VALUATION AND RISK MANAGEMENT IN ENERGY MARKETS

Valuation and Risk Management in Energy Markets surveys the mechanics of energy markets and the valuation of structures commonly arising in practice. The presentation balances quantitative issues and practicalities facing portfolio managers, with substantial attention paid to the ways in which common methods fail in practice and to alternative methods when they exist. The material spans basic fundamentals of markets, statistical analysis of price dynamics, and a sequence of increasingly challenging structures, concluding with issues arising at the enterprise level. In totality, the material has been selected to provide readers with the analytical foundation required to function in modern energy-trading and risk-management groups.

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Preface

In the summer of 1998, I was working at a hedge fund in Bermuda and contemplating returning to the United States, the plan being to continue working in a fixed-income quantitative role of some sort. Fortunately, I suppose, a former student of mine at Cornell, Dana Thorpe, strongly encouraged me to look into the energy markets, particularly electricity. Dana had worked in this area for a few years and described the modeling and risk-management state of affairs as being in a nascent stage and largely virgin territory.

As it turned out, several shops had already been systematically building very solid analytics, architected by some of the now best-known minds in the business, and academics were becoming increasingly interested in energy. However, despite the considerable efforts of regiments and brigades of researchers, including groups that I have had the opportunity to run over the years, Dana's assessment made fifteen years ago feels disturbingly close to the truth even now.

My first significant tour of duty in energy was at Constellation Power Source (CPS), at the time the name of the merchant arm of Constellation Energy. Initially, CPS was a joint venture between Goldman Sachs and Baltimore Gas & Electric (BG&E). Perceptions of hubris aside, Goldman management was shrewd enough to know that when entering a business as peculiar and complex as electricity, it might not be a bad idea to partner with people who have been working within the context of the physical system for decades. In many respects this collaboration was successful, with first-rate trading systems and risk-management experience afforded by Goldman coupled with the seasoned skepticism and engineering knowledge of BG&E.

While personalities and value systems converged over the years, a striking feature of the operation was the yawning gap between the valuation system (which is, in fact, quite impressive) and the realities facing the teams running the assets. The risk system could accommodate the litany of conventions

of physical and financial settlement of any commodity, notably the hourly or subhourly calculations that are required. Forward valuation was also extremely flexible, provided that transactions were represented as derivative constructs with all the implicit assumptions underpinning complete markets and risk-neutral valuation. This is true of most risk systems, both commercial and in-house. Transactions must be boiled down to a representation that requires forward curves, implied volatilities, implied correlations, and all the other usual inputs, each of which is presumed to be tradable in some fashion.

The problem that confronted portfolio managers, and does to this day, is that many commonly traded structures in energy involve risks that trade so rarely and in such small size that market activity is at best an indication of how others are assessing the risk. At worst, such can be outright disinformation to confuse market participants in advance of large transactions or auctions. In such situations, any notion of market completeness is moot. Extrinsic value as ascertained in idealized settings simply cannot be captured. Structures that look like quantos cannot be hedged when one leg does not trade at all.

Other ways of thinking about valuation and risk are required.

In the course of what follows, much of the standard liturgy on valuation of energy structures will be described in full detail. However, substantial attention also will be paid to the ways in which common methods fail and to alternative methods when they exist. In some situations, the conclusion will be that researchers and practitioners simply do not yet know how to properly handle some transactions. Rather than being bad news, this is what makes the field of energy trading and structuring particularly vibrant: even after several decades of thought, open problems abound.

This book is descendant from a sequence of lectures that I started giving each spring at New York University in 2008. I was working at Credit Suisse at the time, and the bank accommodated and supported the effort over the following years to have practitioners interacting directly with financial engineering students, no small number of which I have seen on the desks at the bank in subsequent years. Ultimately, these lectures evolved into a collection of material that will hopefully prove useful for "quantitative types" with a commercial orientation entering the business and joining a trading desk.

This book is structured in six parts. Part I is an overview of some of the distinguishing features of energy markets and a survey of important fundamental and econometric attributes of the core markets discussed – crude oil and refined products, natural gas, and electricity. Part II covers basic "zeroth-order" valuation before moving into a more detailed analysis of the empirical features of price dynamics and the implications for managing swaps books. While the content of the first two parts is clearly oriented toward "stylized facts" about markets, modeling in the absence of such information is not a good idea.

Bona fide valuation activities begin in Part III, which is a survey of standard methods for dealing with the simplest "nonvanilla" structures that arise in practice. Part IV discusses modeling approaches from a more general perspective, exploring the dialectic between the tractability of various modeling paradigms and their consistency with empirical facts and utility in practice. In Part V we explore the application of these methodologies and their limitations in three settings that have challenged practitioners for years – natural gas storage, tolling transactions (generation hedges), and variable-quantity swaps. Finally, in Part VI we turn to broader considerations at the level of enterprise risk management and control, concluding with a discussion of the future of energy markets.

It sounds (and sounded to me) like a routine affair to convert a reasonably seasoned sequence of lectures into a book, but the experience was anything but straightforward. While all remaining errors are mine, this work would be a pale shadow of itself were it not for the remarkable efforts of many of my colleagues and friends. Michael Coulon, formerly at Princeton and now at the University of Sussex, and Radu Haiduc at Credit Suisse proofed the entirety of the manuscript at a level of detail and "no holds barred" critique that simply defies description. Their input not only reduced the error count by an order of magnitude but also improved the manuscript at a fundamental level. Richard Lassander was a close collaborator on large parts of the book, particularly those focused on fundamental aspects of the markets and trading, not to mention his help on the dauntingly high-dimensional task of index creation. Eric Grannan and Peter Jenson made numerous suggestions and helpful comments. Sheela Kolluri, a statistician in the pharmaceuticals business and lecturer at Columbia, provided the refreshing perspective of someone completely outside the business. Stefan Revielle and Soumya Kalra provided a great deal of assistance on data and many helpful comments and insights along the way. I would also like to express my appreciation to Rene Carmona for numerous invitations to conferences and workshops, in addition to a continuing sequence of fascinating discussions when we manage to find time to meet in Princeton.

I was introduced to the Cambridge team by Robert Dreesen, who assisted in many ways in guiding the process and for whose assistance I am grateful. In addition, this work benefited substantially from the efforts of Scott Parris and Kristin Purdy, and more recently Karen Maloney, as well as the Cambridge team broadly. Thanks also to two anonymous referees whose input and critique were very helpful.

Last, and certainly most, my wife, Adviti Muni, not only carefully and repeatedly proofed the manuscript, but more important, she also provided the critical ingredient of encouragement at those moments when I was inclined to back-burner the effort in favor of the incessant barrage of other seemingly, but fleetingly, more pressing matters.

This book is graphically and data intensive. While specific sources are mentioned for "one-offs" throughout the text, in general, most data were either sourced from Bloomberg LLC, notably weather, spot, and forward price data, as well as implied volatilities, or were drawn from my lectures written when I was at Credit Suisse.