



Aaron Brown

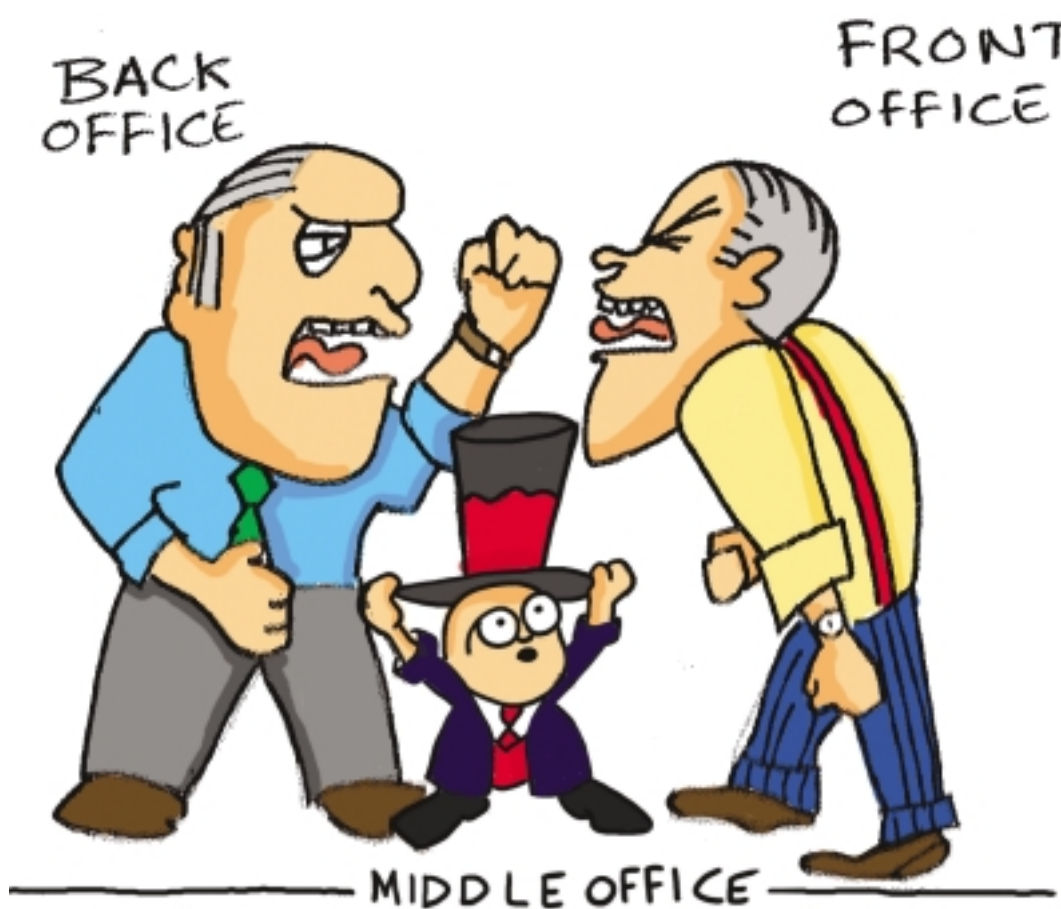
Toward a Unified Theory of Risk Management

Differing definitions of risk are a historical legacy that overcomplicate successful enterprise ...

There are two opposing common stereotypes of a financial risk manager. Some people imagine a large group of workers compiling firmwide reports for limits monitoring and financial and regulatory reporting. Others think of an older trader or former trader mentoring the young traders, counseling them to cut losses or take profits, advising them how to size trades; and also leading deskwide discussions of which risks are attractive and how to exploit them. These are back-office and front-office risk management, respectively.

Front-office risk management exists whenever more than a few traders are sharing the same risk capital. In smaller groups it may be done by the head trader, or the founder of a hedge fund. In larger groups the role may be delegated, formally or informally, to another senior trader, often the oldest trader on the desk. In still larger groups, or ones integrated into diversified financial institutions, it is usually a full-time position filled by a former trader.

Although I wrote “trader,” and will be thinking of modern financial trading organizations throughout this article, front-office risk management is the trading desk version of risk-takers’



Half empty, half full, or errr ...

risk management. It is the oldest and most basic kind of risk management. To be successful, risk takers need to consider the range of possible outcomes of their actions. Expected utility is not the criterion because they’re not going to take the one risk and stop. What matters is the result of the aggregation of many risks.

Back-office risk management appears much

later in history. Its roots are in accounting. Before writing was invented, people wrote lists of things they owned and owed (in fact, this likely evolved into writing). As economic life got more sophisticated, each of these items was assigned a value, which allowed adding things up to get a balance sheet, and differencing balance sheets over time to get income statements.

One problem was how to account for things of uncertain value. If you wrote a contract for marine insurance, bought a life annuity, or held a forward contract to buy grain; what value should each be assigned? In some cases, accountants could fall back on the principle of “lower of cost or market.” In other cases, reserves were assigned (essentially, contingent assets and liabilities were represented by their expected values) and supplementary disclosures like gross and net notional amounts were offered to allow readers to make their own estimates of uncertainty.

This developed first in the insurance business. Actuaries were invented to gather data and apply newly developed theories of statistics to help make business decisions (such as the pricing of policies) and support internal and external reporting. In the 1950s, inspired by academic work, these ideas spread to other financial institutions. Asset liability management, for example, attempts to quantify the effect of interest rate movements on highly levered portfolios held by banks and insurance companies. Beginning in the 1970s, regulators began a shift from fixed-fraction-of-notional rules to risk-based computations for capital and reserve requirements. Investors and fiduciaries began compiling and analyzing detailed statistical information about candidate managers.

Although front and back offices use the same word, “risk,” they use it with respect to different underlyings. Consider the life plan of a risk taker. She expects to take lots of risks. They will not be perfectly independent, but they will be over a long period of time in lots of different areas, so she expects considerable independence among them. Moreover, the risks she chooses are dominated by risks she cannot control. These are independent of her chosen risks, by definition. From this view, the standard deviation of any individual chosen risk adds only a negligible amount to her lifetime total risk. There is one exception to the argument above, which by itself suggests ignoring risk and making all choices to maximize expected value. Some risks affect your ability to take further risks. The obvious one is anything that risks death, risks losing the expected value from all future risks (there are some philosophical and theological subtleties here, but few

risk takers seem interested in philosophy, theology, or subtleties). As David Peoples has Will Munny tell the Schofield Kid in *Unforgiven*, “It’s a hell of a thing, killing a man. Take away all he’s got and all he’s ever gonna have.”

More relevant to a modern trading floor is that your success in one bet allows you to make a bigger bet the next time. If you lose 10 percent of your wealth, and therefore size all future bets 10 percent smaller, you end up with 10 percent less terminal wealth. You never make that money back. When you multiply results instead of adding them, the law of large numbers doesn’t hold.

Multiplying results is characteristic of risk takers. Most people take measured amounts of risk in order to accomplish predefined goals. Risk takers think in terms of maximizing terminal

as the number of bets increases, have more wealth than anyone following any essentially different rule. This is a risk taker’s criterion. It says nothing about the probability of achieving some reasonable level of wealth, attaining any goal, or avoiding poverty; it just says you do better than anyone else.

There are some specific assumptions in Kelly’s original paper, but most of these are technical; you can get a similar but more complicated result without them. The key assumption that makes generalized-Kelly work is that wealth is both the limit to risk taking (you aren’t allowed to risk more than your wealth) and the goal (you choose strategies to maximize wealth). This makes sense to a risk taker, but most people treat these as different things. If you borrow money, you increase your ability to take risk, without

Although front and back offices use the same word, “risk,” they use it with respect to different underlyings

outcome, without defining that outcome. Alexander the Great went from conquest to conquest. Each conquest increased his resources, integrated foreign soldiers into his army, and opened up further places to conquer. He was not trying to accomplish a specific result, for, at the end, “he wept for there were no more worlds to conquer.” Actually, the story has no support, Alexander was in fact planning new campaigns at the time of his death, but it makes a great metaphor for the unboundedness of risk takers’ goals. The more they win, the more they try to win. They only stop if they win so much that no one else can take their bets, at which point they often seem aimless, giving away their money or ignoring the administration of the lands they’ve conquered. Traders like to say, “money is just a way of keeping score,” and are famous for wasting or giving away money.

The simple mathematical expression of this is the Kelly Criterion. Someone sizing bets according to Kelly will, with probability approaching 1

increasing the wealth available to satisfy other desires (assuming you plan to pay it back). Many things that make people happy are intangible or have specialized personal value, and cannot be used as collateral for a trade. Other intangible things, like trust of other people and legal status, increase your ability to take risk without increasing spendable wealth.

One advantage of assuming that satisfaction and the ability to take risks are the same thing is that you can manage risk in the present. To Kelly, the past is irrelevant; your current state is defined by your wealth. The future is also irrelevant, except to specify that it will include plenty of risk taking. All that matters is the expected return and risk of the next bet.

The other big advantage of Kelly is that the personal risk preferences of traders sharing a pool of capital are irrelevant. Traders may disagree owing to different estimates of the expected return of a trade, but not to different attitudes toward risk. If you are allowed to bet any amount

you want at even payout with probability p of winning, Kelly says to bet your edge, $2p - 1$, times your wealth. Traders may argue about what p is, but should not argue about the bet size, given p . This makes it much easier for traders to work together.

The back-office view of risk is much different, which explains why many economists (most notably Paul Samuelson) were deeply hostile to the Kelly Criterion. Economists generally prefer utility theory, which fits into the back-office view. Rational risk decisions can only be made in the context of personal utility. It is common for academic theories to assume that everyone agrees on p ; any disagreement about bet sizing must reflect differences in utility. It is also common for academic theories to ignore the time dimension, to solve only one-period problems with known param-



There were exceptions, a few public companies that managed to combine large size with consistently successful risk taking, but it was done by creating a culture, not by formal risk management

ters (i.e., no period in the past used for parameter estimation), or successions of mathematically similar problems.

Back-office practitioners, on the other hand, and academics when doing empirical work, have to deal with past and future explicitly. There is, however, no present. In order to present consistent reports, everything must be stated “as-of” a fixed date and time. Reports are produced at some delay, typically a few minutes for a “real-time” report up to a few weeks for audit-quality numbers. The time from as-of time to report release is only part of the delay; the data itself may be based on transactions that took place before the as-of time. The result is that reports describe a time that is always in the past.

The future is essential because frequentist methods define probability over repeated future observations. Bayesian methods substitute a subjective hypothetical probability distribution of future events, but I have never heard of rigorously Bayesian back-office methods. In any event, there is still no objective present, just a present subjective belief about the future. So, back-office reports summarize the past in a manner that allows prediction of the future, a future that has already begun by the time the reports are available.

The key assumption that allows back-office risk management is that all positions have a price. This was the initial assumption that allowed lists of assets and liabilities to be aggregated in balance sheets, adding apples and

oranges and getting money as a sum, and differenced into income statements. It is a fiction, of course, even for the most liquid assets and liabilities. It is impossible to determine genuinely simultaneous prices for a large book, and realized prices from liquidating positions would differ from an instantaneous ideal price anyway.

In perfectly efficient markets, both front-office and back-office assumptions should be true, and should lead to the same definition of risk. But in real markets things are different. As a result, for many years, we had front-office-run operations with private capital and limited size, and back-office-run operations which could grow much larger and access cheap public capital, but often had mutually unsatisfactory relations with risk takers.

There were exceptions, a few public companies that managed to combine large size with consistently successful risk taking, but it was done by creating a culture, not by formal risk management. The economic turmoil of the 1970s destroyed some of these cultures; others proved unable to keep up with the pace of innovation in the 1980s and 1990s. There are few surviving examples today.

Far more common are companies formed by merging back-office and front-office cultures. In finance, these were created when commercial and investment banks bought or created large trading organizations, beginning in the late 1970s and accelerating ever since. The people creating and running these hybrids found that they did not have the tools for risk management. Back-office reports of gross and net notional, notional leverage, duration-weighted present values, liquidity, and other risk parameters could not capture the overall risk of the business. Each risk had its own report, too crude to capture reality, too indirect to be actionable, and, in any event, available too late with too much error to use. These reports were arguably meaningful for a firm run in a stable way under stable conditions, with top management intimately familiar with the business. They were little help to nontrader bank executives in managing the risk of aggressive desks in fast-changing markets.

The front office put all risks in one report,

but each desk had its own version; only an experienced market participant could interpret them. The data could not be aggregated across the firm. Risks that appear only at the firm level were absent. This led to the invention of the middle office. A century ago, brokerage houses had a front room, where customers came and met with brokers, and a back office, where the paperwork was processed, a place the customers never saw. They didn't have a middle office. As time went by, physical office organization changed, but banks maintained the distinction between employees who produced revenue by interacting with clients or markets – the front office, and employees in support roles who did not generate revenue and who interacted only with other employees or their opposite numbers in other firms – the back office.

The middle office was invented in the late 1980s, with two functions: capital management and risk management. Institutions without middle offices, or with weak middle offices, failed. Front-office risk management, while still the most important risk management, was not enough by itself. It was not independent of the desk, which led to some spectacular disasters owing to groupthink and desk loyalty outweighing firm loyalty. It could not be aggregated across desks, and it could not be controlled easily by top management. Back-office risk management was independent, aggregated across desks, and easily controlled; but it could not be aggregated across risk types and it was not sophisticated enough to capture much of the risk.

The middle office was unable to come up with a consistent definition of risk that made sense in the front office, the back office, and the executive boardroom. Instead, a series of tools were invented to work around the inconsistencies. This proved reasonably successful. Middle-office ideas were exported to the back office, in the form of AIRB Basel II regulation. To a lesser extent, the ideas have had an effect on the front office. Instead, the middle office has taken over front-office-like functions, such as hedging firmwide risks (such as counterparty credit risk) and active capital management (instead of generating revenues on assets and trying to maximize, generating negative revenues on liability and

equity and trying to minimize).

Nevertheless, it would be nice to have a unified theory of risk management. The only current concept that offers a hope for unification is economic capital. The term “economic capital” has several definitions. I am referring to the broad concept of estimating the amount of capital necessary to support a specific risk-taking activity.

Setting economic capital strikes me as the right way to control front-office risk. Currently, firms rely mainly on limits, a back-office concept. Since the control is crude, the limits have to be set high to allow sufficient freedom for risk taking; thus, they are not a precision tool. They have to be set arbitrarily, and are often influenced by firm politics. Most importantly, they are not meaningful in the front office, except as arbitrary constraints.

It makes much more sense to tell a risk taker:

The only current concept that offers a hope for unification is economic capital. The term “economic capital” has several definitions. I am referring to the broad concept of estimating the amount of capital necessary to support a specific risk-taking activity

here is the amount of money you have to lose; if you lose it, you have to stop. As long as you have any left, you should strive not for any predetermined goal, but to do as well as possible. That generally means sizing bets proportionately to the current level of economic capital. This is a concept that makes sense in the front office. It is also a sensitive and precise control parameter; top management can add or subtract capital to manage the level of risk taking.

The job of the middle office becomes managing real capital – external capital – against the economic capital allocated to the risk takers. One simple strategy is to sum the allocations. If you

raise that amount, it will be very low risk capital, since each desk individually is supposed to be run so as not to lose more than its economic capital amount. So you'd need a lot of external capital, but it would be cheap. In fact, you might be able to invest the actual cash raised to return almost enough to pay for the capital.

More complex strategies would raise less capital – after all, it's unlikely that every desk would lose its maximum at the same time. That capital would be riskier, and come at a higher cost. In practice, there are many different kinds of capital available. It's a complex problem to decide on the optimal mix for a firm, but this is the kind of problem that middle-office people are good at solving. Once you know the actual capital mix, you know the cost of economic capital, which allows you to evaluate risk takers.

Economic capital is also something that back

offices can measure and report. Instead of putting a lot of unaggregatable positions on the balance sheet, and leaving a lot of other risk off the balance sheet, you have economic capital of various types on the left side, and actual capital of various types on the right side.

Although this is only a quick sketch, I think it points to a possible unification of risk management. Other approaches are, of course, possible. But without unification, risk gets very confusing. The front office is doing one thing, the back office is reporting another, the middle office is trying to make sense of the two, and top management lacks information and control.