Corporate Risk Management and the Role of Value-at-Risk

by

Dwight R. Sanders and Mark R. Manfredo

Suggested citation format:

Sanders, D. R., and M. R. Manfredo. 1999. "Corporate Risk Management and the Role of Value-at-Risk." Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL. [http://www.farmdoc.uiuc.edu/nccc134].

Corporate Risk Management and the Role of Value-at-Risk

Dwight R. Sanders and Mark R. Manfredo*

Value-at-Risk (VaR) estimates the downside risk of a portfolio of assets, usually derivatives, at a particular confidence level over a specified time horizon. VaR plays an important role in corporate risk management. This discussion piece highlights the role of VaR in the context of a corporate risk management system. The informational demands of such as system are presented in the context of a foodservice business that uses derivatives products to manage absolute price risk. Risks inherent in the use of derivatives products are also outlined. Through an examination of the informational demands of corporate risk managers, as well as the risks of derivative products, avenues for future research regarding the estimation of VaR measures are presented.

Introduction

Corporate risk management is the process of identifying, measuring, and controlling relevant risks that impact the business unit. Value-at-Risk, also known as VaR, plays an integral role in overall corporate risk management systems and is a powerful risk measure. Value-at-Risk estimates the downside risk of a portfolio at a particular confidence level over a given time horizon. For example, a VaR of $1 million with a 95% level of confidence suggests that potential portfolio losses will exceed $1 million with a 5% probability over the given horizon (e.g., one-day). The popularity of VaR has generated considerable interest among financial economists. Therefore, the academic literature regarding VaR has focussed on procedures for estimating the risk measure. This line of literature, while important, neglects to address the realistic needs of corporate risk managers. Subsequently, the objective of this research is to describe one potential corporate risk management system for a commodity end-user, illustrate the role that VaR plays in this process, and identify avenues of research that consider the needs of corporate risk managers in the development of VaR measures.

This piece discusses VaR from a business perspective. After briefly reviewing the existing literature on VaR, we examine Value-at-Risk in the context of a corporate risk management system. For instance, what drives the business demand for VaR estimates, and how is this demand met with the known statistical attributes of the different VaR estimation methods? We examine these issues from the perspective of a traditional commodity end-user who utilizes derivatives for controlling costs. Furthermore, in developing the paper's framework, we review the types of risk derivatives users inherently face. One potential risk management system is presented that focuses on the informational demands placed on VaR. From this exercise, insight is gained into the practicing risk manager's needs; thereby, we provide an agenda for future research regarding VaR estimation.

Review of Literature

Value-at-Risk estimation procedures are typically divided into two major classes: parametric and simulation. Parametric procedures rely on point estimates of portfolio volatility forecasts that are scaled to a desired confidence level under the assumption of normality. Simulation procedures include historic and Monte-Carlo simulation, where the entire portfolio

* Dwight R. Sanders is the Manager of Commodity Analysis for Darden Restaurants, Inc., Orlando, Florida. Mark R. Manfredo is an assistant professor in the Morrison School of Agribusiness and Resource Management at Arizona State University.

return distribution is simulated and the VaR measure is taken as the percentile associated with the desired confidence level (Manfredo and Leuthold; Linsmeier and Pearson; Jorion; Duffie and Pan). Due to its intuitive appeal, VaR has been touted as "state-of-the-art" in measuring derivative portfolio risk.

As a result of the interest in VaR, considerable research effort has been expended to determine the statistical attributes for the various methodologies of computing Value-at-Risk measures. This research yields numerous insights into the performance of the competing methodologies. It has been found that both parametric and simulation procedures adequately capture portfolio losses at modest confidence levels (e.g., 90% and 95%) despite the common acceptance that the distribution of returns for financial assets are fat-tailed (Hendricks; Mahoney; Jackson, Maude, and Perraudin). However, debate continues as to the most robust procedure for estimating VaR over a wide range of potential portfolios, confidence levels, and time horizons.

Value-at-Risk plays a key role in a corporation's overall risk management system. Therefore, it is important that researchers understand the business demand for VaR estimates by focussing on this role. VaR is not a stand-alone risk management system, and it is not a panacea for poor risk management practices. Rather, it is one tool in the risk manager's toolbox and one component of the risk management process. Because of this, there are other considerations than simply the statistical accuracy of the VaR estimate. These include: reporting procedures, accounting requirements, management needs, ease of implementation, the ability to handle various instruments (futures, options, forwards, and exotics), as well as the appropriate parameters for the VaR estimation (time interval and confidence level).

Risks Faced by the Derivatives User

The desire to control *price risk*, unexpected changes in the market value of an asset or liability, creates the demand for derivatives. However, the practice of using derivative instruments themselves inherently introduces a new set of risks that must be managed. Presumably, the collection of derivative risks and the benefits of hedging are preferred to the initial price risk to which the firm is exposed. Keeping with the theme of this paper, we discuss these risks from a commodity end-user's point of view.

A derivatives position entered into as a hedge against price risk does not completely eliminate *market risk* in so far as there exists *basis risk*, *rollover risk*, *liquidity risk*, and *funding risk*. *Basis risk* results from utilizing a derivative whose underlying asset is somehow different from that being hedged. *Rollover risk* stems from an inability to match the derivatives' maturity date exactly with the timing of an intended cash transaction.[1] *Liquidity risk* is the cost associated with finding an immediate buyer/seller of a derivative contract. Liquidity risk is proportional to the ratio of the position size to market size. *Funding risk* is the ability to meet cash flow requirements associated with derivative positions (e.g., margin calls). Funding risk can be exacerbated by a failure to properly tail a long-term hedge (see Smithson and Smith). *Credit risk* is the possibility of payment default associated with derivative positions, especially those derivative products that are not exchange traded. *Operational risk* stems from a lack of control and human error in derivatives trading. In particular, operational risk is associated with potential

[1] Rollover risk, in particular new crop-old crop rollover risk, was the unanticipated market risk that caused financial distress for grain elevators using hedge-to-arrive contracts (see Lence, Hayenga, and Harl). A Value-at-Risk simulation for these hedges may have prepared the elevators for this possibility.

fraud and unauthorized trading resulting from a lack of transparency in the management process (e.g., the Barring's Bank Scandal). In addition, operational risk includes risks associated with use and potential failure of quantitative models and technology. *Legal risk* stems from shareholder lawsuits, and it includes compliance, regulatory, and accounting issues. *Systemic risk* is the risk of a system wide financial collapse (perhaps due to derivative payment defaults).

Senior management might view these outlined derivative risks as greater than the initial price risk; hence, "no derivatives" policies may be formed. A corporation's risk management process must function to measure and control (monitor) all of these risks. This is not an easy task. In this paper, we focus on the role of Value-at-Risk (VaR) in the management process. Although VaR is frequently thought of as simply a means of measuring market exposure. It can actually provide a much more robust tool for the corporate risk manager. To illustrate its uses we examine the hypothetical use of VaR in the context of a commodity end-user.

The Case of a Commodity End-User

The Risk Management Process: An Example

Let's take the case of a publicly held foodservice firm that manages raw commodity price risk with a simple hedging program. We assume that the forward pricing tools at the firm's disposal are restricted to exchange traded futures and options on futures. The firm implements the risk management process shown in Diagram 1.

Diagram 1 presents one potential process for monitoring and controlling risk within a firm. The process itself is designed to combat *operational risk* (*i.e.*, fraud and unauthorized trading) inherent in a derivatives operation. The key to curtailing operational risk is transparency, communication (i.e., reporting), and the separation of activities. VaR is an important tool in keeping the process transparent and communicating risk to key players. It is the role of the risk manager to provide timely and accurate information in a usable format. The following discussion is centered on the players and information needs illustrated in Diagram 1. First, the general structure of the risk management process is outlined, and then the role of VaR is examined.

The top line of control is the Board of Directors. They approve the firm's official operating policies and procedures which establish markets and instruments that can be traded, approve overall risk limits for the firm, and designate the senior executive officers who can authorize trading accounts. Senior purchasing officers establish internal guidelines based on business objectives. They are responsible for designating trading authority and authorizing accounts as well as assuring that the firm has competent personnel in each position.

Strategic pricing decisions are a function of the firm's business objectives within the existing market environment (current and anticipated price levels and market risk). Pricing decisions are made with input from business managers, commodity analysis, traders, buyers, and the risk manager (who provides feedback as to the risk associated with particular pricing decisions). Pricing decisions are typically expressed in terms of time. For instance, the decision-makers may decide to forward-price the equivalent of three months of soybean oil usage and six months of coffee usage.

Pricing decisions are implemented by the trader, who initiates transactions with a futures broker.[2,3] The broker is provided with a list of authorized traders, markets, and maximum order size. Although not legally responsible for exceptions, the broker is asked to confirm deviations from this list with purchasing management. All funds flow between the Treasury Department and the broker's Futures Commission Merchant (FCM). The Purchasing Department is not authorized to perform wire transfers involving the futures account. Hedge gains or losses are communicated to the Accounting Department who couples them with the cost of goods sold under GAAP and FASB guidelines. This information is worked into the appropriate financial statements, which must include a disclosure of derivatives positions and their risk. Eventually, the firm's financial performance is reported to the Board of Directors and ultimately evaluated by (potential) shareholders.

Value-at-Risk is a valuable communication tool in this process. However, the information that is contained in the VaR estimate differs depending on the audience and its intended use. It is the role of the risk manager to communicate appropriate information to each member of the organization. In the context of a traditional commodity end-user, we discuss the different informational demands placed on VaR estimates by the various members of the organization represented in Diagram 1.

Informational Demands

A Value-at-Risk calculation conveys a dollar amount at risk over an interval of time at a given confidence interval. Immediately, three issues arise: Dollars at risk versus what benchmark? Or, value of what? What is the relevant time horizon? What is the appropriate confidence interval? These are just some of the issues involved in providing meaningful VaR calculations.[4] Despite the statistical rigor that can enter a VaR calculation, it is still a management tool. Thus, the correct information must be calculated and explained to a potentially non-technical management team. In fact, the popularity of Value-at-Risk is partially due to its ease of understanding by managers with limited statistical expertise (Jorion; Linsmeier and Pearson; and Manfredo and Leuthold). In the course of this discussion it is useful to remember the typical management goal of VaR: no surprises. Therefore, it is crucial that the communicated VaR adequately measure the appropriate risks for the given audience. Consequently, there may not be a single VaR within a given firm at a point in time. In the following, we discuss some of the different informational needs within the firm.

---

[2] The trader's job is tactical in nature. He is given the task of executing the strategic pricing decision in an optimal manner. As an example, the strategic pricing decision may be given in terms of delta (e.g., three months of delta equivalent coverage). The trader may decide to accomplish this with a combination of futures and options (as opposed to just buying three months of futures) based on their assessment of market conditions. Clearly, the trader's performance must be measured on a risk-adjusted basis versus a benchmark to determine if they are adding value to the process. Likewise, all market related decisions should be evaluated on a risk-adjusted basis. Often, a form of VaR is used as the measure of risk in this analysis.

[3] Most end-user firms also employ commodity buyers. Buyers essentially purchase logistics, manufacturing services, and quality for particular commodities. Their role in risk management and pricing is minimal except to the extent they work with the trader to coordinate cash, futures, and basis positions.

[4] It has been suggested that the appropriate time horizon is that which is required for an orderly liquidation of the portfolio (see Jorion). However, that implies that the liquidity risk of immediate execution is more costly than the additional market risk inherent in the time required to perform an orderly liquidation.

The Treasury Department is responsible for settling cash balances with the FCM. Futures and options positions are marked-to-market daily. Cash settlement may occur daily, or an agreement may be reached with the FCM to wire weekly unless the daily equity balance exceeds a predetermined amount which requires an immediate wire (e.g., weekly wires versus Friday's settle, unless the equity balance exceeds $500,000 which requires immediate wire). Clearly, the settlement terms determine the type of VaR needed for cash management. Treasury must know the potential cash demands at any point in time. So, the relevant time horizon used in a VaR calculation may be daily or weekly (or both). Risk is measured versus the market—i.e., cash flows due to adverse market price movements. Furthermore, the confidence interval needs to be very high (e.g., 99%), because the clearing firm retains the option to liquidate positions if cash is not presented upon request. Also, an unexpectedly large cash requirement may draw upon suboptimal financing which increases the cost to the corporation.

Estimating funding requirements for cash management involves a thorough understanding of exchanges' cross margining among futures and options (*i.e.*, SPAN). For instance, option premiums paid can serve as initial margin on futures, but maintenance margin must be met with cash. Therefore, a synthetic call constructed with futures and at-the-money puts has funding risk that is not shared by its economically equivalent at-the-money call option. It is important that the risk manager thoroughly understand the margining and costs associated with the trader's positions so as to provide the relevant VaR to the cash manager.

The VaR information required by purchasing decision-makers can be quite different from that of Treasury. Here, the informational demand revolves around the pricing decision. Thus, the relevant time horizon used in the VaR estimate tends to be longer (e.g., the average length of time hedges are held). However, the confidence interval need not be quite as high as it is for cash management purposes. The benchmark tends to be the market; but, it is not uncommon to measure risk versus some other pricing alternative or internal benchmark. For instance, purchasing managers may want to know their risk versus a planned cost for the quarter. Again, this requires a very different VaR calculation than one that conveys strict exposure versus the market.

Other departments have informational needs unique to their positions. For instance, Accounting and Corporate Reporting's informational needs are largely determined by guidelines set by outside regulatory agencies (e.g., S.E.C.). This information may or may not be met by an existing VaR calculation. The trader, on the other hand, most likely wants to know their market risk exposure on a day-to-day basis. Again, this may require a VaR that is different from others being calculated.

The Board of Directors sets a VaR limit that is all-inclusive and represents the firm's tolerance to meet current changes in pricing with anticipated future revenues (cash flow at risk due to derivatives positions). This VaR is the risk manager's veto on proposed and/or existing derivative positions. The VaR approved by the Board typically refers to a time horizon relevant from an operations and reporting standpoint (e.g., a month or a quarter), and it includes all risks and costs associated with the derivative positions. This might include option premiums, market risk, liquidity risk, rollover risk, and credit risk. Essentially, anything that can create a current cash liability in the hedge account must be captured in this measure.

It is the role of the risk manager to adequately measure and control risk within the system. He must make sure that each concerned party gets the appropriate information to perform their function while effectively monitoring the overall risk exposure of the firm. At the same time, the risk manager must be certain that the measurement techniques being utilized (e.g., VaR) are accurate and robust in regards to unique combinations of futures, options, and spreads. In the following we look at a very simple example of how VaR calculations can aid in this process, and illustrate some of the practical considerations for any risk measurement tool.

Value-at-Risk: An Example

Let's assume that a foodservice firm's essential inputs include soybean oil (frying shortening), wheat (hamburger buns), boneless beef (hamburger patty), and raw coffee beans (coffee). The pricing tools at the firm's disposal are relatively simple: exchange traded futures and options. The buyer has arranged for particular items to be priced on a cost-plus formula from the nearby futures price for each raw commodity. So, the price of each commodity-driven input (shortening, buns, beef patties, and coffee) is directly tied to the nearby futures price and *basis risk* is not an issue. Therefore, the firm's raw commodity risk is defined by wheat futures (Kansas City), soybean oil futures, coffee futures, and boneless beef futures. Likewise, since the derivative instruments are exchange traded, we will ignore *credit* and *systemic risk* for this analysis.

The risk manager must decide upon a method(s) for calculating Value-at-Risk for futures and options positions in these markets (e.g., parametric or simulation approaches). Although there are many commercial packages available, he decides to perform the calculations himself to guarantee a thorough understanding of what underlies the resulting VaR. The available options include a traditional variance-covariance portfolio approach, historical simulation, and monte carlo simulation (Linsmeier and Pearson; Jorion; Manfredo and Leuthold). Worried about the fat tails associated with asset returns, yet not wanting to use a methodology that is too difficult to explain, the risk manager chooses the historical simulation for generating the desired information.

Summary statistics for weekly nearby futures returns (Friday-to-Friday log relative price changes) are presented in Tables 1 and 2. The data are collected from April, 1986 through June, 1998 (635 weekly observations). Boneless beef futures are relatively new, so cash prices are used as a proxy for nearby futures. [5,6]

Assume that the pricing coverage in Table 3 is proposed. The risk manager's first priority is to make sure that the VaR associated with this position does not exceed that approved by the Board of Directors, $1.000 million at the 95% confidence level for a one month holding period. To assess the risk associated with this position (futures only), the risk manager performs a boot-strap historical simulation. That is, weekly historical return data is sampled (10,000 draws with replacement) to simulate a new price distribution four weeks hence. The proposed

[5] This is a common problem with new commodity markets. That is, historical time series data may be difficult to obtain (especially high frequency observations). This makes all VaR estimation procedures tenuous in the sense that the distribution of past returns is not available from which to form expectations concerning future returns.

[6] It is clear that coffee is the most volatile commodity followed by boneless beef, soybean oil, and wheat (Table 1). The variances are statistically different at the 1% level for each market pair except soybean oil and wheat (p-value = 0.1085). In Table 2, only soybean oil and wheat demonstrate a correlation that is statistically different from zero (5% level). This information is useful if the risk manager decides to use the variance/covariance parametric estimator for VaR. It also conveys to the risk manager the diversification inherent in the derivatives portfolio.

portfolio is re-valued at the simulated prices, and the change in its value is the Value-at-Risk. The VaR is shown in the histogram in Figure 1.

The VaR at the 95% confidence level is $334 thousand and it is $477 thousand at the 99% confidence level. The data presented in Figure 1 raises a few interesting points. First, we are ignoring all risk except market risk (adverse price moves). In particular, we have not addressed the liquidity risk associated with a new and relatively illiquid boneless beef futures market. Second, the worst-case scenario (minimum) in the simulated distribution is $854 thousand (still a safe distance from the $1 million mark). Third, the distribution is positively skewed, the largest move is up $1.265 million. Can the risk manager be comfortable that this move cannot occur in the lower tail of the distribution?

Treasury settles with the FCM weekly on Friday evening versus that day's market settlement price. Therefore, the Treasury Department needs a one-week VaR that reflects funding risk for the position. This VaR is simulated by sampling (10,000 times with replacement) from the weekly return data and generating a price distribution for one week hence. The portfolio is revalued at the simulated prices and the change in its value is calculated. The resulting VaR is shown in Figure 2.

The VaR at the 99% confidence level for one-week is $253 thousand, and it is $152 thousand at the 95% confidence level. So, Treasury must be prepared to wire at least $152 thousand almost three times per year (assuming the portfolio and its estimated market risk doesn't change). Again, the simulation method allows us to see the worst case scenario as well as the shape of the distribution. The worst-case (as defined by this particular data set) is a market loss of $369 thousand. However, the upper-tail contains an observation at $591 thousand. The cash manager and risk manager should be aware of this information. Although, it is not a VaR measurement *per se* this information is somewhat akin to stress testing, and it provides a thorough picture of potential cash flows.

Discussion and Assessment

As discussed in the literature review, academic research has focussed on the statistical properties of VaR, in particular the sensitivity of alternative procedures to various data sets, portfolio composition, confidence levels, and tail behavior. This research needs to be continued, especially since VaR has been advocated for new uses beyond obvious applications for risk reporting and disclosure (e.g., agricultural risk management). However, the previous discussion regarding the risks associated with holding derivatives positions, as well as the informational demands of risk management decision makers, is useful in identifying future research frontiers related to VaR estimation. Specifically, this discussion helps to pinpoint areas in which current research regarding VaR can be expanded.

Value-at-Risk is designed to capture low probability events associated with adverse price movements; a form of market risk. However, the holding of derivatives positions, while limiting absolute price risk, introduces other forms of risks that can not be ignored (e.g., liquidity risk, funding risk, and rollover risk). While adequately addressing the question of statistical accuracy of alternative VaR estimation procedures, researchers have not engaged the question of how these procedures capture these "other" risks. Are there certain procedures that are more robust in capturing these risks? Furthermore, it is apparent that the informational demands placed on VaR by different players in a corporate risk management system are varied. Each corporations' risk management system is unique, thus further complicating the problem. Is it necessary for a risk manager to calculate the VaR differently for each decision-maker in the risk management process (Diagram 1)? Ideally, procedures for estimating VaR should be robust to a wide range of relevant derivatives risks and should also be sensitive to varying informational demands. This is an important and needed line of research.

Another factor to consider is the correlation among various risks in times of distress. Assume that a 1% event does occur and our VaR estimate is exceeded. Low probability events put the most stress on the entire system. For instance, if there is a large tail event, most likely this is also a time when defaults (i.e., credit risk) are likely to occur for non-exchange traded derivatives positions (e.g., swaps, over-the-counter options). Similarly, liquidity risk is also high during a tail event. This may be a period of time when a futures price is locked-limit or gaping, making it difficult to get out of a position. This liquidity risk may be exacerbated if the position held is large versus the size of the market. Do existing methods of calculating VaR estimates consider this correlation among risks? Is it necessary to scale a VaR estimate upward to account for these other types of risks or are they adequately captured through existing estimates? Tail events (i.e., large losses) also create the greatest incentive for traders (and others) to cover-up bad trades. Is transparency in the risk management system maintained when a tail event occurs?

Given that academics have focussed on the statistical properties of VaR estimates, it is important to consider if differences in VaR forecasts resulting from alternative estimation procedures (e.g., parametric and simulation) are really economically significant. Consider the previous example where a board of directors mandates VaR to be no more than 1.000 million dollars at the 95% level of confidence. The VaR calculated at the 95% level for this example was $334 thousand. Obviously, this VaR is well below the mandated VaR of 1 million. However, what if the estimate using a historic simulation approach were $950 thousand at the 95% level? Would the risk manager engage in strategies that yielded a VaR so close to the board mandated limit? A prudent risk manager is unlikely to engage in strategies that push this limit, especially if he is aware of the risks which standard VaR measures do not capture (e.g., liquidity risk). Suppose now that the same risk manager also computed VaR using a variance-covariance (parametric) approach instead of a simulation approach for the same underlying strategy, yielding a VaR estimate of $900 thousand. Will the risk manager now engage in the strategy given this new VaR estimate? Is a VaR of $900 thousand still to close to the mandated limit? Despite the potential differences in VaR estimates among estimation procedures, one must ask if these differences are economically significant given that a risk manager is unlikely to accept a strategy that pushes the VaR limit set by the board of directors.

It is important to note that the examples presented in the previous section are simplistic in that they only consider risks inherent in nearby futures positions. In reality, hedges may be placed in contracts that are more distant than the nearby contract. In these cases, it may be necessary to model the returns of more distant contracts as well as the nearby contract, thus complicating the VaR estimation process. This is especially true for hedges in annual crops where the hedge may span a crop year. Another consideration is the treatment of options positions. The existing literature has acknowledged the inherent difficulty of developing VaR estimates when options positions are included in the derivatives portfolio, yet the literature has provided few solutions. Several researchers (Jorion; Ho, Chen, and Eng; Risk Metrics) have advocated the use of option deltas and gammas in approximating the non-linear risks of options positions. However, little if any empirical research has been conducted examining the accuracy and robustness of these recommended procedures. Furthermore, if a tail event does occur, and options are held in a derivatives portfolio, how will the increased volatility resulting from the tail event affect the VaR estimate? In these situations, is it also necessary to consider vega estimates in addition to deltas and gammas?

Conclusions

This discussion piece examined Value-at-Risk from a corporate risk management perspective. Specifically, this research isolated the informational demands placed on VaR in the context of a hypothetical but realistic corporate risk management system for a commodity end user. In addition, this paper identified various risks associated with holding derivatives positions. From this analysis, research ideas related to the estimation and use of VaR were identified.

Currently, research related to VaR estimation centers on testing various parametric and simulation procedures over alternative portfolios, data sets, confidence levels, and holding periods. This research continues to be important, especially since there is no consensus as to a "best" estimation procedure. As Value-at-Risk continues to gain popularity among financial economists and risk management practitioners, academic research related to the topic will continue to grow. Therefore, it is important that research related to the estimation of VaR consider both the informational demands placed on VaR as well as the inherent risks to which derivatives users are exposed. As with any modeling exercise, it is difficult to develop VaR estimates that capture all the informational demands and risks faced by corporate risk managers. Despite this, the search for procedures that are robust in capturing derivatives risk and the informational demand of risk managers appears fruitful.

References

Duffie D. and J. Pan. "An Overview of Value at Risk." *The Journal of Derivatives*. 4(1997): 7-49.

Hendricks, D. "Evaluation of Value-at-Risk Models Using Historical Data." Federal Reserve Bank of New York Economic Policy Review. April 1996, pp. 39-69.

Ho, T.S.Y., Chen, M.Z.H., and Eng, F.H.T. "VAR Analytics: Portfolio Structure, Key Rate Convexities, and VAR Betas." *The Journal of Portfolio Management*. 23(1996):90-98.

Jackson, P. D.J. Maude, and W. Perraudin. "Bank Capital and Value at Risk". *The Journal of Derivatives*. 4(1997):73-89.

Jorion, P. *Value at Risk: The New Benchmark for Controlling Derivatives Risk.* Irwin Publishing, Chicago, IL. 1997.

JP Morgan *Risk Metrics*^{TM}. Technical Document 4th Edition, Morgan Guaranty Trust Company, New York, 1995, http://www.jpmorgan.com/RiskManagement/RiskMetrics

Klein, R.A. and J. Lederman. Editors. *Derivatives Risk and Responsibility*. Irwin Professional Publishing, New York, 1996.

Lence, S.H., M.L. Hayenga, and N.E. Harl. "The Failure of Multiyear Hedge-to-Arrive Contracts." *Choices*. First Quarter 1999, p.p. 37-41.

Linsmeier, T.J. and N.D. Pearson. "Quantitative Disclosures of Market Risk in the SEC Release." *Accounting Horizons*. 11(1997):107:135.

Manfredo, M.R. and Leuthold, R.M. "Agricultural Applications of Value-at-Risk: A Perspective." Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. April 1998, pp. 293-306.

Manfredo, M.R. and Leuthold, R.M. "Value-at-Risk Analysis: A Review and the Potential for Agricultural Applications." *Review of Agricultural Economics*. 21(1999):99-111. *Forthcoming.*

Mahoney, J.M. "Empirical-based versus Model-based Approaches to Value-at-Risk: An Examination of Foreign Exchange and Global Equity Portfolios." Federal Reserve Bank of New York. Unpublished Manuscript. September 1995.

Schwartz, R.J. and C.W. Smith. *Derivatives Handbook*. Wiley, New York, 1997.

Smithson, C.W. and C.W. Smith. *Managing Financial Risk*. McGraw-Hill, New York, 1995.

Table 1. Summary Statistics for Weekly Futures Returns, 1986-1998

	K.C. Wheat	Boneless Beef	Soybean Oil	Coffee Beans
Mean	0.0011	-0.0001	-0.0008	-0.0014
St. Dev.	0.0279	0.0342	0.0298	0.0529

Note: returns are the log relative price change, $\Delta p_t = \ln(P_t/P_{t-1})$ for the nearby futures contract (635 observations).

Table 2. Correlation Matrix for Weekly Futures Returns, 1986-1998

	K.C. Wheat	Boneless Beef	Soybean Oil	Coffee Beans
K.C. Wheat	1.0000			
Boneless Beef	0.0228	1.0000		
Soybean Oil	0.2391	-0.0005	1.0000	
Coffee Beans	0.0795	0.0456	0.0385	1.0000

Note: simple correlation coefficients between log relative price changes, $\Delta p_t = \ln(P_t/P_{t-1})$. The standard error of the estimate is $(1/n-3)^{0.5}$. So, with n=365, the standard error is 0.0526 and a correlation greater than 0.1030 is statistically different from zero at the 5% level (two-tailed test).

Table 3. Value-at-Risk Example Portfolio Characteristics

	Monthly Usage	Months Coverage	Current Price ($)	Position Value ($)	Portfolio Weight
K.C. Wheat (bu.)	25,000	6	3.50	525,000	0.1104
Boneless Beef (cwt.)	20,000	1	125.00	2,500,000	0.5255
Soybean Oil (cwt.)	4,800	6	25.00	720,000	0.1514
Coffee Beans (cwt.)	1,125	6	150.00	1,012,500	0.2127
Total				4,757,500	.0000

Diagram 1: Risk Management Roles and Responsibilities

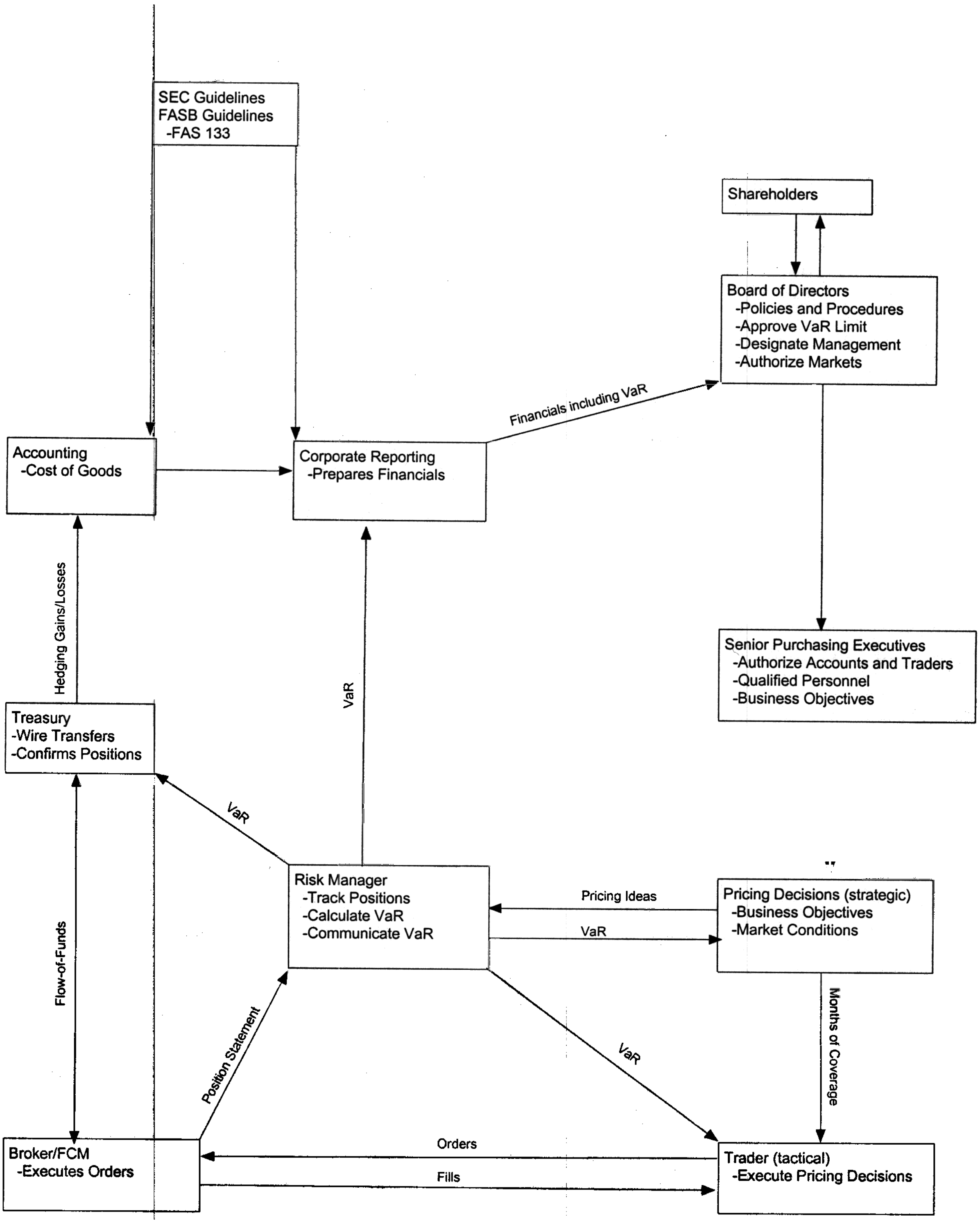

Figure 1. Four Week Value-at-Risk Example

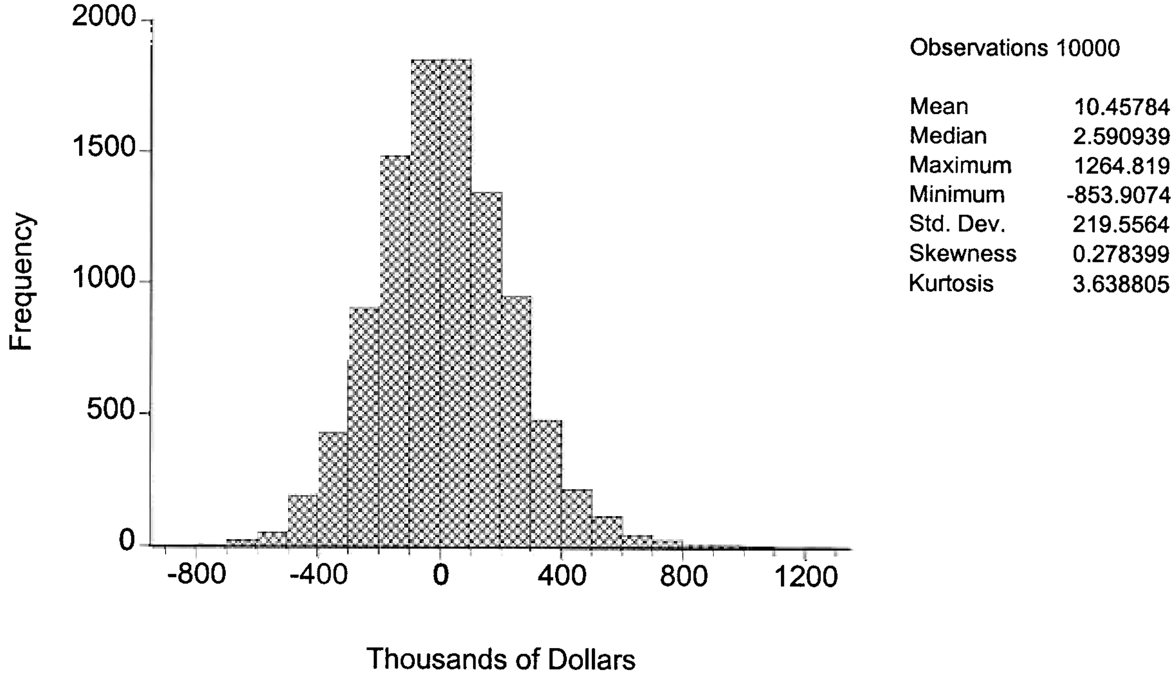

Figure 2. One-Week Value-at-Risk Example