Deconstructing Market Risk: Finding the Smallest Chunks

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Value at Risk (VaR) is a highly integrative activity for assessing market risk. Quite correctly, the risk management industry has focused upon generating enterprise-wide VaR numbers, by incorporating the analysis of trading books, legacy contracts, treasury activities, real assets, insurance, and a host of other enterprise exposures. Correspondingly, most sophisticated risk players recognize that VaR is not merely an add-on feature within any single portfolio management system, but instead represents a systematic attempt to span multiple portfolio management systems, multiple deal types, multiple users, and multiple views into their common risk model. And yet while such extensive integration is a key aspect of thinking about risk management, it is also important to consider the disaggregation, or "deconstruction," of risk.

It is the deconstruction of VaR that provides a most important benefit: enabling *drill-down* into the sources of risk. Without the ability to determine exactly where risk is coming from, VaR is merely a number, relegated to the role of passive risk measurement, and cannot pretend to enable risk *management*.

To actively manage risk, we need to understand its sources. In a series of earlier articles,[1] I have described one method of analytic VaR drill-down known as Component VaR (CVaR). CVaR is a sub-portfolio metric that possesses two crucial properties: (1) additivity, and (2) incremental accuracy. Additivity means that the CVaRs for all sub-portfolios partitioning a larger portfolio will always add up to that portfolio's total VaR. Incremental accuracy means that if a small amount of a sub-portfolio is subtracted, the VaR will change by a subtraction of the corresponding CVaR. As it happens, there is only the one definition of CVaR that satisfies both these properties.

In order to move CVaR from the realm of pure theory towards practical software systems that implement this VaR deconstruction metric (or any competitive but additive metric), we need to answer one important conceptual

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[1] "Improving on VaR," RISK, May 1996, vol. 9, no. 5, pp. 61-63 (http://www.fea.com/pdf/risk_delvar.pdf) and "Taking VaR to Pieces," RISK, Oct 1997, vol. 10, no. 10, pp. 70-71, (http://www.fea.com/pdf/componentvar.pdf)

question: what is the smallest "chunk" of risk? This risk granularity must be selected so as to be sufficiently fine, because it needs to support almost all of the drill-down risk reports that users will expect to see. It should also not be defined too finely, otherwise it will become an annoying and burdensome task to later aggregate risks into more meaningful chunks.

In my experience, almost every market risk drill-down report can be constructed by aggregations that take into account two basic dimensions: trades and risk factors. By "trades" I mean the most elementary units of transactions executed with counterparties. (Some institutions instead term these the "legs" of a trade.) By risk factors, I mean the most elementary descriptors of market risk employed in the VaR method. These are called "vertices" in RiskMetrics, and are so named here also. My claim is that, provided we know how much CVaR each given trade associates with each given vertex, almost all other VaR drill-down questions are quickly answered. Figure 1 illustrates the situation.

	Vertices					
Trades	√	√	√	√	…	√
	√	√	√	√	…	√
	…	…	…	…	…	…
	√	√	√	√	√	√

Figure 1

The table of Figure 1 would of course be quite huge, since many financial institutions will have hundreds of thousands of trades (rows), and perhaps hundreds of vertices (columns), so this table should be thought of as a conceptual framework, not as a representation of any actual computation. The check marks within the table represent the varying amounts of CVaR lying at each intersection of a vertex and a trade. The sum of all the CVaR numbers (or alternative additive metric) in the table is the total VaR. So let us suppose that we establish the cells of Figure 1 as a by-trade by-vertex "atomic element" of risk, the finest granularity of risk we will consider.

Next, we partition both vertices and trades by various criteria. For example, counterparty, trader, desk, corporate division, trade type, or any of a number of other criteria could be used to partition trades. These will be represented by groupings of the rows of the table. Similarly, vertices (columns) can be partitioned by sectors, fiscal quarters, credit market types, and similar discriminations. The result will be "blocks" of CVaR within the table, as represented in Figure 2, where these blocks are colored.

	Vertices					
Trades	**1st qtr**		**2nd qtr**		**Long-dated**	
Joe's book	√	√	√	√	…	√
	√	√	√	√	…	√
Sam's book	…	…	…	…	…	…
	√	√	√	√	√	√

Figure 2

In the example depicted by Figure 2, we have chosen to partition the vertices into calendar periods, while the trades have been partitioned by trader. Thus, the drill-down report conceptually depicted here is a by-trader, by-period risk report. The numbers that go into the report are merely the summations of the CVaRs of the blocks of cells having the same color. I would assert that, by considering the various partitions possible for these two dimensions, 98% (but perhaps not all) of the useful VaR drill-down reports will be provided a conceptual expression in this fashion.

To summarize, your choice of the smallest, or "most atomic" chunks of risk will dictate the limits of your risk drill-down capability. While it is certainly true that risk drill-down in practice proceeds in a top-down fashion, (while we have described it conceptually from a bottom-up viewpoint here) it is clear that we need to think in advance about what the finest level of risk granularity will be. On one hand, *some* level of finest granularity is forced upon us by the practicalities of software solutions. On the other hand, we will be unable to answer risk queries involving any lower level of granularity. A reasonable choice, recommended here, is a *by-each-trade-on-each-vertex* granularity. With this level of granularity, almost all of the important risk drill-down questions can be answered efficiently.

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