CFTC or any other regulatory body aware of the increasing risk they were taking. In fact, in an instant message conversation on April 25, 2006, Brian Hunter wrote about ICE that "...one thing that's nice is there are no expiration limits like NYMEX clearing." (Senate Report, p. 98).

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[33]The reason that the percentage of Amaranth positions is greater than 100% is twofold. Firstly, included in this calculation are Amaranth positions on ICE, which thus is additional contracts to what NYMEX has. Secondly, the measure of Amaranth's positions included options, swaps, and other instruments that are not strictly NYMEX natural gas futures contracts, but are natural gas futures equivalents as computed by the Senate Subcommittee and NYMEX. Thus, only in Figure 4C should percentages not be greater than 100%. In Figure 4C, only Amaranth NYMEX natural gas futures positions are compared to NYMEX natural gas futures open interest.

[34]Here we are speaking about the total losses of $3.296 billion that would have resulted had they held their August 31, 2006 positions until September 21, 2006. The actual Amaranth natural gas losses were even higher at $4.071 billion, while the total change in net asset value to the main funds was $4.942 billion. These discrepancies are discussed in more detail in Section II.2.

Figure 8. The Amaranth Positions as a Percentage of NYMEX Open Interest (August 31, 2006)

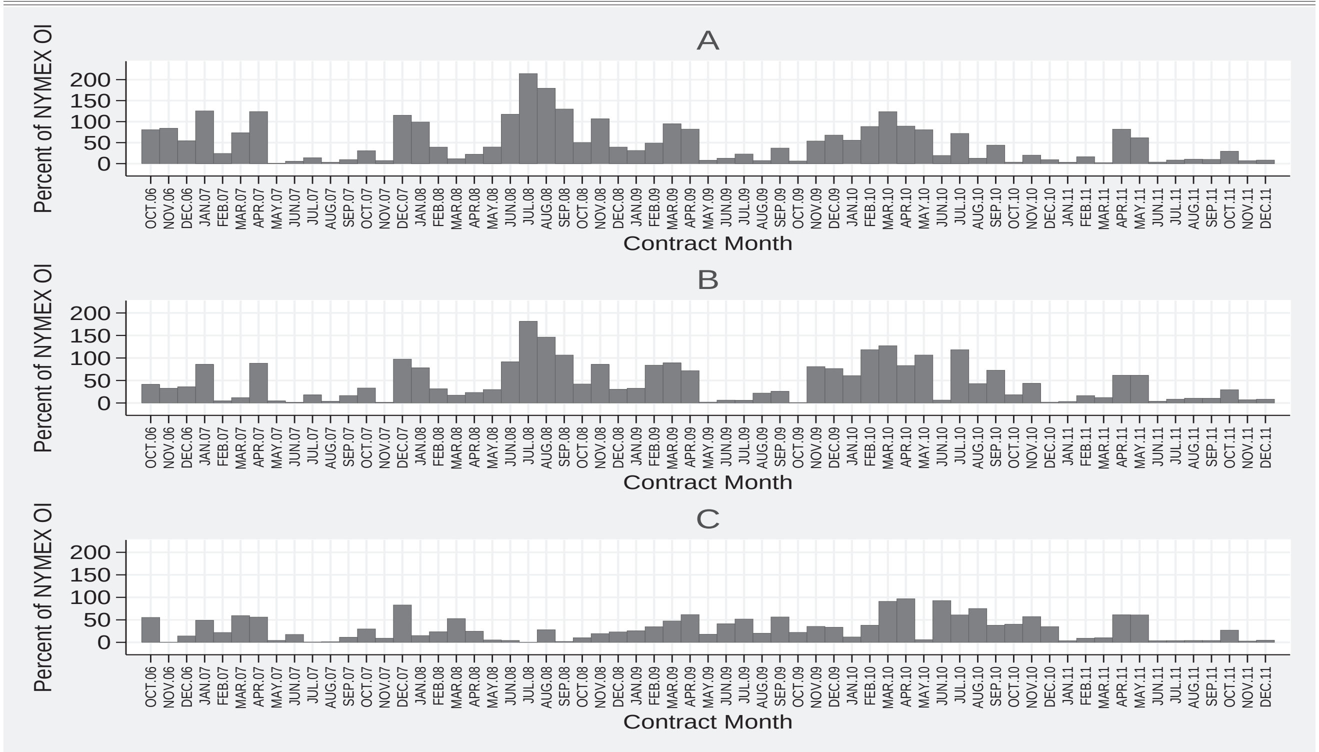
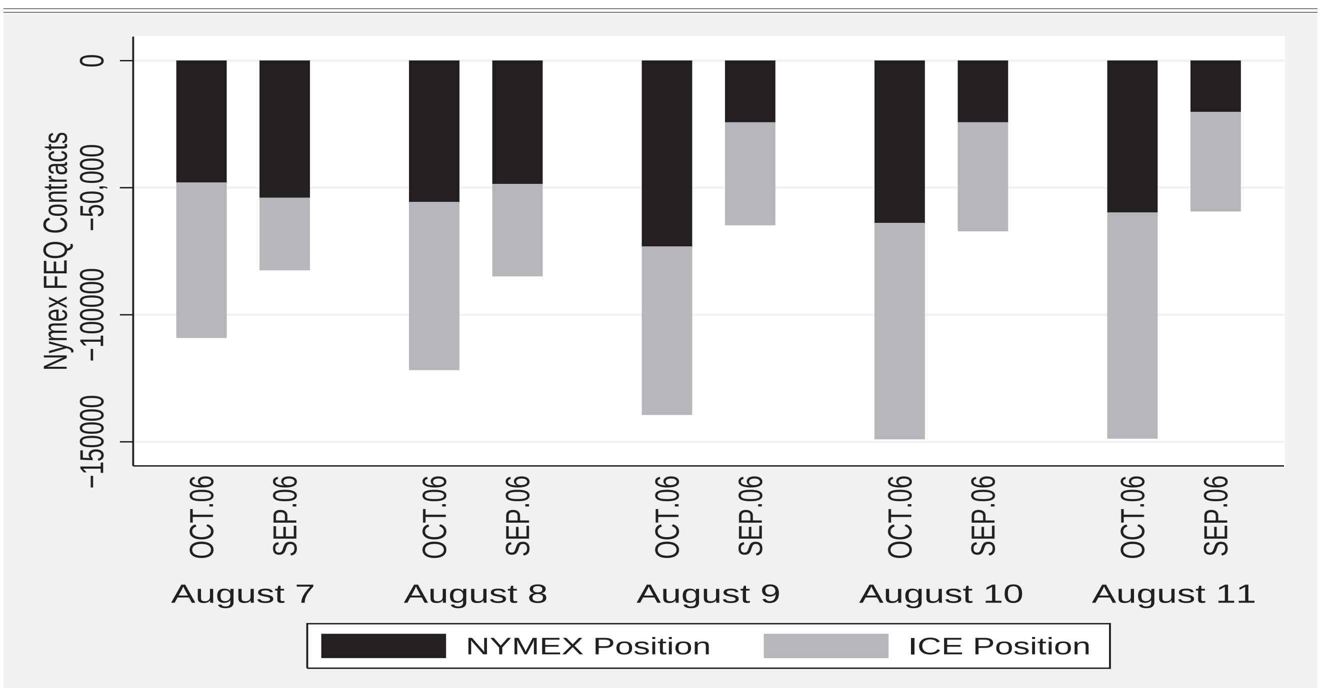


Figure 9. The Amaranth Positions in Response to NYMEX Position Limit Phone Calls



Although NYMEX only uses its position limits as guidelines of whether or not to investigate an entity's position, it is interesting to note how far above these guidelines Amaranth was. The NYMEX guideline is to examine entities with an amount over 12,000 contracts in any given maturity. One can see from Figure 8 that Amaranth had exceeded this "guideline" by a substantial amount. Perhaps a quantitative rule would be better than a qualitative rule. With quantitative rules, Amaranth's positions would never have been able to be so large.

The reconstruction of the VaR of Amaranth's positions on August 31, 2006 was high, but cannot entirely explain Amaranth's losses in September 2006 unless one designates the Amaranth collapse as a 5 standard deviation event.[35] It appears Amaranth's traders and senior management were well aware of a VaR number similar to the one produced in this paper. It seems that they were willing to take this amount of risk given the expected return they hoped to achieve. With regards to their liquidity risk, while the traders were very aware of the size of their positions, it is not clear that senior management in Greenwich really understood the extent of it. First, Amaranth's risk management with regard to liquidity did not explicitly specify position limits as a percentage of volume traded or open interest on the exchanges, so risk of this type may not have been on senior management's radar in an explicit way. Second, Amaranth allowed Brian Hunter and his trading team to move to Calgary without any risk management team (FERC Report, p. 18-19). Third, Amaranth was slowly increasing the size of their natural gas positions over the summer of 2006.

It appears that Amaranth's senior management allowed Hunter too much freedom because they had enjoyed his prior success and wanted to believe that he really was "...brilliant..."[36] and also independently "...really, really good at taking controlled and measured risk."[37] Even this statement by the CEO reveals problems with their risk management philosophy. It should not be the trader that one is confident about with regards to risk management, but rather the risk manager which is monitoring that trader's risk.

In summation, the energy traders of Amaranth were well aware of the large size of their positions and either did not care (i.e. the free option) or did not realize how perilous such a position could be. As far back as May, they seemed to be aware of the large size of their positions. In interviews by the Senate Subcommittee with Amaranth traders, they stated after the losses in May that they were waiting to see if the liquidity in the markets would come back so that they could reduce the size of their winter/summer spread positions at favorable prices.

We thought about pulling the trigger and taking the loss. We had many discussions about it. We figured we could get out for maybe a billion dollars. But we decided to ride it out and see if the market would come around.—Interview with Amaranth trader. (Senate Report, p. 77)

Yet, despite being apparently aware of the liquidity issues with their natural gas positions, they continued to act perilously and actually increased the size of their positions from the end of May to the end of August (the leverage of the natural gas positions with respect to the fund increased from 3.83 to 5.23) perhaps because they ultimately believed that the market was wrong and they were right. In their monthly letter to investors explaining the losses of May, they said "...we believed certain spread relationships remained disconnected from their fundamental value drivers." (Senate Report, p. 73).

With respect to management, the senior management in Greenwich knew of the market risk but overlooked the position size by giving too much credit to Hunter, partly out of their own greed.

C. Funding Risk

Funding risk is related to liquidity risk, but is focused on leverage in particular. [38] Any leveraged position implies that the trader borrowed some of the capital to finance his position. Leverage and funding risk are very much interlinked. For example, if a trader purchases a futures contract but keeps the remainder funds in cash (e.g. $56,250), the trader will never have funding risk, because although the future contract was purchased on margin, the trader's fund is not levered. Suppose the trader buys 2 contracts, although he only has capital to cover 1 contract. This trader's fund now has a leverage of 2 (notional value of position / cash on-hand plus initial margin). Now there is some funding risk, although it is still low. The trader will be able to meet all margin calls until the position falls by more than 50%. Thus, a rule-of-thumb in this simple example is that a trader will face funding risk anytime the return of his levered position falls by more than $1/L$, where L is the amount of fund leverage. Of course, this is only true in our simplified example where all excess capital is held in cash. It becomes even more complicated when some of this excess capital is invested in other assets.

In Amaranth's case, the leverage of natural gas future equivalents on August 31, 2006 was 5.23 ($53,524,979,537 / $10,228,192,000) with respect to just their natural gas

[35]This would imply a VaR at a 99.99997% confidence level.

[36]Unidentified trader's email to Brian Hunter when he was making money in July. Source: Senate Report, Exhibit #9.

[37]Public statement by CEO Maounis about Hunter.

[38]A more detailed version of this section is available on the the *JAF* website: www.fma.org/jaf.htm. For other descriptions of funding risk, see Culp and Miller (1994), Edwards and Canter (1995), and Mello and Parsons (1995).

exposures. To the extent that they were investing on margin in other markets, their leverage might have been even higher. Amaranth had set aside up to $3 billion of their capital in cash to meet liquidity needs according to Mr. Artie DeRocco in conversations with Nymex's Michael Christ on August 15, 2006. To the extent that only $3 billion might have been available for margin calls, Amaranth's leverage could have been considered as high as 17.84 ($53,524,979,537 / $3,000,000,000). That would imply that even a -5.6% return on their futures position would cause them funding problems. On August 31, 2006 Amaranth's initial margin on NYMEX exceeded $2.5 billion. This high margin requirement was primarily due to the notional size of Amaranth's position. In fact, if we assume that NYMEX required the maximum margin for each NYMEX natural gas equivalent, then Amaranth's positions would require $5,306,512,760.[39] Even the actual margin requirement on that day of $2.5 billion left very little room for adverse returns for Amaranth. If we observe Figure 6 on Amaranth's daily profit-and-loss from their natural gas positions, one can see that by the close of business on September 7, 2006, their total additional margin required would have been $697 million. By September 15, the additional margin required would have been $3.009 billion, and by September 21, it would have been $4.433 billion. Clearly, this was unsustainable as Amaranth did not have the cash to meet these margin calls. If we assume that on August 31, 2006 they had exactly $2.5 billion in initial margin, by September 21, 2006 they would have required around $6.933 billion of margin.[40]

What differentiates this sort of risk from other risk is that even if the strategy turned out to be profitable by month-end (which it did not), Amaranth would not have had enough funding in place to hold on to their positions until month-end. Thus, even if Amaranth's trade had been logical from a VaR perspective and a liquidity perspective, it would have not been logical or prudent from a funding risk perspective.

[39]Of course, this is unrealistically high, because it requires many assumptions. The primary assumption is that for every natural gas equivalent held, NYMEX would require the full non-member initial margin. For spread positions, consisting of two months of contracts, the initial margin requirements are much less per position at $1000 per position. Also some of these positions are for option contracts that might not require margin. Thus, this number represents an upper limit of the total margin required. Finally, this also assumes that the initial margin was calculated as if all positions were constructed on that particular day. To actually reconstruct the exact margin required by Amaranth on that day is not possible without further information that is not available. However, we do know from statements by NYMEX that on August 31, 2006 the actual margin requirement on that day exceeded $2.5 billion.

[40]Of course, this is only approximate, as some of the natural gas equivalent positions were options. Also, this would be the total margin on NYMEX and ICE together.

V. Five Lessons for Regulators and Hedge Funds

It is difficult to construct lessons after major crises because often times the specific corrections to certain situations will only cause new crises to occur under different loopholes or conditions. Nevertheless, lessons from other crises have been useful. For example, after the LTCM crisis of 1998, hedge funds learned that making sure lines of credit are really lines of credit is extremely important. Hedge funds also learned that stress testing sophisticated trading systems includes the worst case scenarios, for example when the correlation of seemingly unrelated strategies goes to one.

In the aftermath of the Amaranth collapse, there are five lessons as well.

1. First, liquidity risk is a real risk that must be accounted for by both exchanges and hedge funds, money managers, or traders. For exchanges, it means strict 'concentration limits' should be placed on a customer's positions. While NYMEX has soft position limits, they allowed human judgement, conversations with Amaranth, and greed to soften those limits up to a point, where they did not really know the severity of the enormous positions of Amaranth. By 'concentration limits', I refer to limits that are based upon some percentage of the open interest that would be dynamic over time rather than static as position limits are. The limits might also vary by contract maturity. But not only should exchanges consider strict concentration limits, they should also consider quantitative rules for managing these limits rather than ad hoc human judgement. For hedge funds, money managers, and traders, the lesson has long been known—don't own too much of a market in combination with leverage. If prices move adversely against one's levered position, margin calls might require the trader to reverse the positions to acquire cash to make the margin calls. These position reducing trades may make the prices move further adversely and perhaps cause prices to deteriorate so much that the investor loses more than his or her capital and goes bankrupt. If a trader limits the concentration of his position in a certain market, it will help insure that in the case he would like to reduce or close his position, there will be a sufficient number of other traders to absorb his selling pressure without moving prices too much.

2. Transparency across exchanges in the same market may be useful. In the case of Amaranth, the NYMEX knew of Amaranth's NYMEX positions, but did not know of the other positions held with ICE. Although the CFTC oversees the NYMEX, they had no jurisidiction over ICE, since ICE is an unregulated energy trading platform. Were there a system held by the CFTC that could oversee all positions on energy platforms, the excesses of Amaranth could have been spotted. By forcing Amaranth to hold much more reasonable positions, Amaranth investors would have ultimately been better off. Also, the possible manipulation by one entity of security prices would be avoided. Amaranth's selling of large positions may have caused intense volatility in natural gas prices causing actual users of natural gas (i.e. households) to pay high prices which may have been artificially high due to the excessive positions of Amaranth. In fact, Amaranth and Amaranth traders are currently being sued over the matter (FERC (2007)).

One of the steps to improve transparency in the U.S. markets is a bill introduced on September 17, 2007 by Senator Carl Levin of Michigan to regulate electronic energy trading facilities by registering with the CFTC (Levin (2007)). The bill also proposes to provide trading limits for energy traders that can be monitored by the CFTC across all energy trading platforms and exchanges, and requires that large domestic traders of energy report their trades on foreign exchanges. The bill defines precisely what constitutes an "energy trading facility" and an "energy commodity".

3. More standard measures of liquidity risk ought to be devised so that, as with VaR, traders, risk managers, regulators, and exchanges have a language to communicate with each other.

4. There are lessons for internal risk management. It might be important to have risk managers in the same location as traders, rather than thousands of miles away. It might also help to follow guidelines that many large banks have of allotting only certain risk capital to certain traders and diversify across the firm, rather than have one trader, like Hunter, use the majority of the firm's capital and be responsible for the majority of the firm's performance. After all, Amaranth was not an energy trading hedge fund, it was a multi-strategy hedge fund. Along that line of thought, one might even consider a different incentive scheme for risk managers. Risk managers are not paid as well as traders. This causes their voice to be less important in the firm. And of course, risk managers' bonus also depends on firm profits. Thus, to a certain extent they will also be reluctant to reduce the firm's aggressive trading activities. They have a "free option" too. It is not clear that there is a simple way to restructure the incentives of risk managers, but it might be worth thinking about.

5. Spread positions can lose money and are not "arbitrage positions", especially when the size of these positions is large. Spread positions are usually thought of as less risky than outright positions, since by being long curtain contracts and short other contracts, the position is less exposed to the directional volatility of the natural gas market. It should be stressed that these positions have lower risk, but they do have risk. That is, the returns of these positions do exhibit some volatility, even if this volatility is smaller than outright positions. If a trader leverages these spread positions, the volatility increases linearly with the leverage. Thus, for a large enough leverage, the spread position can be as risky as or even riskier than an unleveraged outright position. This is because the spread positions are not arbitrage positions, they are just less volatile positions. Thus, when evaluating spread trades, one should consider the amount of leverage and its effect on actual volatility and not naively assume they have lower risk.

There are critics of the new proposals for regulation in the US natural gas markets. The criticisms fall into four categories. First, there is a camp that believes Amaranth's positions were not too big for the market and that setting strict positions limits will compromise "...the efficient transfer of risk in the market place," (Watkins (2007)).Second, some people do not wish there to be multiple regulatory agencies regulating the natural gas futures market. Third, some people worry that regulation will cause business to transfer to overseas markets. Finally, some argue that the regulation will ultimately not work, because market participants will find other loopholes (Watkins (2007)).

Each of these criticisms will be discussed in more detail along with my own thoughts with respect to each of them. The first criticism is that position limit constraints will prevent "...legitimate speculation..." and thus make markets less efficient. Also, the critics worry that position limits and laws can become outdated. The first comment assumes the proportion of arbitrageurs is very small in the market place. To the extent that there are many speculators in natural gas, the transfer of risk can still be accomplished — it just will reduce the likelihood that the speculation is in the hands of just one large speculator. While it is true that laws will become outdated, it doesn't mean they are not useful in the short-run. In addition, position limits can be made relative so that they do not become outdated quickly. For example, rather than have a limited specific number of contracts for each speculator, an exchange could have that number depend upon some percentage of average daily trading volume or of open interest. Also, regulation could allow exchanges and governing bodies to update position limits as market conditions change.

The second criticism is about the number of regulatory bodies in the natural gas markets. Currently, some market participants, including major investment banks like Goldman Sachs, Morgan Stanley, Merrill Lynch, and J.P. Morgan, are opposed to having both the FERC and the CFTC with authority over the commodities markets. Their argument is that too many regulatory agencies might raise confusion and costs among market participants. While this is certainly a negative, the Levin proposal does not encourage multiple regulatory bodies. It specifies the CFTC as the only regulatory body. However, the reality is that when market participants are perceived to have acted incorrectly, many affected parties may resort to legal action, as the FERC has done with regards to Amaranth, even if they are not explicitly assigned the role of regulator.

The third criticism is that increased regulation will lead market participants to overseas trading venues, such as Singapore. While this is always a possibility, it could be argued that the increased transparency and minimal standards of the US exchanges may draw people to the US exchanges precisely for these reasons. For example, although listing requirements on the NYSE are more stringent that those of NASDAQ, the NYSE has not gone out of business despite the rise of the NASDAQ. There will, of course, be firms that find it more desirable to go elsewhere.

The fourth criticism is that regulators "...will always be one step behind the innovating and evolving markets" (Watkins, 2007). This statement is absolutely true. However, this does not mean that regulatory constraints in cases where market failures or externalities exist are not appropriate. The correct question is whether or not externalities and market failures potentially exist in the market for natural gas. In the end, we must answer this crucial question before deciding whether regulation is a good or a bad thing.

Without regulation, Amaranth was able to acquire enormously large positions on NYMEX and ICE that may have led to a distortion of natural gas prices which ultimately affected consumers of natural gas.[41] However, even though Amaranth's positions on NYMEX were regulated by the CFTC, they still were extremely large. So it is not clear that the regulation *per se* will solve the problem. The position limits on NYMEX were very loosely enforced and subject to interpretation by NYMEX officials. It was only at late stages of the Amaranth debacle that Amaranth moved substantial positions from NYMEX to the unregulated ICE.

Although this paper was not primarily concerned with Amaranth's effect on natural gas futures prices, a preliminary investigation was done using data on daily natural gas returns and trades by Amaranth. Some evidence was found that contracts which Amaranth sold led to lower returns than other contracts in which Amaranth was not trading. For a more detailed discussion of this analysis, see the supplemental section entitled *The Price Impact of Amaranth's Trading* on the JAF website.

VI. Conclusion

The collapse of the hedge fund Amaranth Advisors in September of 2006 drew a flurry of attention. There are several reasons why this hedge fund failure attracted such widespread media attention. First, the size and speed at which Amaranth made losses. In less than 14 days, from September 7, 2006 to September 21, 2006, they had lost almost $4 billion. Second, their losses occurred in the natural gas markets. There is some evidence that Amaranth's trading activities in the natural gas markets distorted market prices and ultimately hurt consumers of natural gas. For instance, the Municipal Gas Authority of Georgia (MGAG) complained that its hedging costs with abnormally high winter natural gas prices caused its consumers losses of $18 million during the winter of 2006-2007 (Senate Report, p. 115). Third, the failure raised new concerns about risk management and leverage. In particular, it raised questions about how large a position and influence an individual entity should have over a financial market, like the natural gas futures market.

This paper dealt specifically with examining the actual positions of Amaranth in the natural gas market to understand whether conventional risk measurement tools could have estimated the large risks that caused their collapse in September 2006. The paper finds that Amaranth's VaR on August 31, 2006 was $1.334 billion and $2.048 billion at the 99% and 99.95% confidence level. Although large, these numbers of rather low probability events still underestimate their actual losses in natural gas of $4.433 billion and decrease in their net asset value of $4.942 billion. In fact, the paper finds that it was the management of their liquidity risk that was vastly irresponsible. Amaranth's NYMEX natural gas futures equivalent positions in certain maturity contracts exceeded 200% of the NYMEX natural gas open interest. Their ownership of NYMEX natural gas futures contracts alone was, in certain maturities, close to 100% of the open interest. When markets turn against a trader's position, futures exchanges will require additional margin to maintain those positions. Once the trader's cash on-hand and borrowing sources are exhausted (funding risk), he can only meet margin calls by selling the underlying assets. If that trader owns a large percentage of that market, he can only sell those assets by forcing the prices even lower and thus creating further losses and further margin calls. This is known as liquidity risk. A combination of liquidity and funding risk ultimately caused Amaranth's collapse.

There are several lessons from the Amaranth debacle that have to be relearned. First, even if a strategy has a positive excess return with low volatility historically, with or without a theoretical justification for the strategy, that strategy can still have negative returns in the future. With leverage, these negative returns are amplified. Second, firms need to manage liquidity risk explicitly. The inability to sell a futures contract at or near the latest quoted price can be related to one's concentration in the security. In Amaranth's case, the concentration was far too high and there were no natural

[41]A distinction should be made between manipulation of natural gas prices and impacting natural gas prices due to the large size of a trade. The former is illegal according to Sections 6(c), 6(d), and 9(a)(2) of the Act of the CFTC which authorizes the CFTC to bring enforcement actions against any person who is manipulating or attempting to manipulate or has manipulated or attempted to manipulate the market prices of any commodity in interstate commerce or for future delivery on or subject to the rules of any registered entity. Both price manipulation and price impact are valid concerns for regulators, but one is illegal.

counterparties when they needed to unwind the positions. Third, exchanges can only adequately manage their position limits if they have disciplined rules for doing so and transparency. Currently, a bill has been introduced by Senator Carl Levin to address the second point and regulate energy trading facilities (Levin, 2007). The importance of limiting concentration comes also through the potential for price manipulation which can distort prices and have an unfair income distributional effect. It can also lead to larger uncertainties and less effective decision making by individuals. Amaranth is currently being sued by the Federal Energy Regulatory Commission (FERC) for price manipulation in specific instances. Their intent is to penalize Amaranth for unjust profits and civil penalities, in addition to seeking $30 million from Brian Hunter as well (FERC, 2007).

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