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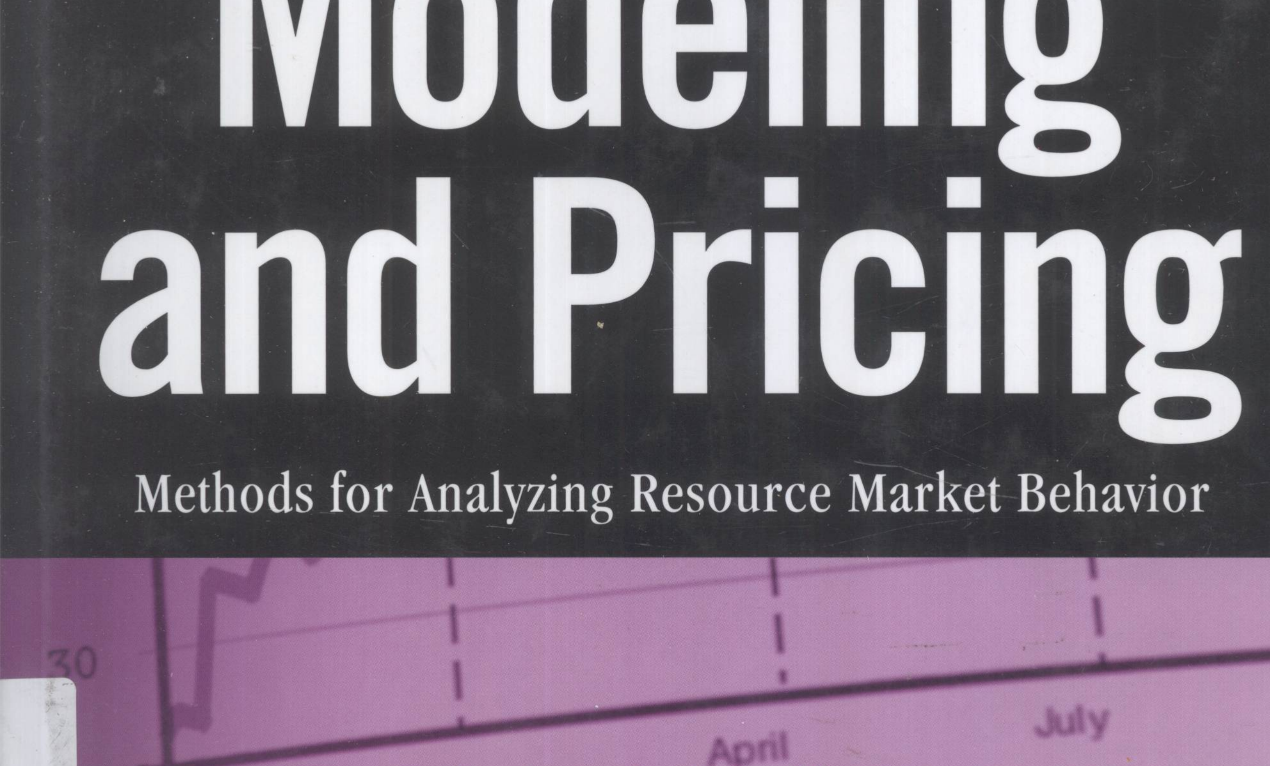
Commodity Modeling and Pricing

Methods for Analyzing Resource Market Behavior



Peter Schaeffer

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John Wiley & Sons, Inc.

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Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

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Library of Congress Cataloging-in-Publication Data:

Schaeffer, Peter V.
Commodity modeling and pricing : methods for analyzing resource market behavior / Peter V. Schaeffer.
p. cm. – (Wiley finance series)
Includes index.
ISBN 978-0-470-31723-5 (cloth)
1. Commodity exchanges–Mathematical models. 2. Primary commodities–Prices. 3. Prices–Mathematical models. I. Title.
HG6046.S353 2008
332.64′4–dc22

2008022839

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

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In Memoriam

Daniel J. Gijsbers and Thomas F. Torries

Preface

Resource commodity markets are extremely important to agricultural producers, processors, consumers, foresters, and the wood processing industry and in the mineral and energy industries. They play a central role in economic development, international trade, and global economic and political stability. Globalization and the spectacular growth and industrial development of China, India, and other Southeast Asian countries have significantly added to total resource commodity demands and caused price increases. Additional pressures on prices have come from an increased use of agricultural commodities, particularly corn and sugar, for ethanol production, a recent development that has had significant impacts on food prices. In general, the closer integration of resource markets has been accompanied by growing economic and financial instability.

Resource-producing countries need export revenues: Brazil, from Amazon timber; Chile, from copper; Iraq, from crude oil; South Africa, from diamonds; and Argentina and the United States, from wheat. Resource-consuming countries need imports for industry: China, India, and Japan for raw materials and energy, the United States for crude oil. Because of cycles in consumption and production, these markets face high price instability. More than 60 commodity futures markets exist to ameliorate this problem. World commodity markets are again under scrutiny, and the economic analysis and modeling of these markets is as important as ever before.

This collection of chapters reflects the influence of Professor Walter C. Labys on the development of econometric methods for forecasting commodity prices. The contributors are former students and collaborators, ranging from practitioners in private industry, public sector and nongovernmental organizations, to scholars in higher education. They are from Australia, China, France, Indonesia, the Ivory Coast, Luxembourg, Tunisia, and the United States. Some of them came together in Morgantown, West Virginia, on the occasion of Professor Labys's retirement from West Virginia University for a symposium showcasing the current state of the art in commodity price modeling and forecasting, while the others joined them later to produce this volume.

During his career, which spanned over 40 years, Professor Labys published 15 books, 150 research articles, and gave 130 invited lectures. His many honors and recognitions include being appointed the first Gunnar Myrdal Scholar by the United Nations in Geneva, receiving a Master Knighthood in the Brotherhood of the Vine in California, being named a Benedum Distinguished Scholar at West Virginia University, and garnering the William H. Miernyk Award for Career Scholarly Achievement by the Regional Research Institute at West Virginia University.

Professor Labys grew up in southwest Pennsylvania. He received his undergraduate education at Carnegie Tech, now Carnegie Mellon University, where he studied engineering and also took courses in painting and sculpture. He then earned a master's degree in Economics at Harvard University. While attending a seminar presentation there, he met Professor Clive W.J. Granger, who would later become the 2003 Nobel laureate in economics. When Professor Granger moved to the University of Nottingham, Professor Labys followed him to complete a Ph.D. in Economics under his direction.

Shortly after receiving his Ph.D., he started work as a consultant for the Commodities Division at the World Bank, where a chance encounter with Alfred Maizels led to an invitation to join the United Nations Conference on Trade and Development in Geneva as a commodities specialist. At the time, the United Nations in Geneva was a virtual whirlwind of economic activity and research, and Professor Labys encountered many eventual Nobel laureates in Economics. He was coached through his first commodity model by Lawrence Klein, and made the acquaintance of Harry Johnston, Robert Mundell, James Meade, and Richard Stone.

Eventually Professor Labys moved back to the United States, opting for West Virginia University in Morgantown to be near his parents, rather than joining his doctoral advisor, Professor Granger, at the University of California in San Diego. His work continued to take him back to Europe, where he consulted with the United Nations in Geneva, the Food and Agriculture Organization in Rome, and the International Institute for Applied Systems Analysis in Vienna while maintaining academic affiliations with several French universities.

During his long career, Professor Labys served as advisor to many students both in the United States and abroad. His relationship with his doctoral students was characterized by strong support, with a willingness to help at any time and in any way possible. This collection of chapters is in part the result of such relationships.

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Acknowledgments

The Division of Resource Management and the Regional Research Institute financially supported the symposium that brought together the initial core of speakers and papers that led to the idea for this book. My West Virginia University colleagues Jerald J. Fletcher and Tim T. Phipps provided organizational support for the symposium, as did our secretary, Lisa Lewis. Randall W. Jackson, director of the Regional Research Institute, provided additional funding for technical support during the production of the manuscript. Walter Labys took pleasure and pride in this project and provided feedback and editorial advice on many issues and chapters. I benefited greatly from the advice and guidance of John Wiley & Sons' Debra W. Englander, Executive Editor, Stacey Small, Editorial Assistant, Kelly O'Connor, Development Editor, and Michael Lisk, Senior Production Editor. Jacquelyn Strager created the base map of Indonesia that served as the basis for Figure 11.1 and Gloria Nestor assisted with Figure 14.1. Ika Rahmawati helped with translating statistical information from Indonesian into English. Weslie Boyd's expert assistance was invaluable in getting the manuscript ready to meet the publisher's guidelines.

Editing this book was interesting and rewarding, but also time consuming and at times, it interfered with family life. I therefore very gratefully acknowledge my wife's love, support, and patience.

PETER V. SCHAEFFER

Contents

PART One

Dynamics of Commodity Price Behavior

At times the prices of many commodities display volatile behaviors. Since agricultural commodities and minerals, such as crude oil and metals, are among the fundamental inputs of our economies on the production and/or the consumption side, price volatility causes disruptions and can lead to crises. An improved understanding of the dynamics of price behavior is therefore highly desirable from a policy as well as from a consumer and supplier perspective.

Part One consists of four chapters, each written from a different point of view. In Chapter 1, the recently retired chief economist of Arcelor-Mittal and two colleagues from academia present a new method for estimating long memory processes from small samples, a common problem in industry, where forecasts frequently have to be made from very short series. This contribution provides a theoretically sound and interesting solution to a practical problem.

While the first chapter takes an industry and firm perspective, the second chapter analyzes time-series data to study the link between commodity price developments and business cycles. The question asked many times is whether commodity prices lead inflation or inflation leads commodity prices. The answer is not immediately visible from looking at the data, because trends can be obscured by short-run occurrences. This chapter's analysis offers a method to uncover the true trend and provides evidence that, on balance, commodity prices are procyclical. The exceptions are the price of gold, which is countercyclical, and the price of sugar, which is acyclical.

Chapter 3 also studies the connection between inflation and commodity prices. The author uses a recently developed procedure to test the possible presence of nonlinearity in the comovement of commodity prices and the consumer price index. The results reveal interdependences between the different price series, with policy implications, for example, on how to combat inflation.

Chapter 4 also is focused on macroeconomic issues, but the issue of interest turns from domestic policy to the world market. The chapter deals with the relationship between the dollar and the oil price. The real price of the oil in every currency depends on a variety of factors, including OPEC policy. The price of crude oil is in

U.S. dollars, but most of the imports of the largest oil-producing member countries originate in the euro zone or in Japan. Hence, the devaluation of the dollar lowers the purchase power of OPEC member countries, which they try to regain by adjusting the price of oil upward.

Together, these four chapters provide models, data, results, and insights that enhance our understanding of the dynamics of commodity price behavior. They use the most current models and techniques in time-series analysis and illustrate their application. The chapters complement each other by providing information at different levels of aggregation while dealing with the same general subject. Because of their mixed background in terms of professional experiences and geographic location, the authors also bring different perspectives to their respective tasks.

CHAPTER 1

Indirect Inference and Long Memory

A New Truncated-Series Estimation Method

Armand Sadler, Jean-Baptiste Lesourd and
Vêlayoudom Marimoutou

INTRODUCTION

Long-memory processes are an important and even fundamental advance in time-series modeling. More precisely, the so-called autoregressive fractionally integrated moving average (ARFIMA) model has been introduced by Granger and Joyeux (1980) and Hosking (1981). It is a generalization of the ARIMA model, which is a short memory process, by allowing the differencing parameter d to take any real value. The goal of this specification is to capture *parsimoniously* long-run multipliers that decay very slowly, which amounts to modeling long memories in a time series. ARFIMA processes, however, are associated with hyperbolically decaying autocorrelations, impulse response weights, and spectral density function exploding at zero frequency. As noted by Brockwell et al. (1998), while a long memory process can always be approximated by an ARMA(p, q) process, the orders p and q required to achieve a good approximation may be so large as to make parameter estimation extremely difficult. In any case, this approximation is not possible with small samples.

ARFIMA processes are defined as follows in their canonical form:

$$\Phi(L)(1-L)^d y_t = \mu + \Theta(L)\varepsilon_t, \quad \varepsilon_t : iid(0, \sigma^2) \tag{1.1}$$

where $d \in (-0.5, 0.5)$ is the fractional difference operator and μ can be any deterministic function of time. If μ is zero, this process is called fractionally differenced autoregressive moving average (e.g., Fuller (1996)). The *iid* (independent and identically distributed) assumption is the strongest assumption; it implies mixing, that is, conditions on the dependence of the sequence. For a stationary sequence, mixing implies ergodicity (restrictions on the dependence of the sequence). Ergodic processes are not necessarily mixing; mixing conditions are stronger than ergodicity. For details, see White (1984) and Rosenblatt (1978).

For general overviews on long memory processes, surveys, and results, we refer the reader to Baillie (1996); Brockwell and Davis (1998); Fuller (1996); Gouriéroux and Monfort (1995); Gourieroux and Jasiak (1999); Hamilton (1994); Jasiak (1999, 2000); Lardic and Mignon (1999); Maddala and Kim (1998); and Sowell (1990) as well as to the discussions and comments by Bardet (1999), Bertrand (1999), Gourieroux (1999), Jasiak (1999), Lardic and Mignon (1999), Prat (1999), Renault (1999), Taqqu (1999), and Truong-Van (1999). Concerning recent research on the topic of long memory, we refer the reader to Andrews and Guggenberger (2003), Andrews and Sun (2004), and Davidson and Terasvirta (2002). Note also the presentation of a new stationarity test for fractionally integrated processes by Dolado, Gonzalo, and Mayoral (2002). Among the most important papers concerning estimation techniques for these ARFIMA model are Fox and Taqqu (1986), Geweke and Porter-Hudak (1983), Li and McLeod (1986), and Sowell (1992a). Tests for long memory across a variety of commodity spot and futures prices can be found in Barkoulas, Labys, and Onochie (1997, 1999) as well as in Cromwell et al. (2000).

The methods for estimating *d*, the long-range dependence parameter, can be summarized in three classes:

1. The heuristic methods [the Hurst (1951) method, the Lo (1989, 1991) method, the Higuchi (1988) method]
2. The semiparametric methods [Geweke and Porter-Hudak (GPH) (1983) method, the Robinson (1983, 1995a, 1995b) estimation methods]
3. The maximum likelihood methods [the exact maximum likelihood method, the Whittle (1951) approximate maximum likelihood method]

For a comparison of these classes of estimators, refer to Boutahar et al. (2005).

The estimation of fractional integration exponents leads to significant problems in some cases. In the case of small samples, as often encountered with industrial data, it is even impossible. Long-memory estimations often are performed with financial time series with large numbers of observations (5,000 observations and more are not uncommon). However, small samples of 50 to 100 observations are the order of magnitude usually encountered in industrial forecasting problems. In such cases the need for a consistent and precise estimation technique is of great interest. Thus, we motivate the need for a new estimator for the long-memory parameter by the small sample sizes often encountered in practice. Why should we care about long memory in those situations? For instance, one could argue that from a forecasting perspective, long memory starts to make a difference only when forecasting over long horizons. In situations when you only have a few observations available, you would not forecast too many steps ahead. The reply to this comment covers three aspects:

1. What really matters in time series analysis is the span, not the number of observations. Fifty yearly observations on apparent steel use in a region have another informational content than 5,000 real-time observations over a short period of time on some financial stock index.
2. Many industry sectors are producing medium- and long-range forecasts based on a relatively small number of yearly or quarterly observations. A steel producer planning to invest in a new rolling mill or a new greenfield facility can not wait for a long time series before making a decision but has to work with the actually available data.

3. We have come to believe from our past studies that for transfer function models (models with explanatory variables), long memory does not even exist. Detected long memory always followed some misspecification of the actual model. If a model is correctly specified, long memory should disappear. In this sense, we look at long memory as a specification test.

By using indirect inference to adjust for the bias, is the computational burden increasing? The answer is no. We suggest the use of our reference tables to correct for the bias. To our knowledge, since the work of Li and McLeod (1986), no new estimation techniques that are valid for small samples have been proposed in the econometric literature. Moreover, Li and McLeod developed an estimation technique based on truncating the power series defining the process after about 50 terms.

In this chapter, we propose a completely different approach based on low-order truncation (after about five terms). Li and McLeod considered their truncated model as approximating the true model, whereas we explicitly consider our low-order truncated model as an instrumental model that is necessarily biased. The bias is corrected by an indirect inference technique, through minimizing a distance function.

This chapter aims at defining an estimation technique of the fractional integration exponent d for comparatively small samples. Its asymptotical properties are based on a result established by Mira and Escribano (2000) about the almost sure consistency of a nonlinear least square (NLS) estimator. The hypotheses used by these authors are shown to apply to our particular case of truncated series. A new method for identification and estimation of these truncated series is developed and applied to steel consumption time series as well as to the analysis of atmospheric carbon dioxide (CO$_2$) concentrations derived from in situ air measurements at Mauna Loa Observatory, Hawaii.

ALMOST SURE CONSISTENCY OF THE NLS ESTIMATOR FROM OUR TRUNCATED MODEL

We consider the simplest ARFIMA process, also called fractionally differenced (or integrated) white noise (see, e.g., Fuller (1996) or Brockwell et al. (1998)):

$$(1 - L)^d \, y_t = e_t \tag{1.2}$$

with $e_t \sim iid$, or $y_t + \sum\limits_{j=1}^{\infty} \kappa_j(d) y_{t-j} = e_t$.

$$\kappa_j(d) = [\Gamma(j+1)\Gamma(-d)]^{-1}\,\Gamma(j-d) = \prod_{i=1}^{j} i^{-1}(i-1-d)$$

Γ is the gamma function and $d \in (-0.5, 0.5)$. If ξ is not an integer, then $\xi = n + \phi$, $\phi \in (0, 1)$: $\Gamma(\xi) = (\phi + n - 1)(\phi + n - 2)\ldots(\phi + 1)\phi\Gamma(\phi)$. We define the truncated version of this model by:

$$y_t + \sum_{j=1}^{r} \kappa_j(d) y_{t-j} = e_t \tag{1.3}$$

In addition, we relax the *iid* assumption for e_t and replace it by the less restrictive α-mixing assumption, thus allowing for some heteroscedasticity (see White (1984) for details). In the appendix we show that the parameter d of model (1.3) can be consistently estimated and that the true fractional parameter can be estimated by indirect inference.

In the next section, we show how to identify and estimate the truncated long memory process.

IDENTIFICATION AND ESTIMATION OF THE TRUNCATED LONG MEMORY PROCESS

We define the combined consumption model (CCM) as a transfer function model including long memory. The starting point is either a cointegration relationship between variables having a common stochastic trend or a stable relationship between stationarized variables. In the case of structural breaks, the break may be in level, in slope, or in both. Care has to be taken with the specification because, as pointed out by Diebold and Inoue (2001), long memory and structural breaks are easily confused.

The CCM is thus aiming at a parsimonious representation of reality by focusing on a few key explanatory variables, an ARMA part in order to take account of short memory and a fractional parameter representing long memory. With this definition, the estimated parameter d will always lie in the open interval (–0.5, 0.5). An estimated parameter d out of that range is an indication that the series have not been correctly stationarized because the process is only both stationary and invertible if $d < 10.51$.

If long memory is specified by a truncated version of the model, the CCM can be estimated easily. The next estimation procedure follows the outline proposed by Hosking (1981), except that we change the order of the steps and estimate the combined model. To illustrate the estimation procedure, let us start with the ARFIMA model

$$\Phi(L)\left[y_t + \sum_{j=1}^{r} \kappa_j(d)\, y_{t-j}\right] = \Theta(L)\,\varepsilon_t \tag{1.4}$$

or

$$F(L)\,\nabla^d y_t = \Theta(L)\,\varepsilon_t \tag{1.5}$$

Define

$$u_t = y_t + \sum_{j=1}^{r} \kappa_j(d) y_{t-j} \tag{1.6}$$

so that $\{u_t\}$ is an ARIMA $(p, 0, q)$ process.

$$\Phi(L)[u_t] = \Theta(L)\,\varepsilon_t \tag{1.7}$$