J.P. MORGAN CENTER FOR COMMODITIES
UNIVERSITY OF COLORADO
DENVER BUSINESS SCHOOL

GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

WINTER 2019

Supported by a
generous grant from

CME GROUP
FOUNDATION

Business School
UNIVERSITY OF COLORADO **DENVER**

GLOBAL COMMODITIES APPLIED RESEARCH DIGEST

Vol. 4, No. 2: Winter 2019

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Introduction

The *Global Commodities Applied Research Digest* (*GCARD*) is produced by the J.P. Morgan Center for Commodities (JPMCC) at the University of Colorado Denver Business School. The aim of the *GCARD* is to serve the JPMCC's applied research mission by informing commodity industry practitioners on innovative research that will either directly impact their businesses or will impact public policy in the near future.

Updates from the JPMCC

This article provides a brief update on the many events and initiatives that have taken place since the digest's last issue, including (a) the appointment of the JPMCC's Executive Director; (b) the launch of the JPMCC's Geopolitical Oil Price Risk Index; (c) the Center's forthcoming newsletters; (d) CU Denver Business School's expanded commodities curriculum; (e) the Program Director's recent press interview; and (f) the Research Director's highly successful international commodities symposium.

Research Director Report

In this report, the JPMCC's Research Director provides updates about the Center's research activities from January 2019 through August 2019 with the focus on two international commodities conferences organized or co-organized by the Research Director on behalf of the JPMCC. Those conferences, in turn, were the "International Conference on Derivatives Market and Risk Management," held in Shanghai, China; and the JPMCC's 3rd Annual International Commodities Symposium, held at the CU Denver Business School. Regarding the latter conference, the Research Director especially thanked the CU Denver's senior leadership team for their support of the JPMCC and its international commodities symposium.

Advisory Council

The JPMCC's Advisory Council consists of members of the business community who provide guidance and financial support for the activities of the JPMCC, including unique opportunities for students. Advisory Council members also contribute practitioner-oriented articles to the *GCARD*.

Research Council

The JPMCC is honored to have a distinguished Research Council that provides advice on shaping the research agenda of the Center. Amongst its articles, the *GCARD* draws from insightful presentations by the JPMCC's Research Council members.

Editorial Advisory Board

The *GCARD*'s international Editorial Advisory Board consists of experts from across all commodity segments, each of whom have an interest in disseminating thoughtful research on commodities to a wider audience.

CU Denver Business School

The J.P. Morgan Center for Commodities is housed at the University of Colorado Denver Business School. The Business School at CU Denver, in turn, offers industry-focused programs in commodities, energy, entrepreneurship, information & innovation, international business, risk management & insurance, and sustainability.

Program Director's Outreach and Applied Research

Earlier this year, the JPMCC was honored to host three experts on cryptocurrencies during a panel presentation organized and moderated by the JPMCC's Program Director, Dr. Yosef Bonaparte. This article recounts the insights of Mr. Bill Sinclair, Dr. Andrei Kirilenko, and Mr. Colin Fenton during their respective presentations.

This digest article describes a new research project at the JPMCC: the launch of the Geopolitical Oil Price Risk Index (GOPRX), which is designed to reflect the impact of geopolitics on oil prices, volatility, and supply in one succinct metric.

Research Council Corner

In this report, the author delves into the longer-term forces of financial panic, disruptive technology, and trade protectionism to understand why the correlation structure among key commodities may occasionally diverge

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sharply from its longer-term pattern only to return eventually back to form.

Liquidity Issues in the U.S. Natural Gas Market: Part 1 of 2 **47**

By Gary Mahrenholz, Ph.D., Economist, Office of Enforcement's Division of Energy Market Oversight, U.S. Federal Energy Regulatory Commission and Vincent Kaminski, Ph.D., Professor in the Practice of Energy Management, Jesse H. Jones Graduate School of Business, Rice University and Member of the JPMCC's Research Council

This paper is the first in a two-part series. In the current paper, the authors review the definition of liquidity, its importance to market practitioners and policymakers and discuss different measures of market liquidity. In the second part of this series, which will be included in the next issue of the *GCARD*, the authors will review the unique features of the U.S. natural gas market and how price formation occurs for the various types of natural gas products. This paper will also provide an assessment of liquidity in the U.S. natural gas market.

Practical Considerations for Commodity Investment Analysis **66**

By Thomas Brady, Ph.D., Executive Director of the JPMCC and Member of the JPMCC's Research Council

This article provides practitioners seeking to value investments across the commodity sector with practical guidance on how to calculate discount rates and importantly, how to communicate these rates to the many disparate stakeholders within and outside of a firm.

The Relationship between Oil Prices, Exchange Rates and Interest Rates **92**

By Lutz Kilian, Ph.D., Senior Economic Policy Adviser, Federal Reserve Bank of Dallas and Member of the JPMCC's Research Council and Xiaoqing Zhou, Ph.D., Economist, Federal Reserve Bank of Dallas

This digest article discusses how modeling the relationship between oil prices, exchange rates and interest rates raises some interesting identification challenges. Recent research shows how the workhorse structural oil market VAR model may be modified to overcome these challenges. The resulting structural model sheds light on common conjectures about the determinants of the variability of the real exchange rate, the real price of oil, and the U.S. real interest rate. The model estimates provide a more nuanced understanding of historical oil price fluctuations, but substantively agree with earlier historical narratives.

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Speculative Pressure **102**

As summarized by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics, Cass Business School, City, University of London, U.K. and Member of the GCARD's Editorial Advisory Board

This digest article examines the information content of futures markets speculators' net positions. The article shows that long-short portfolios based on speculative pressure capture attractive premia in commodity, equity and currency futures markets. The thus formed speculative pressure factors are able to explain the cross-section variation in futures returns after controlling

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for tradeable (carry, momentum and value) factors and non-tradeable global macroeconomic factors.

Demystifying Commodity Futures in China 107
As summarized by John Hua Fan, Ph.D., Griffith Business School, Griffith University, Australia

This digest article examines systematic investment strategies in the Chinese commodity futures market. The paper's results indicate that momentum and term structure strategies generate statistically significant profits across the futures curve, in the most liquid markets and in randomly selected sectors. In addition, the paper presents a head-to-head comparison of the important institutional settings with the U.S. market.

On Commodity Price Limits 112
As summarized by Xiao Qiao, Ph.D., Paraconic Technologies US Inc. and Member of the GCARD's Editorial Advisory Board

This digest article examines the behavior of futures prices and trader positions around price limits in commodity futures markets. The authors ask whether limit events are the result of shocks to fundamental volatility or the result of temporary volatility induced by the trading of non-commercial market participants (speculators). The paper finds little evidence that limit events are the result of speculative activity, but instead are associated with shocks to fundamentals that lead to persistent price changes. When futures trading halts, price discovery migrates to options markets, but option prices provide a biased estimate of subsequent futures prices when trading resumes.

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How to (Potentially) Weather the Storm in Risk Premia Strategies in the Commodity Markets 117
By Hilary Till, Solich Scholar, J.P. Morgan Center for Commodities, University of Colorado Denver Business School; and Principal, Premia Research LLC

This article describes risk premia strategies and notes how commodity risk premia strategies are an extension of ideas that originated in the equity markets. The paper then covers various techniques which attempt to minimize the inevitable losses that can arise from such strategies. The article concludes with several hypotheses on why commodity risk premia strategies have historically earned high average returns and does so by identifying the risk exposures that investors are taking on and for which they need to be compensated.

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Oil in the Long Term 126
By Abhishek Deshpande, Ph.D., Executive Director, Head of Global Oil Market Research & Strategy, J.P. Morgan

This article notes that investors in general remain wary of investing in oil especially if returns are likely to be challenged by the peak demand theory, or low-cost shale production in the medium term, or oil producers shifting their extraction of resources ahead of any pre-announced implementation of climate-based policies. Given the lack of investments in the sector

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Advisory Council Analysis
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and demand for oil being driven predominantly by non-OECD economies where population growth is on the rise, oil as an asset class could end up providing positive returns. Additionally, geopolitics will always be core to oil at least in the next decade.

Industry Analyses

Will the U.S. Become the Home of LNG Price Formation? 141

By Adila Mchich, Director, Research and Product Development, CME Group

The nature of price formation in the global Liquefied Natural Gas (LNG) market is increasingly the subject of both industry and academic attention. As the market shows greater appetite to gradually transition from oil indexation towards gas-to-gas pricing, many alternative price references have emerged as regional price signals, reflecting their respective markets. The article examines, from a market microstructure prospective, how a new U.S. business model is altering the structure of LNG trading transactions and subsequently positioning the U.S. to be the most likely anchor for price formation for the global LNG market.

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By Thomas Babbedge, Ph.D., Chief Scientist and Deputy Head of Systematic Strategies and J. Scott Kerson, Senior Managing Director and Head of Systematic Strategies, Gresham Investment Management

In Part 1 of 2, we explore the reduced performance of trend followers over the past decade but fail to find evidence that this is due to the commonly proffered reason of overcrowding of the strategy. Instead we find that the cause can be laid at the feet of the markets themselves – those markets commonly traded by trend followers have simply not trended as strongly in the past decade. In Part 2 we will turn our attention to the "trendiness" of a novel dataset of alternative commodity markets, selected based on a set of simple criteria. This will feature in a forthcoming edition of the *GCARD*.

Commodity Portfolio Management 155

By Vito Turitto, Lead Quantitative Analyst, S&P Global Platts (U.K.)

Managing a commodity portfolio is not particularly easy because commodities markets respond to idiosyncratic features, which cannot be found in equities, nor in the fixed income markets. In fact, their response to changes in the macroeconomic, financial and geopolitical landscapes might considerably differ from one commodity to another. In order to better address these problems, this paper examines four important aspects of commodity portfolio management: (1) commodity market returns; (2) commodity volatilities; (3) commodity seasonal volatility; and (4) trend and mean reversion.

Regulatory Review

This report describes research conducted on entering orders manually and automatically in commodity futures markets in the United States to determine how technological change is affecting futures trading.

Interview

In this issue of the *GCARD*, we have the immense privilege of interviewing Blythe Masters, a former senior J.P. Morgan executive, who has distinguished herself as a thought leader and innovator across many disciplines, including in derivatives, commodities, and in digital asset technology.

Editorial Advisory Board News

This section provides updates on conferences that EAB members have participated in or organized, along with their prestigious new appointments.

CU Denver Global Energy Management Program

CU Denver Business School's commodity expertise includes not only the J.P. Morgan Center for Commodities, but also its Global Energy Management (GEM) program. The Business School's Master of Science in Global Energy Management is a business and leadership degree, offered in a hybrid format that turns today's energy professionals into tomorrow's leaders. This degree prepares students to advance in their current field or to shift into a new role or sector.

J.P. MORGAN CENTER FOR COMMODITIES
UNIVERSITY OF COLORADO DENVER BUSINESS SCHOOL

GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

The *Global Commodities Applied Research Digest* (*GCARD*) is produced by the J.P. Morgan Center for Commodities (JPMCC) at the University of Colorado Denver Business School.

The JPMCC's leadership team is as follows. Dr. Thomas Brady, Ph.D., is the JPMCC's Executive Director. The JPMCC's Research Director is Dr. Jian Yang, Ph.D., CFA, who is also the J.P. Morgan Endowed Research Chair and Professor of Finance and Risk Management at the University of Colorado Denver Business School. In addition, the JPMCC's Program Director is Dr. Yosef Bonaparte, Ph.D., who is also an Associate Professor of Finance at the University of Colorado Denver Business School. The JPMCC's Program Manager, in turn, is Mr. Matthew Fleming.

The aim of the *GCARD* is to serve the JPMCC's applied research mission by informing commodity industry practitioners on innovative research that will either directly impact their businesses or will impact public policy in the near future. The digest covers topical issues in the agricultural, metals and mining, and energy markets as well as in commodity finance.

The *GCARD* has been made possible by a generous grant from the CME Group Foundation and is published twice per year. Complimentary subscriptions to the *GCARD* are available at: http://www.jpmcc-gcard.com/subscribe. Periodic updates on *GCARD*-related activities can be found at https://www.linkedin.com/company/jpmcc-gcard/.

Since the Spring of 2016, the *GCARD*'s editorial and project management staff has been as follows. The *GCARD's* Contributing Editor is Ms. Hilary Till, M.Sc. (Statistics), Solich Scholar at the JPMCC and member of the JPMCC's Research Council. In addition, Ms. Till is a Principal of Premia Research LLC. The *GCARD's* Editorial Assistant is Ms. Katherine Farren, CAIA, whom, in turn, is also a Research Associate at Premia Research LLC.

The *GCARD* benefits from the involvement of its distinguished Editorial Advisory Board. This international advisory board consists of experts from across all commodity segments. The board is composed of academics, researchers, educators, policy advisors, and practitioners, all of whom have an interest in disseminating thoughtful research on commodities to a wider audience. Board members provide the Contributing Editor with recommendations on articles that would be of particular relevance to commodity industry participants as well as author articles in their particular areas of commodity expertise.

The *GCARD* also benefits from its academic and professional society partnerships in furthering the international recognition of the digest. These partners include ECOMFIN, the IAQF, and CAIA. Specifically, the Director of the Energy and Commodity Finance Research Center (ECOMFIN) at the ESSEC

Business School (France, Singapore) serves on the *GCARD*'s Editorial Advisory Board while the *GCARD*'s professional society partners, in turn, are the International Association for Quantitative Finance (IAQF) and the Chartered Alternative Investment Analyst (CAIA) Association.

The *GCARD*'s logo and cover designs were produced by Jell Creative, and its website was created by PS.Design. The *GCARD*'s layout was conceived by Ms. Barbara Mack, MPA, of Pingry Hill Enterprises.

Updates from the J.P. Morgan Center for Commodities' Leadership Team

We are delighted to welcome you to the eighth issue of the *GCARD*! We are very grateful that members of both the JPMCC's Research Council and Advisory Council continue to support this publication by providing insightful articles from both academia and industry, and which are included in this issue.

The J.P. Morgan Center for Commodities (JPMCC) is also happy to provide the *GCARD*'s readers with a brief update on the many events and initiatives that have taken place since the digest's last issue.

Executive Director Appointment

We are very pleased to announce that Dr. Thomas Brady has been named as the JPMCC's Executive Director. Dr. Brady was previously the Chief Economist at Newmont Mining Corporation and has been a long-time supporter of the JPMCC, having served on the JPMCC's Advisory Council and Research Council as well as serving on the *GCARD*'s Editorial Advisory Board.

The Geopolitical Oil Price Risk Index

The JPMCC has created a brand new and unique index that reports monthly on how geopolitical risk appears to be influencing oil prices. This index is called the Geopolitical Oil Price Risk Index (GOPRX); and the JPMCC's Program Director, Yosef Bonaparte, Ph.D., describes the index's launch in this issue of the *GCARD*. In brief, the index utilizes data from Google Trends to obtain search volume for keyword phrases commonly associated with oil and politics. A proprietary application of factor analysis is then employed to compose the monthly GOPRX from relevant search terms.

Newsletters

The JPMCC will be launching two quarterly newsletters: one for students and one for the general public. Interested parties will be able to subscribe to the JPMCC's newsletter through our website: www.business.ucdenver.edu/commodities.

Educational Curriculum

The JPMCC has revised and updated our curriculum to include a new class, "Commodity Valuation and Investment." This class joins our "Foundations of Commodities," "Commodity Supply Chain Management," and "Commodity Data Analysis" suite of courses.

Press

The JPMCC's Program Director was interviewed by Denver's Fox television affiliate on financial market volatility, demonstrating the relevance of the JPMCC's expertise to the concerns of investors (Kruegel, 2019).

International Commodities Symposium

In August 2019, the JPMCC hosted the 3rd Annual International Commodities Symposium. This highly successful conference was organized by Dr. Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair & JPMCC Research Director, who was also the conference's program chair. Dr. Yang describes the conference and its international impact in this issue's Research Director Report. In addition, the conference was coordinated by Mr. Matthew Fleming, the JPMCC's Program Manager.

The *GCARD* team notes that this year's conference was the most successful yet and congratulates Dr. Yang on this accomplishment. The 2019 symposium featured distinguished participants from academia, policymaking institutions, and leading natural resource companies.

Ms. Kassie Davis, Executive Director of the CME Group Foundation, concurred with the positive assessment of this year's conference: "This is my third year attending the conference, and one of the things that keeps getting better and better each year is the industry panels," noted Davis in Robinson (2019). Davis continued: "There's an amazing caliber of professors here from universities all over the world, and the impact of that can't be underestimated. But the industry panels really tie the whole event together."

The JPMCC leadership team is very pleased that both academic and industry participants have agreed to provide research summaries from their conference presentations in both the current and next issue of the *GCARD* for the benefit of the digest's readers.

Feedback

As always, if you would like to provide us with feedback on the *GCARD*, please feel free to contact us at gcard@ucdenver.edu, and thank you for your interest in both the JPMCC and the *GCARD*!

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Kruegel, E., 2019, "Dow Sinks 800 Points as Bond Market Flashes Recession Warning," Fox Denver News, August 14. Accessed via website:
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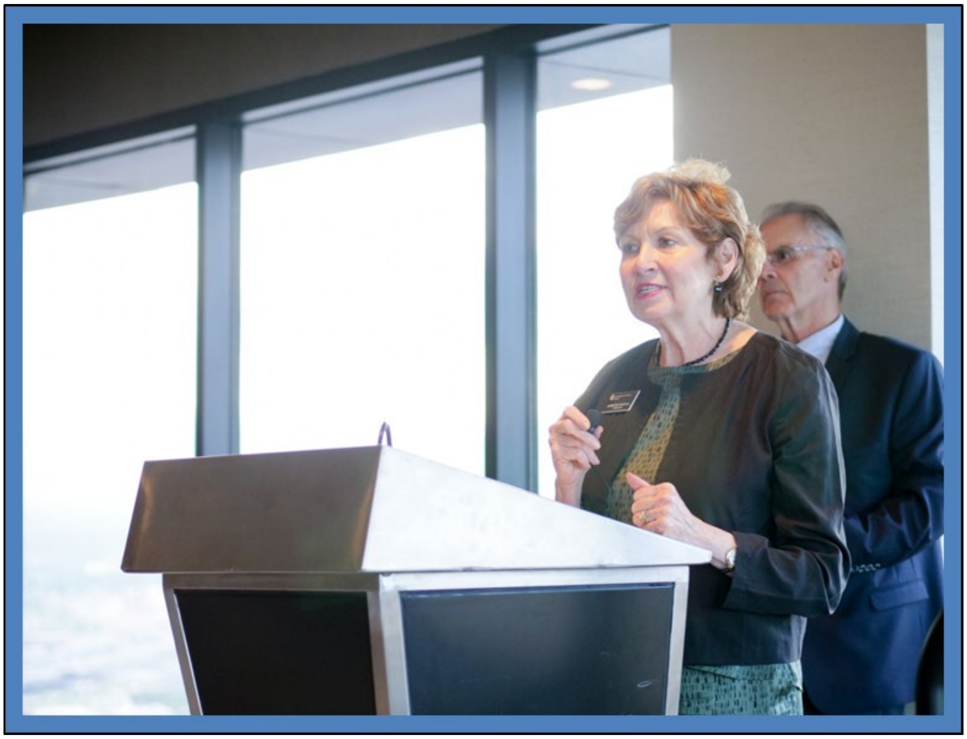
Update from the Research Director of the J.P. Morgan Center for Commodities

Jian Yang, Ph.D., CFA
J.P. Morgan Endowed Research Chair, JPMCC Research Director, and Professor of Finance and Risk Management, University of Colorado Denver Business School

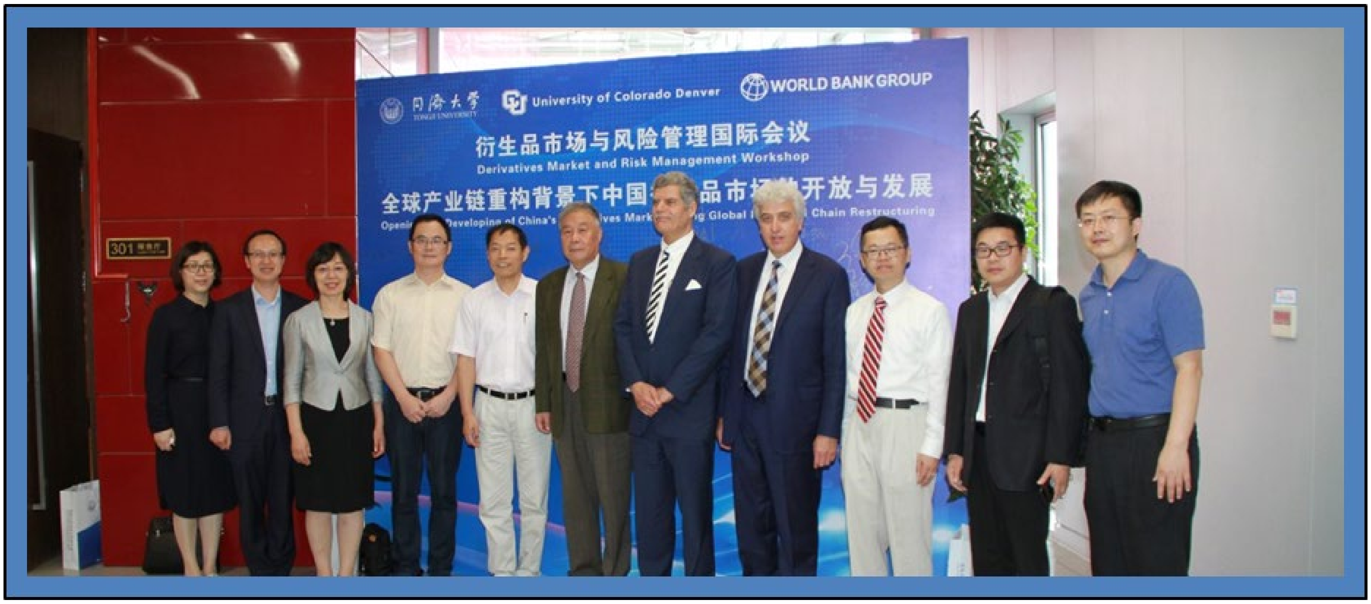


University of Colorado Denver Chancellor **Dorothy Horrell**, Ph.D., graciously provided closing remarks at the JPMCC's 3rd Annual International Commodities Symposium on August 13, 2019, which was followed by CU Denver Business School Interim Dean **Gary Colbert**, Ph.D. (in background) initiating the symposium's award ceremony. *We are very grateful to CU Denver's senior leadership team for their support of the JPMCC and its international commodities symposium.*

In this report, the JPMCC's Research Director will provide updates on the Center's research activities from January 2019 through August 2019 with the focus on two international commodities conferences organized or co-organized by the Research Director on behalf of the JPMCC.

Highlights of the First International Commodities Conference Co-organized by the JPMCC Outside the U.S.

On July 3, 2019, serving as one of the two conference co-chairs, the J.P. Morgan Endowed Chair and Research Director represented the J.P. Morgan Center for Commodities in successfully co-organizing the "International Conference on Derivatives Market and Risk Management" in Shanghai, China, together with Tongji University in China (School of Economics and Management and Shanghai Futures Institute) and the World Bank. *Funding was entirely provided by the local host and sponsors in China.* This conference attracted more than 200 participants from several countries with most of the audience being industry professionals from finance and energy companies working in China and the rest being university professors and students.



Some of the speakers at the July 2019 "International Conference on Derivatives Market and Risk Management" in Shanghai, China are included in this photograph. The speakers with a JPMCC affiliation are **Dr. Robert Webb**, Ph.D., University of Virginia; and Editor of the *Journal of Futures Markets* (fifth from right); **Dr. John Baffes**, Ph.D., of the World Bank (fourth from right); and **Dr. Jian Yang**, Ph.D., CFA, of the University of Colorado Denver Business School (third from right). Dr. Webb is a member of the JPMCC's Research Council, and Dr. Baffes is a member of the JPMCC's *Global Commodities Applied Research Digest* Editorial Advisory Board. Dr. Yang, in turn, is the J.P. Morgan Endowed Chair as well as the JPMCC's Research Director.

Based on his most recent research project, the JPMCC's Research Director also delivered a keynote presentation at the Shanghai conference on the first active contract of China's oil futures market launched in March 2018. This research compared China's oil futures contracts against the most actively traded contracts in the world during the same period and showed that the new contract had good liquidity with drastic improvements over a short period of time, as covered in Dou (2019). The research concluded that although China's oil futures market faces many structural challenges, it was responsive to market fundamentals and can have a noticeable impact on international futures oil trading.

This is the first time the J.P. Morgan Center for Commodities has organized an international conference/workshop hosted outside the United States. Almost all major financial news media outlets in China covered the event and/or the Research Director's keynote speech on China oil futures. There are at least 10 media articles in both Chinese and English that have been published, featuring the JPMCC and the Research Director in such newspapers as *Economic Daily* (of the State Council of China), *China Securities Journal*, *Yicai Global*, *Shanghai Securities News*, *Securities Times*, *China Chemical Industry News*, and *Futures Daily*. Several media articles including *Economic Daily* in Chinese and *Yicai Global* in English provided an exclusive report on the Research Director's keynote speech.

Clearly, the capacity to organize an influential workshop with excellent attendance and international news coverage in the world's second largest economy (China) is an impressive display of the JPMCC's credibility as a global commodities research leader.

Highlights of the JPMCC's 3rd Annual International Commodities Symposium

The JPMCC organized the 3rd Annual International Commodities Symposium at the University of Colorado Denver Business School on August 12 through August 13, 2019.

Dr. Jian Yang, Ph.D., CFA, J.P. Morgan Endowed Research Chair, JPMCC Research Director, and Professor of Finance and Risk Management at the University of Colorado Denver Business School, provided an overview of the conference at the outset of the JPMCC's 3rd Annual International Commodities Symposium on August 12, 2019.

We were very fortunate to have two wonderful keynote speeches at the symposium. Dr. K. Geert Rouwenhorst, Robert B. and Candice J. Haas Professor of Corporate Finance and a former deputy dean at Yale School of Management, shared his historical and analytical insights on the functioning of commodity futures markets with a lecture on "The Commodity Risk Premium: 1870-2019." Dr. Rouwenhorst is also the JPMCC's Distinguished Visiting Fellow in 2019 and a member of the JPMCC's Research Council.

Dr. K. Geert Rouwenhorst, Ph.D., CFA, Robert B. and Candice J. Haas Professor of Corporate Finance, Yale School of Management, provided a keynote address during the JPMCC's 3rd Annual International Commodities Symposium.

In addition, Dr. Frank A. Wolak, Holbrook Working Professor of Commodity Price Studies, Stanford University, and the National Bureau of Economic Research, delivered a keynote speech on "The Benefits of Purely Financial Participants in Commodity Markets." Dr. Wolak's speech was also livestreamed.

Dr. Frank A. Wolak, Ph.D., Holbrook Working Professor of Commodity Price Studies, Stanford University, also provided a keynote address during the JPMCC's 3rd Annual International Commodities Symposium.

The symposium's Best Paper was awarded to both Dr. Thibault Fally and Mr. James Sayre of the University of California, Berkeley, for their paper, "Commodity Trade Matters." Their paper was selected by the symposium's Best Paper Award Selection Committee, chaired by Dr. James Hamilton, Professor of Economics at the University of California, San Diego. In addition, Dr. Ryan A. Decker at the Federal Reserve Board and Professor Craig Pirrong at the University of Houston were selected to receive the Best Discussant Awards. Professor Craig Pirrong also serves on the JPMCC's Research Council. Congratulations to this year's award winners!

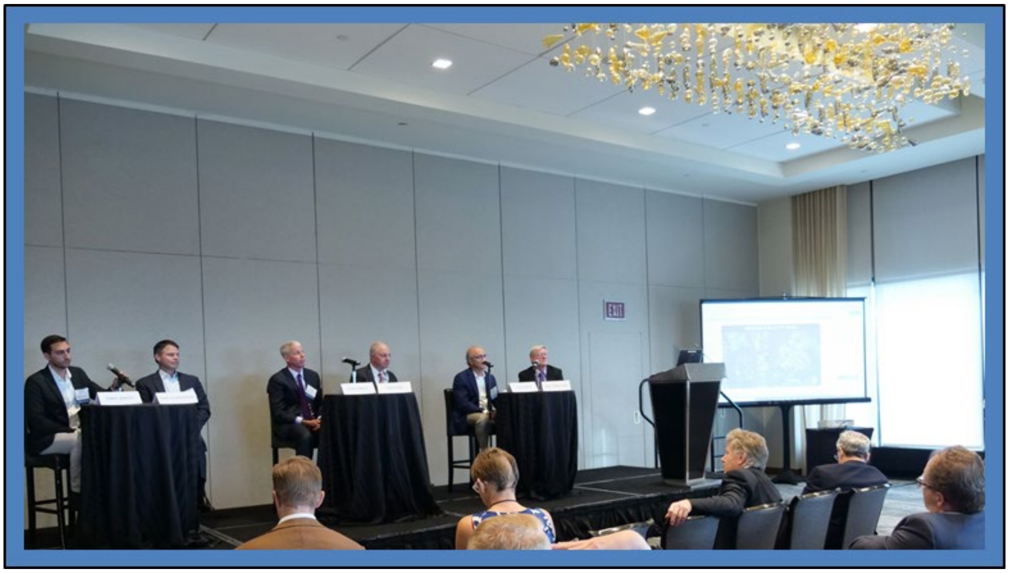
Dr. Craig Pirrong, Ph.D., Professor of Finance and Energy Markets Director for the Global Energy Management Institute at the Bauer College of Business, University of Houston, participated as a discussant and co-author during the JPMCC's 3rd Annual International Commodities Symposium.

As the organizer and program committee chair, the Research Director is very pleased to see that the 2019 symposium continued to experience significant growth in both the conference program and attendance. There was greater support from participants along with even more positive feedback, all of which has enhanced the conference's reputation.

Compared with last year, the conference program this year was restructured to substantially increase (by about 50%) the number of contributors to the program in 10 sessions (6 paper sessions, 1 poster session, and 3 industry panels.) In addition, we added a new feature in having a joint energy panel with the CFA Society of Colorado (CFACO). We also included a poster session for the first time. As a result, the total number of attendees was over 140 (versus fewer than 100 in the last two years.)

The symposium attracted the most international attention since its inception two years ago. Academic scholars from 13 countries (Argentina, Australia, Canada, Chile, China, Denmark, France, Germany, India, Singapore, Spain, the U.K., and the U.S.) submitted their research work for presentation at the symposium. In addition, academic and industry professionals from 11 countries (Argentina, Australia, Canada, China, Germany, Poland, Netherlands, Singapore, Spain, the U.K., and the U.S.) attended the symposium.

Additionally, the joint panel with the CFA Society of Colorado showcased energy leaders, including from Colorado. The panel addressed key energy issues, which are important to Colorado and beyond, both from an industry standpoint and policy perspective; and we are happy to note that the CFA Institute covered the event in their magazine, *Connexions*. We also gratefully thank Invesco for sponsoring this event during our symposium.



Participating in the joint panel on energy with the CFA Society of Colorado (from left to right) were Daniel Baruch, Director, Global Energy Markets & Business Development, Ursa Space Systems, Inc.; Charles Anderson, Client Portfolio Manager, SteelPath midstream energy investment team; Chris Wright, CEO & Chairman, Liberty Oilfield Services; Tom Petrie, Petrie Partners; Dave Neslin, Davis Graham & Stubbs LLP; and Paul Teske, Ph.D., Dean of the University of Colorado Denver School of Public Affairs (moderator).

The symposium benefited from much greater support from participants than previously. Top academic scholars have continuously contributed to the conference program, including chair professors or senior professors from Yale, Stanford, MIT, and UC-Berkeley, and distinguished scholars (e.g., Canadian Research Chair) from top non-U.S. universities such as Tsinghua University and HEC Montreal.

The 2019 symposium also received significantly stronger support from policy researchers with managerial/administrative responsibilities, whom in turn contributed to or attended the event. A partial list of this year’s participants includes the Commodity Chief of the International Monetary Fund, a Federal Reserve Board Assistant Director, the Associate Director of the Commodity Futures Trading Commission’s Chief Economist Office, a Senior Economic Policy Advisor at the Federal Reserve Bank of

Dallas, the Associate Deputy Director of the U.S. National Renewable Energy Laboratory, a former Chief International Economist at the White House Council of Economic Advisers, a former Undersecretary of State in the Ministry of Finance in Poland, and officials from the U.S. Energy Information Administration.

Dr. Abhishek Deshpande, Ph.D., Executive Director, Head of Global Oil Market Research & Strategy, J.P. Morgan, participated in an industry panel on the commodities markets during the JPMCC's 3rd Annual International Commodities Symposium. Dr. Abhishek also generously contributed an article to this issue of the *GCARD* on topics related to his presentation.

In addition, the 2019 symposium had greater participation from leading industry practitioners with managerial responsibilities (e.g., managing directors, executive directors, vice presidents, and senior managers) from over 50 international and local companies (including companies attending the JPMCC-CFACO panel.) A representative list includes J.P. Morgan, the CME Group, CoBank, Robert Bosch GmbH (a German-based Fortune Global 100 company), Uniper (a German-based Fortune Global 100 company in the energy markets), JBS (a Brazilian-based Fortune Global 200 company in the meat-processing industry), KGHM (a Polish multinational corporation that mines copper and silver), Morningstar, APG Asset Management (a major asset manager for pension funds in Europe), Encana Oil and Gas, Ardent Mills (North America's leading flour supplier), Janus Henderson Investors (a leading global active asset manager), Johns Manville (a wholly-owned subsidiary of Berkshire Hathaway), and CEOs and C-suite executives from several Colorado-based companies, among others. We are also very grateful for the support of J.P. Morgan (and our Advisory Council Chair) for sending the firm's Head of Global Oil Market Research & Strategy to contribute to the conference program.

The symposium this year also greatly benefited from strong support from many professors including several department chairs and chair professors at several other major research universities in the Front

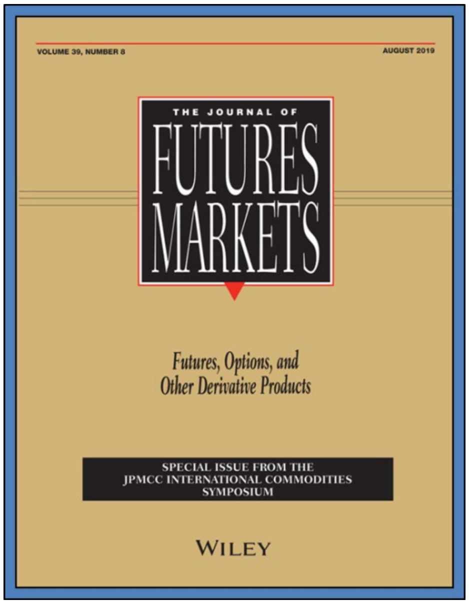
Range region, including CU Boulder, Colorado State University, Colorado School of Mines, University of Denver, and University of Wyoming.

Finally, we are very pleased to hear of the positive feedback regarding the 2019 symposium, which reinforces the reputation of the symposium as an international premier commodity conference. As detailed in Robinson (2019), both top academic scholars (e.g., Professor K. Geert Rouwenhorst, a Chair Professor of Finance at Yale School of Management) and leading industry practitioners (e.g., Dr. Bluford Putnam, Chief Economist & Managing Director at CME Group) praised the 2019 symposium as very unique compared to other conferences in (a) its focus on the common interests of both academics and practitioners, (b) the great caliber of academic presenters and industry panelists, and (c) the close interactions between the two groups. (Robinson (2019) was republished in the newsletter, *CU Connections*, which reaches over 100,000 students and employees of the CU system.)

Dr. Bluford Putnam, Ph.D., the Chief Economist of the CME Group, answers a question during a commodity industry panel at the JPMCC's 3rd Annual International Commodities Symposium. Joining Dr. Putnam during the panel discussion were (from left-to-right) Dr. Karl Skold, Head of Agricultural Economics, JBS; Mr. Lance Titus, Managing Director, Uniper Global Commodities; and Ms. Julie Lerner, Chief Executive Officer, PanXchange. Dr. Putnam is a member of both the JPMCC's Research Council and Advisory Council and has also generously contributed an article to this issue of the *GCARD* on his panel presentation. Mr. Titus, in turn, is also a member of the JPMCC's Research Council, Advisory Council, and the *GCARD*'s Editorial Advisory Board.

Continuing last year's initial effort of having both local and international media cover the symposium, and with much assistance provided to the media and particularly to the Chinese press, we thus far expect (at least) six articles on the 2019 symposium in both the English and Chinese press. These include the article in the CFA Institute's magazine along with four pieces published in *Asian Avenue Magazine* (Chen, 2019a, 2019b), *Economic Daily*, and *Futures Daily*, with an additional lengthy article scheduled to be published in *China Futures Magazine*. The latter article will extensively share research insights of many of the presenters at the symposium. We are particularly excited about having coverage of the 2019 symposium from *Economic Daily* (经济日报), which is the only newspaper sponsored by the State Council of China and which has about 1 million in circulation. Undoubtedly, the media coverage has increased the visibility of the symposium and the brand awareness of the JPMCC to the greater business community beyond Denver and even the U.S.

There will also be a special issue for the 2019 symposium, sponsored by the prestigious *Journal of Futures Markets* (*JFM*), which will add to the visibility and reputation of the symposium within the academic world. Of note is that the *JFM*'s special issue on last year's JPMCC symposium was published online in August 2019.



In August 2019, the *Journal of Futures Markets (JFM)* featured a special issue of select papers from the JPMCC's 2018 International Commodities Symposium. The *JFM* will do so again next year with top papers from the 2019 symposium. We are grateful to Dr. Robert Webb, the Editor of the *JFM*, for this recognition of the quality of the papers at the JPMCC symposiums.

With the support of both academic and industry leaders, we hope that the JPMCC symposium is well along in advancing toward the goal that the "J.P. Morgan Center for Commodities brings international attention to Denver for commodity expertise" (Chen, 2019a). We look forward to working with more of our colleagues from academia and industry to make the event even better next year! Please feel free to contact me if you have insightful suggestions at jian.yang@ucdenver.edu.

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The JPMCC's Advisory Council consists of leading members of the business community who provide guidance and financial support for the activities of the JPMCC, including unique opportunities for students.

With the support of the Advisory Council, the JPMCC aims to become a global leader in commodities education and applied research. The JPMCC is grateful for the Advisory Council's support of its activities!

Mr. Christopher Calger, Managing Director, Global Commodities, J.P. Morgan, in discussion at a JPMCC Advisory Council meeting at the University of Colorado Denver Business School. Mr. Calger is also the JPMCC's Advisory Council Chairman.

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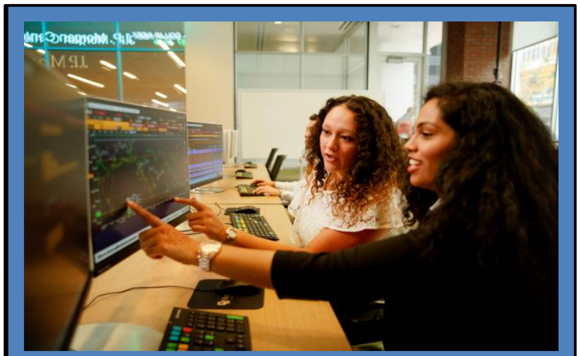

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The JPMCC Panel on Cryptocurrencies

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Introduction

On March 6, 2019, the JPMCC was honored to host three experts on cryptocurrencies during a panel presentation organized by the JPMCC Program Director, Dr. Yosef Bonaparte. This article recounts the insights of Mr. Bill Sinclair, formerly of SALT; Dr. Andrei Kirilenko of Imperial College (U.K.); and Mr. Colin Fenton of Blacklight Research during their respective presentations.

Dr. Yosef Bonaparte, Ph.D., the JPMCC Program Director and Associate Professor of Finance at the University of Colorado Denver Business School, organized and moderated the JPMCC's industry panel on cryptocurrencies.

Some of the panelists' insights rely on prior knowledge of cryptoassets, blockchain, and tokenized securities. For a primer on cryptocurrencies, please see the *GCARD* article, "Cryptocurrencies, Bitcoin and Blockchain: An Educational Piece on How They Work" (in the Winter 2018 issue.) In addition, for a primer on blockchain technology, please see the *GCARD* article, "Blockchain and Financial Innovation" (in the Summer 2019 issue.) Also, for a primer on tokenized securities, please see the *GCARD* article, "Digital Assets: The Era of Tokenized Securities" (in the Summer 2019 issue.)

We will now cover the panelists' views on cryptocurrencies in the order of their presentations.

Bill Sinclair

"Usually the knowledge and ownership of cryptocurrencies is directly proportionate to the lack of gray hair. I happen to be one of the older gray hairs of my organization; that is changing as the adoption of cryptocurrencies is increasing.

I'm going to give you a brief overview of crypto in general. While most of you have heard of it, blockchain and cryptocurrencies are used rather interchangeably. In some cases they are and in many cases they are not. I think it's important to have a baseline for our conversation today. Essentially, blockchains are distributed ledgers.

On top of blockchains, you have cryptocurrencies, which are essentially mediums of exchange or stores of asset value. The most famous one of course is Bitcoin, but since then we have had a number of other ones. The important thing about cryptocurrencies is that they are highly divisible, transparent and available to anyone and everyone. They can be energy intensive at times depending on their consensus mechanism, and are usually decentralized. Some of the newer ones are more centralized, but Bitcoin specifically is not.

Some benefits of blockchain include increased divisibility and reduced transaction costs; obviously these fluctuate with demand. In some cases, they operate for free. They are irrevocable, and they allow us to minimize fraud and enhance our audit capabilities. People talk about cryptocurrencies being used for all sorts of nefarious reasons. The fact of the matter is that for most blockchains out there and cryptocurrencies, transaction history tracing is very simple. Much easier than, say, suitcases full of cash, for instance. Far more fraud is conducted on a percentage basis and obviously on an actual basis in the traditional fiat world than cryptocurrencies and blockchain.

Regarding the different types of digital assets, we have transactional assets such as Bitcoin, and we have utility tokens. SALT specifically operates in that world. There are also security tokens. And then we have platforms where you can actually build the blockchain technology or build use cases on top of this technology.

We are seeing more interest from traditional financial institutions. The most recent one and probably the most famous one in recent years is J.P. Morgan launching their own stable coin designed to reduce the amount of wiring in the wholesale markets. They transact on $5 trillion per day in wholesale markets, and all of that is being handled with wire transfers, which is very inefficient. So they decided they wanted to launch their own stable coin to essentially handle transaction settlements between wholesalers. This is pretty exciting.

I think we will talk a little bit today about government and regulatory issues. These are challenging times if you are in the cryptocurrency space. There is some regulatory guidance. For example, Ethereum and Bitcoin have squarely fallen into the commodities definition. There are other tokens that are being deemed or treated as securities, then others as utilities.

Colorado is actually becoming a blockchain hub. Our previous governor and our current governor have both invested heavily into making the state a standout in the blockchain space. We've had a number of companies start-up here. Some of the more famous ones include SALT. On the top of that list is ShapeShift, which is a famous digital asset exchange. One of SALT's founders is actually on the governor's blockchain council, which led to some recent legislation that was passed about how to create utility tokens that are exempt from Colorado securities laws. This was groundbreaking legislation.

I will conclude with a brief description of SALT. The company has over 60,000 registered users, and is an asset-based lending platform. So essentially people deposit their cryptographic assets with SALT, which takes custody of them, and then SALT lends them fiat currencies. The firm serves crypto-revenue dominated companies like miners and exchanges; the company also serves high net-worth individuals, hedge funds, and other types of institutions. All to provide them liquidity for their blockchain assets. SALT has never lost a dollar of principal in over 14 months of operation. The nice thing about cryptographic assets is that there is a 24-hour market for them all over the world. SALT is growing very rapidly and is very much a software company."

Andrei Kirilenko, Ph.D.

"My career lies at the intersection of finance, technology and regulation. I am a classically trained financial economist; I was trained at Wharton. I have worked as a professor at MIT in finance, [and] I am [now] a professor of finance at Imperial College, … both [of which] … are technology schools. I am [also] a former regulator. During the aftermath of the Global Financial Crisis, I was the chief economist at the U.S. Commodity Futures Trading Commission. ... Technology-wise, a lot of the work that I've done … is primarily in academic finance, … [including] how digital technology changes finance. …

[In the past,] I overlooked a very important aspect of this digital technology – blockchain. As I started looking more and more into the blockchain, and again as you were told, cryptocurrenices and cryptoassets exist on a blockchain, but the blockchain *per se* can be applied … [in other ways.] Cryptoassets and crypto tokens are just one way [that] … blockchain can be used. And blockchain again is a type of database with a consensus mechanism, meaning that it could be distributed. …

In … [a] database, there are three primary functions: … who can read, who can write, and who can edit. The consensus mechanism decides in a way what determines who can read, who can write, and who can edit. What you read, write, and edit is then the subject of whatever this technology does. It could be transactions; it could be records; it could be other things.

Dr. Andrei Kirilenko, Ph.D., Director of the Centre for Global Finance and Technology at Imperial College Business School (U.K.), participated in the JPMCC's expert panel on cryptocurrencies.

A very important part of it, that took me a few years to understand, is that blockchain is a technology that enables the creation of scarcity in the digital domain. It is very difficult to create scarcity in the digital domain because digital objects could be copied infinitely many times. And exact copies of these digital objects can be created. This means that scarcity is very elusive. You can transmit a lot of things; you can make a lot of copies; you can try to protect it; [and] you can create databases. … But blockchain for the first time creates scarcity. Once you create scarcity [for] a digital object, … this digital object can no longer just be replicated and presented as a replica. It exists in the database, [and] only that is the true verifiable object. [The object is] digital in nature, meaning that it never existed in a physical space in the first place. That's where economics kicks in. Once something becomes scarce, it can have value. But that value can be risky. That value can fluctuate. You can have value and risk associated with the digital object, which are the characteristics of an asset – an intangible digitally-native asset. Digitally native objects are very interesting. They can be transmitted with very low frictions. … There is a lot of development, as it turns out, [of] about 30 to 40 years of applied math and cryptography that went into the creation of this digital object.

So once I started looking into that, naturally I started thinking of what does this resemble to me. And what this resembles to me, for the most part, is commodities. In fact, under the existing definition of commodities, cryptocurrencies could be described and fully fit under the existing definition of commodities under the Commodity Exchange Act. You don't need to create any specific regulatory environment for it. It's scarce; it is used for some economic or financial gain; it could be transmitted;

[and] ownership could be changed and so forth. Then the next questions that emerged [were as follows]: 'Is there something more than a digital commodity? Is there something that we can learn from commodities to think about cryptoassets?'

I think one of the important things that I learned from being a regulator is that I've seen firsthand, if you will, when the commodities market started … becoming 'financialized.' Financial investors [who were] only interested in financial gains started moving into commodities and in particular, commodity futures. Things started really changing. … All of a sudden you see booms and busts. You've seen volatility and … a presence of investors who … are different. … They go in and out; they are interested in using it as an asset class [as opposed to analyzing each commodity's fundamentals.] We are seeing cryptoassets experiencing that. … To me it is a natural process. A lot of people may … [see the volatility as] difficult and traumatic, but I've seen it happen before. It is a natural part of something maturing, potentially, as an asset class.

But I would also like to say is that I've heard a lot of things said in the past, and I have repeated them myself, without fully understanding … [the technology's implications.] … [It was] only … about … six months ago [when] I started coding on a blockchain … [that] I start[ed] really understanding what it is and how it really makes you rethink everything.

I judged at a hackathon in London, and the winner of the hackathon [was] … one of the … four providers of enterprise blockchain solutions, [which, in turn, are] Ethereum, Hyperledger, Corda for financial services, and a company called Digital Asset. Digital Asset is the company that won. It is a large start-up. I really like their solutions, and I asked them if they could train myself and my staff the next time they were in London about how to code, using their modeling methods, on the blockchain. And really things changed once you start doing that; you start understanding. The first thing we did [was] we coded money on a blockchain. [One has to figure out] who issues money, how it is transferred, who was potentially double-spending, how you introduce agents, where it was held, and all of that. And it really changes the way you think about things. We started creating … financial accounts. We started coding financial instruments. And all of a sudden, we started realizing that it really is the future, and that is how things should be done because the costs and frictions really become minimal, and we can create on top of the blockchain, lots and lots of different solutions; [that is,] … once the regulatory and other problems are solved. …"

Colin Fenton

"I am going to draw from some illustrative research done by J.P. Morgan and make some comments. But first: 'How many of you were over the age of 12 in 1999?' I ask that because that was the last time we had what we all agree was a bubble, a tech bubble. And a lot of people look at a chart of the market cap for cryptocurrencies or the price itself. They see a big parabolic move up and a big parabolic move down and their mind goes to the financial history. We are at a stage in time when most people who are commenting did not actually live through the tech bubble, let alone what happened in the 1620's in the tulip market. It's really important to recognize that this is much more like what happened with Nasdaq, rising and falling and then coming back and we still have the internet today. I am sure all of you have smartphones and you all have apps and you are still using the internet. It is a totally non-existent parallel to compare the tulip mania with cryptocurrencies.

Mr. Colin Fenton, Managing Partner and Head of Research, Blacklight Research LLC, also participated in the JPMCC's expert panel on cryptocurrencies.

When you see people trying to superimpose a chart of cryptocurrency values on tulip prices, just be aware of that. I also want you to look at this data sourced from J.P. Morgan, which I think is interesting: 97% of all Bitcoin wallets have one coin or less. We can see all the data. You can go to the internet right now and get a whole mapping of all of the wallets. There are people out there with a lot of coins in their wallets, but most of us have few. I should disclose that I actually invested in Bitcoin in 2015, and I still have most of my Bitcoin. I did get out of part of my Bitcoin investment to make sure I had a profit. We now also have futures exchanges with contracts that can be used to bet against the price of Bitcoin. That's really interesting because now you have a two-way market, and you have a really liquid way to use the commodity mechanism we are all familiar with to get price transparency. You have a derivative that provides additional liquidity that we didn't have until recently. We also are able to see how much it costs to produce Bitcoin. We can start to create cash cost curves as we do with gold, and copper and oil and other commodities.

We can see how much it costs to produce 50% of the Bitcoin. It's a little above $2,000, according to J.P. Morgan research from the 4th quarter of 2018. We can see on the high-cost side, it cost about $10,000 per coin. So there is a way to link a physical commodity, electricity, to the value of this product. In 1620, they were planting tulip bulbs in the ground, and there was no such mechanism. It truly was: 'I really hope it comes out pink because that's what I promised the buyer. I really hope it doesn't get too cold.' You were tied to an individual tulip. That's not a commodity, really, right? That's a specific product. It's like owning a specific Stradivarius violin or a specific Monet. Bitcoins are commodities; gold is a commodity, and so on. In the first quarter of 2017, the average low-cost Chinese mining cost, according to J.P. Morgan, was $183. By the fourth quarter it was $850. So you were told to pay attention to the price, this parabolic movement. I want you to pay attention to that average price rising because there is a fixed supply of Bitcoin and now until the middle part of the 22nd century, it is going to cost something to produce this stuff. So there is a sustainability here that has often gone unrecognized. And finally, in terms of the Bitcoin price charts, I want to point out that a lot of people have said: 'it's a bubble;' 'it makes no sense;' 'it's going to go away;' 'Bitcoin is dead.'

I thought this was interesting. J.P. Morgan took the price of Bitcoin and superimposed it on the NASDAQ in the 1990s, on the Nikkei in the 1980s, and on gold, which is the longest chart of the three. I will make two observations. The first is that the first impulse buyer of Bitcoin looks a lot like the first movement of gold in the 1970s. But there was a second bull market for gold in the 1970s that a lot of people tend to forget about, and that's when you got that much higher price. And so it would not surprise me at all to see, after a period of consolidation here, that there is another even more frenzied manic bull market in Bitcoin.

We have all the financial authorities in the world such as the IMF and the BIS writing papers and unwittingly giving us data that shows that putting 1% or 2% of your portfolio into a cryptoasset actually improves the characteristics of an investment portfolio. You are going to find that more and more people are going to say wait a minute, 'Maybe I should do that. Why do I have gold when I could have this cryptoasset? Why do I have the GSCI total return swap when it's so much easier for me to not go to a broker or an exchange? I can just pull out my phone, go to Coinbase and trade the product.'

So that is the backdrop just to orient you, and I will conclude with an argument that Bitcoin is a viable investment strategy as long as you don't put a fork in it. If you're familiar with this market, it has a big supply, but repeatedly Bitcoin has been warped into other products. The problem with that is that you lose the scarcity. There is no longer, at least in the universe of Bitcoin-like things, scarcity; Bitcoin itself though still has the same fixed amount. So I would argue that the proponents see the libertarian aspects of this asset. They see disintermediation of governments and central banks. It is an anti-elitist worldview. Proponents want you to have the power to set money supply and value, and not a committee of central bankers in Washington, Brussels or elsewhere. But on the other side, critics see a financial mania, a Ponzi scheme, and a funding mechanism for criminal activity. Now how many rap songs have you heard about the 'Benjamins'? Cash has a lot of criminal activity attached to it as well.

So here are the three benefits. First, as far as I see it, think of it as a cryptoasset not a cryptocurrency. It is a bet against perpetual debt. What's the flavor of the day? Modern monetary theory [MMT]: this idea that deficits don't matter. Well, if deficits don't matter, why do we tax anyone? Let's get rid of all taxes if deficits don't matter. You can see the problem with this argument. At some point somebody actually owns the debt. And they are staring at you, and they have got to decide whether to trust you to have the capacity to pay them back. So MMT is being spoon-fed into the marketplace and is going to die because it is clear that the people who are making this argument don't understand how bond markets work. Bond traders do actually understand the bond market and especially the people in China who own 3 trillion dollars in U.S. Treasuries. They are fully aware of the risk of MMT. Cryptoassets are a hedge against inflation.

I would argue that when we saw that parabolic movement in Bitcoin, don't think of it as an inflated asset. View that price move as a curtain that got pulled. And you saw very wealthy people's opinion about negative interest rate policy. They were telling you that the true value of the dollar, the euro, and other fiat currencies was much less than you were led to believe because there is a consequence for punishing the savers to reward the risk-takers. They were basically saying, 'I would rather put half a billion dollars into this digital asset than to leave it in a sovereign debt instrument where I am guaranteed a loss. In the latter case, they are going to literally punish me for putting on the trade.' And if you have billions of dollars you can start investing in a cryptocurrency with hundreds of millions of dollars.

The second benefit is that Bitcoin is a haven against despots and tyrannical confiscation of wealth. Think about what is happening in Venezuela right now. It's very easy for investment bank analysts in New York and London to pooh-pooh these digital currencies when they have the rule of law and the sanctity of contracts. They have the security of knowing you can walk down the street in most circumstances and go about your life. You can't do that in Venezuela. There is clear confiscation of wealth. So you have an incentive here to find disintermediation whether it's tyrannical or despotical that either overtakes your wealth or indirectly takes your wealth through mismanagement of the resources in society.

There is a third benefit and that is Bitcoin is insurance against catastrophe. I am always amused when I hear a gold bug say, 'Well, I own physical gold. I am here in London, and my gold is in Switzerland.' That is going to be problematic going into a post-apocalyptic world, and you have to travel across a lot of water and land to go get your coins to trade them in these post-apocalyptic trades. You have to really have a sense that you can port the digital asset, and you really can hoard these cryptoassets in a way you could never do with gold coins or silver. It's true: there are problems using Bitcoin to buy $2 coffee; as such, transaction costs make some of the peer-to-peer payments not practical. But if you did have a problem with the payment system worldwide, you can really move a lot of capital around the world.

Finally, let me just say that we hear a lot of stories and complaints that Bitcoin and cryptoassets are going to break the internet, or going to break electricity limits. I mentioned the story of the Dutch tulips, and the idea they are not backed by any kind of intrinsic value. But on the electricity point, when I ask the question: 'Do any of you know the temperature at which gold melts?' 1,948 degrees. Copper is even higher at 1,984. So when you think about digital assets versus physical gold and physical copper, these metallic monies that literally have to go through processing where we melt rocks and form them into these bars: that uses a lot of electricity, too.

It's true that maybe as much as 1% of global electricity consumption has been directed towards these crypto use applications. And what will happen is that society will demand a growing share of electrical power in order to give us the utility of the distributed ledger, not just for a store of value in cryptoassets, but for all of these useful applications in tracking commodity goods through supply chains and having a very accessible and verifiable system.

So, for me, it makes sense for many institutional investors to look at a central bank policy that promises you that there could be a 1-2% deterioration in the real value of your portfolio through targeted inflation. Ask yourself, 'Well if I put 1% into a cryptoasset, there's a pretty good chance that it doubles at some point, particularly in a hostile market, as defined in the financial markets, so that's a pretty good hedge.' You will find that institutional investors will eventually come around to that argument in the same way that there was financialization of the commodity markets through total return swaps such as the Goldman Sachs Commodity Index. That would be one of the benefits to your own retirement account. You won't trade it; you'll just let it sit there as a form of portfolio diversification."

Conclusion

The JPMCC is grateful to the cryptocurrency experts for their insights on this innovative asset and for their permission to quote from their presentations. As for the *GCARD*, we look forward to providing additional insights on this topic in future issues.

Endnotes

1 These were the respective positions of the panelists as of March 2019.

This article was transcribed and lightly edited by Hilary Till, Katherine Farren, and Meghan Nemechek. For further coverage of cryptoassets and blockchain, the reader is invited to read past *GCARD* articles on these markets and technology.

Of note is that this article does not necessarily represent the views of the JPMCC, its sponsors, or donors. The article is for educational purposes only and should not be construed as investment advice or an offer or solicitation to buy or sell securities or other financial instruments.

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BILL SINCLAIR
Former Chief Technology Officer, Interim President and CEO, SALT

Bill Sinclair has over 20 years of experience in technology and software. He has managed software development teams, IT departments and executed global strategies across industries including finance, energy, Internet of Things (IoT) and blockchain. Mr. Sinclair's domain expertise in the energy industry guided Agelio Networks and the development of MineralFile, a patented SaaS platform for revenue tracking and land management in the oil and gas industry. He sold MineralFile to NeoFirma in 2014. Mr. Sinclair later joined Cartasite as Chief Technology Officer where he aided the company in securing multiple funding rounds, established product management organization, and managed both the product management and engineering teams. Cartasite was later purchased by GeoForce.

In 2018, Mr. Sinclair joined SALT as Chief Technology Officer to manage development of a blockchain lending and custody platform. After the platform launched successfully, he occupied the role of Interim President and CEO before leaving in 2019 to pursue a new opportunity. An early adopter of blockchain technology and cryptocurrency, Mr. Sinclair has significant experience in mining, programming, and developing technology solutions in the space.

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The Launch of the JPMCC's Geopolitical Oil Price Risk Index (GOPRX)

Yosef Bonaparte, Ph.D.
Program Director, J.P. Morgan Center for Commodities (JPMCC), and Associate Professor of Finance, University of Colorado Denver Business School

Professor Yosef Bonaparte, Ph.D., the JPMCC Program Director and Associate Professor of Finance at the University of Colorado Denver Business School, provided an overview on the commodities center at the beginning of the JPMCC's 3rd Annual International Commodities Symposium on August 12, 2019.

Introduction

This digest article describes a new research project at the JPMCC: the launch of the Geopolitical Oil Price Risk Index (GOPRX), which is designed to reflect the impact of geopolitics on oil prices, volatility, and supply in one succinct metric.

Methodology

To construct our index, we utilize data from Google Trends to track attention to several terms related to politics, uncertainty, oil price, and supply. Several studies document that Google's search engine is the leading search tool; for example, NetMarketShare.com (2019) has documented that Google is used in 75.7% of searches among the different search engines on the web. As noted below, there is good academic support for using search activity as a proxy for the intensity of investment concerns.

Studies by Vlastakis and Markellos (2012), Vozlyublennaia (2014) and Dimpfl and Jank (2016) suggest that Google searches function as a good proxy for retail investor news attentiveness. Other papers demonstrate that search intensity varies over time; for example, Dzielinski (2012) shows that investors intensify their search in response to greater uncertainty; and Vozlyublennaia (2014) shows that more stock-related Google searches are conducted when stock prices decline. The search intensity is also studied in economic psychology literature; for example, Lemieux and Peterson (2011) and Abbas *et al.* (2013) provide empirical evidence that in response to great price uncertainty, individuals increase their search activity.

Following these insights, we use Google Trends to track internet news search volume over time, using this as a proxy for investor news priorities. In particular, we use monthly data from Google Trends to obtain search volume for keyword phrases commonly associated with oil and politics. Having identified the most commonly used keyword phrases, we then use Google Trends as our proxy for GOPRX. Specifically, to have comprehensive information about GOPRX, we originally considered 27 different worldwide search terms to measure the relevant trends. These 27 search terms are divided into five groups and are reported in Table 1.

Table 1
Search Term Keywords by Group

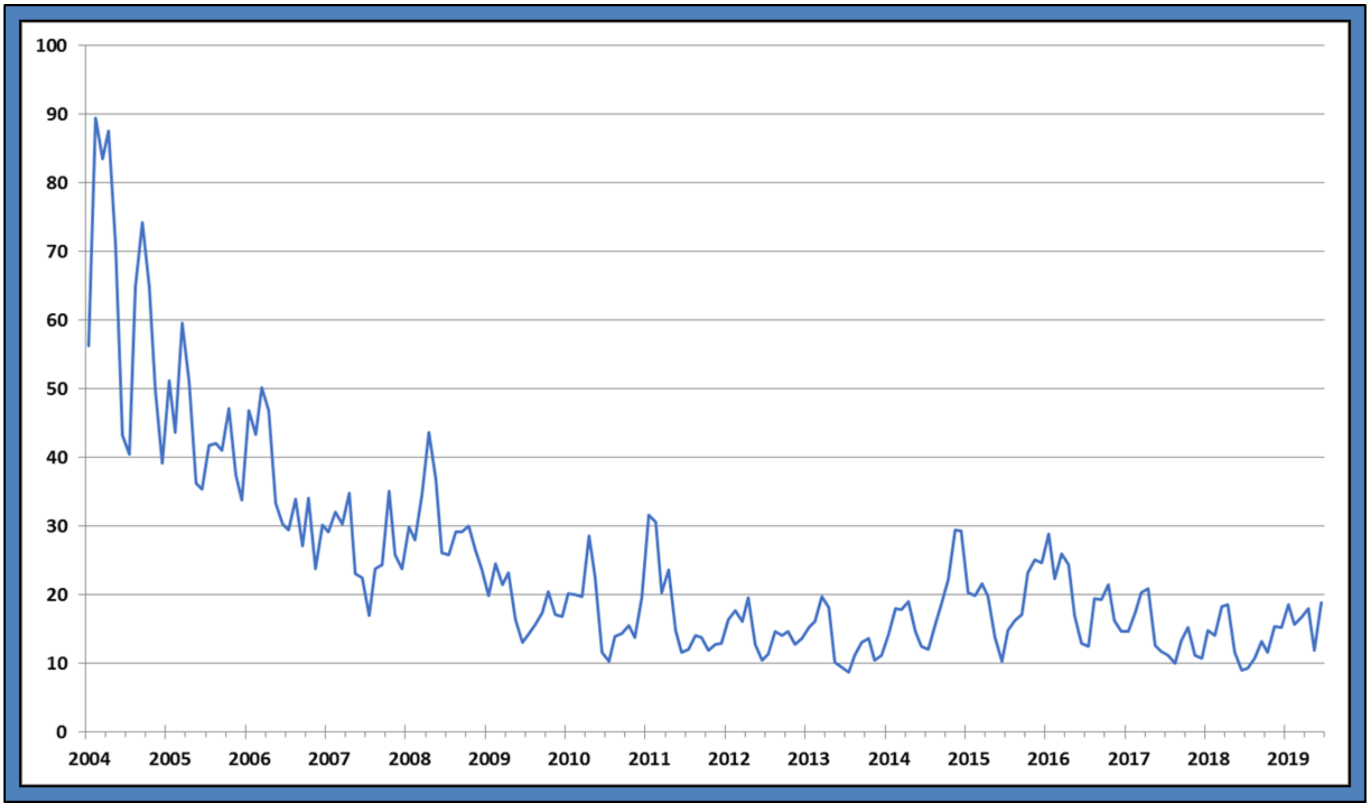
Number	Group 1: Sanction	Number	Group 4: Economic Uncertainty & Geography
1	oil sanction	1	oil price uncertainty
2	Iraq sanction	2	oil uncertainty
3	Iran sanction	3	Strait of Hormuz oil
		4	Gulf of Aden oil
		5	Suez canal oil
Number	Group 2: Countries under Political Tensions	Number	Group 5: U.S. Presidents and Oil Policy
1	Saudi Arabia oil	1	Carter oil
2	Venezuela oil	2	Reagan oil
3	Libya oil	3	Clinton oil
4	Iraq oil	4	Bush oil
5	Russia oil	5	Obama oil
6	Syria oil	6	Trump oil
Number	Group 3: Political Events		
1	Middle Eastern war		
2	Israeli Arab conflict		
3	Gulf war		
4	Terrorism		
5	disruption oil		
6	Aramco oil		
7	OPEC		

We employ a proprietary application of factor analysis to compose the monthly GOPRX from Table 1's data. We normalize the GOPRX, so it will be between 0 and 100, where 100 is the maximum geopolitical risk. Accordingly, we can then evaluate the JPMCC's GOPRX over time.

Results

We plot the GOPRX for the period, January 2004 through June 2019. For capturing the geopolitical oil impact, we find that the keyword phrases, "sanction", "Gulf war" and "Terrorism" are the most suitable ones. Thus far, the GOPRX's peak value was during the Iraq War in 2004 while a recent peak was after the election of President Trump in 2016.

Figure 1
The JPMCC's Geopolitical Oil Price Risk Index (GOPRX)
January 2004 through June 2019 (Monthly Data)



Furthermore, *we find that GOPRX is correlated with the OVX (Oil Volatility Index) and negatively correlated with global oil supply.* These findings suggest that the GOPRX can potentially be useful in monitoring the geopolitical influences on oil price volatility and oil supply.

Endnotes

The author gratefully acknowledges the contributions to this research by Sierra Nelson, research associate; and Meghan Nemechek, research assistant, at the University of Colorado Denver Business School.

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Gold, Copper, and Oil: Dancing to Different Drummers

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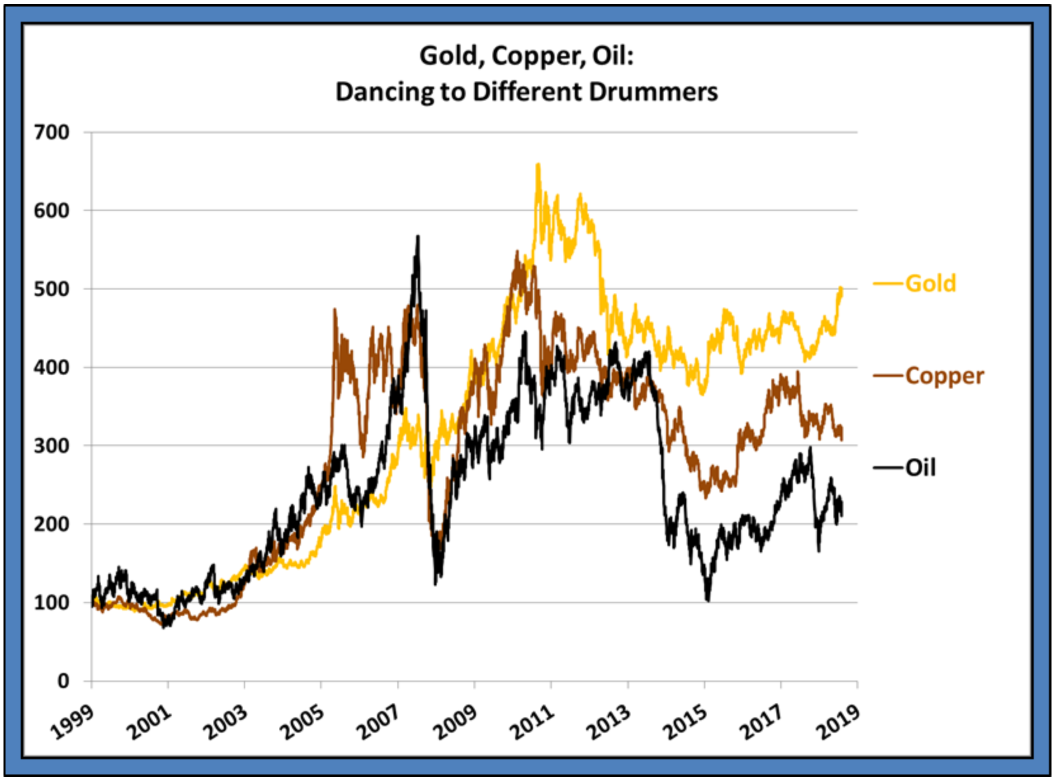
Dr. Bluford Putnam, Ph.D., Chief Economist, CME Group, and member of the J.P. Morgan Center for Commodities' (JPMCC's) Research Council, presented on "The Changing Dynamics of Gold, Copper, and Oil" at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

Back in the early 2000s, the global economic boom driven by the rise of China lifted all boats in the commodity sector. Gold, copper, and oil all saw very impressive price gains. After the Great Recession of 2008-2009, very different dynamics have been driving each of these three commodities; please see Figure 1 on the next page. Gold has become highly sensitive to U.S. short-term interest rate expectations. Copper has become an indicator of the ebb and flow of the U.S.-China trade war. Oil has been disrupted by technological advances. In this report, we will delve deeper into the longer-term forces of financial panic, disruptive technology, and trade protectionism to get a better sense of why the correlation structure among key commodities may occasionally diverge sharply from its longer-term pattern only to return eventually back to form.

Figure 1



Source: Bloomberg Professional (GOLDS, LMACADY, USCRWTIC).
Chart created by CME Group Economics.

Lesson #1: December 2004 through June 2008 – Oil and Copper Depend on China to Lead Growth, Gold Constrained by Rates

The first crack in the mostly synchronized movements of gold, copper, and oil came in 2005 and lasted until the Great Recession hit. From end-1999 through end-2004, price performance was in the same ball park for gold (+52%), oil (+70%), and copper (+76%). From end-2004 through the middle of 2008, gold did rally another 111%, but copper took off for 166%, and oil led the way with a gain of 222%. The difference in performance was mostly attributable to two things. First, demand for the industrial commodities, such as oil and copper, continued to benefit from the impressive real gross domestic product growth of China, which sustained its superlative growth, posting 10%-plus annual gains, and lifting many other emerging market countries with it. Gold, however, had to contend with the rising U.S. short-term interest rates, as the Federal Reserve under Chairman Greenspan, began to raise interest rates because it feared the housing boom would lead to rising inflation.

Lesson #2: July 2008 through February 2009 – Industrial Commodities Collapse, Rate Cuts Cushion Gold

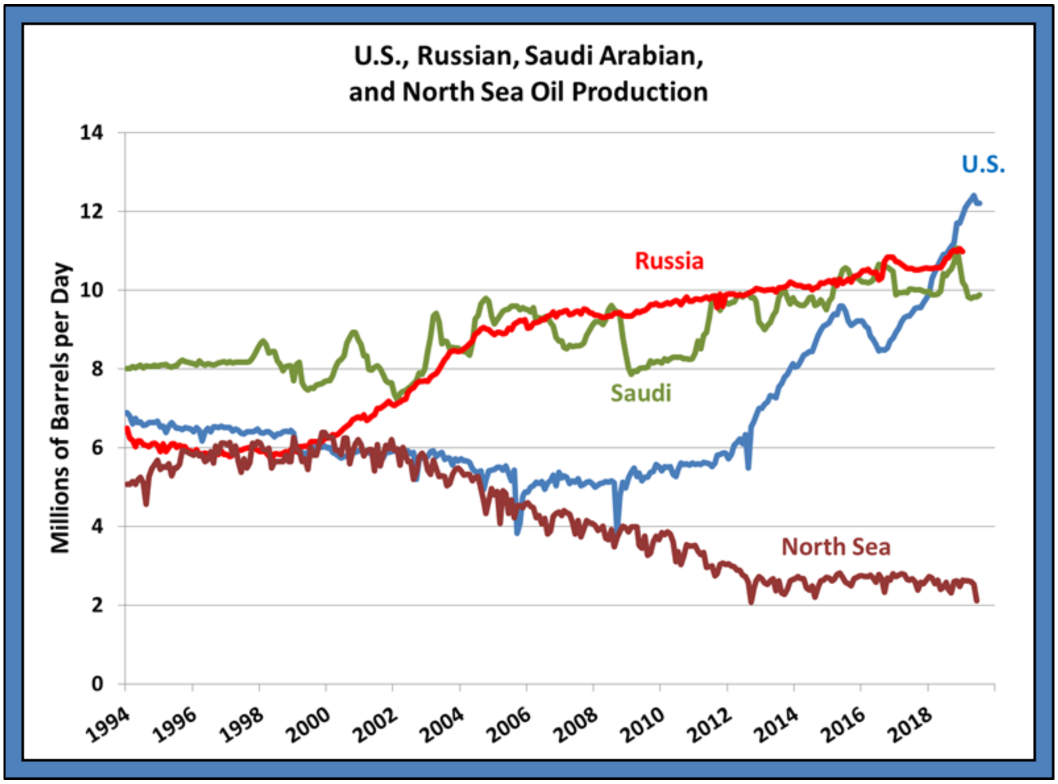
The financial panic hit hard in September 2008 with the very messy bankruptcy of Lehman Brothers and poorly managed bailout of AIG. Within months, the Federal Reserve, along with other major central banks, had lowered short-term rates to zero, and instituted asset buying (Fed) or lending programs (European Central Bank) to prevent the financial sector from collapsing and leading the global economy into a depression. With expectations of a severe global contraction taking hold, copper and oil prices both sunk by over 60% between July 2008 and March 2009. Gold held remarkably steady, showing a gain of just under 2%. Again, the lesson learnt was that the industrial commodities were highly sensitive to a shift in expectations from global economic growth to recession, but that rate cuts associated with the deteriorating economic conditions could cushion the gold price.

Lesson #3: Q4 2014 through early 2015 – Oil Gets Hit by Realization of the Impact of Disruptive Technology

Most commodities were in a downdraft in late 2014. Growth from China and other emerging market countries was decelerating. Hopes for a V-Shaped recovery in the U.S. and Europe from the Great Recession had been dashed. Most importantly, though, for oil was the realization by market participants that the Organization of the Petroleum Exporting Countries (OPEC) was no longer capable or willing to stabilize oil prices given the rapid growth of U.S. shale oil production based on the practical development and implementation of hydraulic fracturing methods. The moment of truth came at the end of November 2014, when OPEC decided it was not worth it to cut production to stem the fall of oil prices. During the short period from October 31, 2014 through March 17, 2015, oil prices collapsed by 46%, while gold (-2%) barely moved and copper (-14%) saw prices fall materially, yet nothing like what was happening in the oil market.

One of the more interesting lessons from the U.S. shale oil revolution is just how long it can take for a massive increase in supply to have any impact on prices. In the case of oil, there was this belief, ultimately proving unfounded, that OPEC could cut production enough to offset the U.S. shale oil revolution. Yet there were quite a few years of sharply rising U.S. oil production before a reckoning took place. Please see Figure 2 on the next page.

Figure 2



Source: Bloomberg Professional (DOETCRUD, OPCRSAUD, DWOPRUSS, PIWANORT).
Chart created by CME Group Economics.

OPEC has also been changed forever. Indeed, many market analysts now only focus on the big three oil producers – the U.S., Russia, and Saudi Arabia. This change of focus has been underscored by the willingness of Saudi Arabia and Russia to cooperate, despite Russia not being a formal member of OPEC. Added to the decline of OPEC's influence is the antipathy between Iran and Saudi Arabia, as well as the U.S. efforts to isolate Iran.

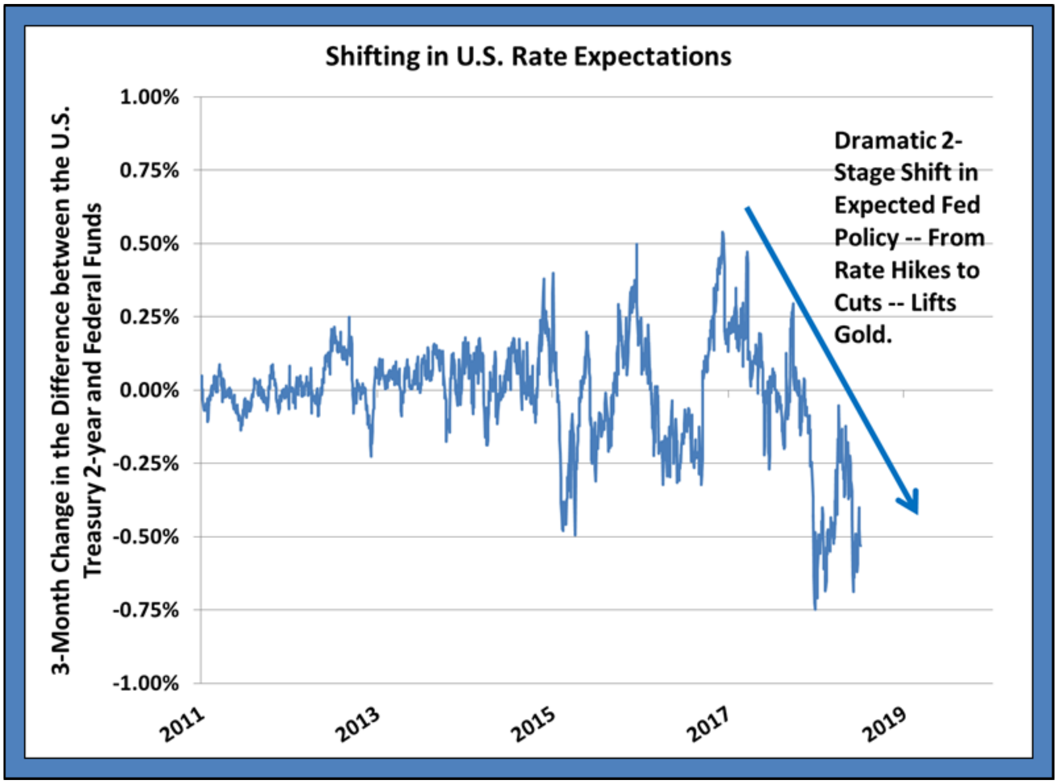
A final note on oil relates to the impact of Mideast tensions. When tankers were attacked and taken hostage in the Strait of Hormuz in the summer of 2019, oil prices rose a little, but not much; and certainly not even half as much as if the same escalation of tensions would have taken place a decade or more earlier. The capability of the U.S. to be a major global exporter of oil has simply rewritten oil dynamics.

Lesson #4: 2018-2019 – Trade War and U.S. Rate Cut Expectations

Gold's sensitivity to U.S. rate expectations was on display in the second half of 2018 and the first half of 2019, while oil and copper prices were stuck in the doldrums as the U.S.-China trade war rhetoric ebbed and flowed and it became apparent that the "temporary" tariffs used by the U.S. as threats to get a better deal were going to be permanent since no deal was in sight.

During the fourth quarter of 2018, expectations for the path of U.S. short-term rates changed dramatically. 2018 had commenced with the Fed guiding that it might raise rates four times in 2018, and then continue the rate rises as if on autopilot through 2019. In Q4-2018, as equities went into a swoon and U.S. President Trump lobbied for lower rates and not rate rises, the Fed changed its tune and guided at year-end 2018 that it was prepared to put rates on hold for all of 2019. During this period in the second half of 2018 when rate expectations underwent a major shift away from higher rates, gold rallied from $1200/ounce to above $1300.

Figure 3



Source: Bloomberg Professional (USGG2YR, FEDL01).
Chart created by CME Group Economics.

In the spring and summer of 2019, U.S. rate expectations underwent another major shift – moving from the "on hold" view to the likelihood of rate cuts in the second half of 2019 and into 2020. The shifts in rate expectations are illustrated in Figure 3. It is highly debatable whether the change of heart by the Fed was based on Presidential jawboning or the bond market screaming for rate cuts, but the change in policy was certainly not based on current economic data. When the Fed made the first cut in July 2019, U.S. unemployment was comfortably under 4%, inflation was hovering just below the Fed's 2% long-term target, and the U.S. expansion had just moved into record territory as the longest economic expansion ever.

One of the key factors cited by the Fed as a reason to cut rates was the anticipation of weaker economic activity around the world due to the ongoing U.S.-China trade war. The worsening of the trade war and realization that the tariffs already imposed would likely be permanent had cast a pall over global economic growth and trade expectations. So, gold was able to rally above $1400/ounce on the back of rate cut expectations, while copper and oil had to contend with a worsening picture for global demand. More specifically, over the period from end-August 2018 through end-July 2019, gold prices rose 20%, while copper prices fell 4% and oil prices fell 20%. The trade war was hitting copper and oil, and oil was hit harder due to rising U.S. production even as Mideast tensions worsened.

Bottom Line

- Correlations among gold, oil, and copper can be stable for long periods and then diverge sharply.
- Gold seems less interested in global dissonance and is often more focused on U.S. rate expectations.
- Copper retains the moniker of “Dr. Copper” as a reliable metric by which to assess expectations of global growth during this trade war era.
- Oil has had to contend with a large dose of technical disruption leading to rising U.S. exports, even as oil still responds to the ebbs and flows of global growth.

Endnotes

Dr. Putnam discussed this paper’s topic at the JPMCC’s 3rd Annual International Commodities Symposium during the conference’s commodity industry panel session on August 13, 2019, which was moderated by the JPMCC’s Solich Scholar, Hilary Till. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

Dr. Putnam is a regular contributor to the GCARD’s Economist’s Edge section.

All examples in this report are hypothetical interpretations of situations and are used for explanation purposes only. The views in this report reflect solely those of the author and not necessarily those of CME Group or its affiliated institutions. This report and the information herein should not be considered investment advice or the results of actual market experience.

Author Biography

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Prior to joining CME Group, Dr. Putnam gained experience in the financial services industry with concentrations in central banking, investment research and portfolio management. He also has served as President of CDC Investment Management Corporation and was Managing Director and Chief Investment Officer for Equities and Asset Allocation at the Bankers Trust Company in New York. His background also includes economist positions with Kleinwort Benson, Ltd., Morgan Stanley &

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Dr. Putnam has authored five books on international finance, as well as many articles that have been published in academic journals, including the *American Economic Review*, *Journal of Finance*, and *Review of Financial Economics* among others. His newest book, Economics Gone Astray, is now available from World Scientific (WS) Professional.

Dr. Putnam is also a member of the J.P. Morgan Center for Commodities' Research Council as well as its Advisory Council.

Liquidity Issues in the U.S. Natural Gas Market: Part 1 of 2

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Introduction

Natural gas is a commodity of critical importance to U.S. economic prosperity, as well as energy and national security. It accounted for about 28% of primary energy consumed in the United States in 2017, and about 32% of electricity generated in the same year. It was also used for heating, heating water and cooking in 86 million of the nation's homes. A network of 300,000 miles of pipelines and 1,300,000 miles of distribution mains help to deliver natural gas every day. In recent years, the U.S. has become the biggest producer of natural gas in the world and will soon be an important exporter of liquefied natural gas (LNG). U.S. natural gas prices are used for price determination in some LNG contracts and will likely become an even more important source of market information in the future. A complex market supports the physical processes behind natural gas production, transportation, storage and distribution, with transactions taking place every weekday at more than 100 trading hubs. This market is host to a rich ecosystem of different participants and a variety of transaction types, often taken for granted, not only by the public at large, but by many industry professionals who do not appreciate its sophistication and intricacies.

Current debates regarding U.S. natural gas market efficiency revolve around several episodes of reduced market liquidity at certain market hubs during periods of extreme weather. High price volatility and price spikes combined with increased market opaqueness – liquidity migrated from the platform of high transparency (Intercontinental Exchange - ICE) to over-the-counter markets, for which information regarding price levels and transaction volumes is limited. Information became scarce when it was most critical to market participants. The second trend that worries regulators is the deteriorating quality of price discovery. The number of market participants reporting transactions on a voluntary basis to the Price Reporting Agencies (PRAs - entities like Platts or Argus Media) has been declining over the last few years with a corresponding decrease in reported transaction volumes. Falling liquidity creates conditions facilitating price manipulation with serious consequences to market integrity and the reliability of price signals critical to optimal asset allocation in the energy industry.

This paper is the first in a two-part series. In the current paper, we review the definition of liquidity, its importance to market practitioners and policymakers and discuss different measures of market liquidity. Assessing market liquidity requires reliance on several measures to capture different aspects of market activity. Each liquidity measure possesses its own particular strengths and weaknesses in capturing the dimensions of liquidity.

Accordingly, we review a number of liquidity measures from the market microstructure literature and discuss their relevance to the natural gas markets. These liquidity measures include transaction volume-based indicators and spread-based indicators, as well as hybrid measures combining transactions and spreads. Each of these measures has particular strengths and weaknesses: using them depends on which dimension of liquidity is of interest.

The choice of a specific liquidity indicator (or a set of liquidity indicators) is a pragmatic decision based on data feeds and their cost, computer systems, availability of commercial software packages, and analytical skills of the staff. Most econometric methods require the history of prices with reliable time stamps. This requirement alone shrinks the range of viable liquidity measures and makes liquidity monitoring feasible only in the case of institutions with considerable resources.

In the second part of this series of articles, which will be included in the next issue of the *GCARD*, we will review the unique features of the U.S. natural gas market and how price formation occurs for the various types of natural gas products traded. We will also discuss our assessment of liquidity in the U.S. natural gas market.

We will now turn to introducing the general concept of market liquidity before considering a number of alternative measures of this concept, including their relevance to the natural gas market.

Definition of Market Liquidity

Market Liquidity: Financial Markets

Liquidity is as important to financial and physical commodity markets as lubrication is to an engine. Decreasing market liquidity is a manifestation of a financial and economic crisis and a factor that may aggravate the crisis by extending it and deepening it through complicated feedback loops. This explains why market liquidity has received a lot of attention from academic economists and trading professionals. Most papers published in the scientific journals revolve around different aspects of liquidity in financial instruments with limited attention paid to the physical commodity markets. This is not surprising – commodity price information is fairly limited and modeling of the price formation processes requires understanding of the unique features of each specific commodity as well as the physical layer of the industry. This two-part series of articles covers the market liquidity issues as identified by the authors in the U.S. physical natural gas markets. Our articles are a work in progress and the authors hope that feedback from researchers and practitioners will help in completing this effort.

Market liquidity is one of the most elusive concepts in finance.[1] Its importance has been recognized by both market practitioners and economists who agree that defining and measuring liquidity is a work in progress:

> "Liquidity is the lifeblood of financial markets. Its adequate provision is critical for the smooth operation of an economy. Its sudden erosion in even a single market segment or in an individual instrument can stimulate disruptions that are transmitted through increasingly interdependent and interconnected financial markets worldwide. Despite its importance, problems in measuring and monitoring liquidity risk persist." (Fernandez, 1999).

In an International Monetary Fund (IMF) paper, Lybek and Sarr (2002) offer the following definition for market liquidity:

> "*Liquidity measures can be classified into four categories: (i)* **transaction cost measures** *that capture costs of trading financial assets and trading frictions in secondary markets; (ii)* **volume-based measures** *that distinguish liquid markets by the volume of transactions compared to the price variability, primarily to measure breadth and depth; (iii)* **equilibrium price-based measures** *that try to capture orderly movements towards equilibrium prices to mainly measure resiliency; and (iv)* **market-impact measures** *that attempt to differentiate between price movements due [to] the degree of liquidity from other factors ... No single measure, however, unequivocally measures tightness, immediacy, depth, breadth, and resiliency*."

The challenge of defining and measuring market liquidity arises from its multidimensional character – it is defined by listing a number of market attributes, enumerated in the IMF paper quoted above, such as transaction volumes, transaction costs and the time required to execute a transaction, which often change in different directions. The most frequently repeated definition of liquidity is the ability to transact in large volumes, over short periods of time, without (or with limited) price impact, and at low transaction costs.[2] Often these objectives conflict as a market participant has to accept trade-offs between the volume and the speed of a trade and the cost of executing that transaction. Increasing transaction volume may require trading over a longer time period, waiting for additional traders to enter the market, or making price concessions to exhaust more quickly the bid / offer stack. Price concessions will be reflected in a higher market impact of a specific set of transactions.

Perceptions of market liquidity depend on which of those different characteristics are important to a market participant. Liquidity, like beauty, is in the eye of the beholder. This explains why the definition of liquidity and its measure cannot be compressed into one sentence or one magic formula. The holistic assessment of market liquidity requires use of multiple indexes which shine light on many different aspects of market activity. The importance and usefulness of these indexes will vary from market to market and from time period to time period. Sometimes the inability to calculate one or several measures of liquidity (discussed below) is the best indicator of extreme market conditions.

It is important to distinguish between market liquidity and funding liquidity as these two issues are often conflated and tend to interact, especially under conditions of economic distress. Funding liquidity corresponds to the ability to obtain access to cash (or cash equivalents such as credit lines) on short notice. Market illiquidity can exacerbate funding illiquidity as a firm may find it difficult to reduce inventories, liquidate certain assets and may face increased costs of acquisition of materials required to carry on its business activities. Funding illiquidity may force potential counterparties to reduce their trading activities and even withdraw completely from the market. U.S. energy industry practitioners still have vivid memories of the paralyzed natural gas and electricity markets in 2002 and 2003, following the Enron bankruptcy.

The definitions of market liquidity available in the economic literature have been developed for the financial markets and, therefore, cannot be mechanically applied to physical energy. Financial instruments can be created and distributed, ignoring physical constraints of the system and exist as records in data servers. In the case of physical energy, trading requires access to the production and distribution infrastructure as uninterrupted flows of commodities between producers and end-users are the overriding concern and the yardstick by which the markets are assessed. A more appropriate definition of liquidity in this case is the ability of the market to absorb supply/demand shocks and keep the proverbial lights on. Other elements of the definition of market liquidity mentioned above are secondary in their importance to the overriding objective of system resiliency.

The Importance of Market Liquidity

Market liquidity, the ability to transact on a short notice, at required levels, and at reasonable cost, is important not just for the convenience of the traders. Liquid and transparent markets are a public good with a positive impact on the overall efficiency of the national economy. To explain this one has to distinguish between physical and financial energy markets.

Liquidity of physical energy markets helps to increase the resilience of the supply chain to demand/supply shocks caused by extreme weather events and forced outages of power generation plants, natural gas pipelines and high voltage transmission lines. For example, an outage of a nuclear power plant triggers a chain of market transactions and physical operations such as the start-up of idle power plants (or expanding output from power plants already in operation), purchases of additional fuel, wheeling electricity from other areas, and extraction of natural gas from storage. In the absence of an efficient market, such operations would be either impossible or time consuming and expensive, and this would in turn result in cascading disruptions of multiple supply chains, affecting many industrial, commercial and residential end users of electricity, declarations of force majeure, and costly legal disputes.

Liquidity of financial energy markets makes a contribution to the national economy through transfer of risks, accomplished through hedging and insurance-like transactions.[3] Availability of hedging instruments insulates energy companies from the consequences of extreme events, reduces the risk of cash shortfalls and suppresses volatility of earnings. This in turn translates into a lower cost of debt, the enhanced ability to fund investment projects and the ability to concentrate on long-term operational challenges. The cost of hedging instruments varies positively with market volatility[4] which is one manifestation of low liquidity. This is another example how lack of liquidity translates into a higher cost of doing business for the producers and the end users of energy.

Low market liquidity is often associated with the potential for market manipulation as relatively small transaction volumes may be associated with significant market impact. Market manipulation undermines confidence in the price system and impedes development of the market for energy related derivatives used for risk management. Derivative contracts are usually cash settled and market participants are reluctant to enter into such contracts if they cannot trust the integrity of the prices used for settlements.

Measuring Market Liquidity

Market microstructure theorists developed several benchmarks for measuring market liquidity and tracking it over time. The benchmarks can be classified based on the type of market information used in their calculation and include:

1. Transaction volume-based indicators;
2. Spread-based indicators;
3. Transaction flow-based indicators; and
4. Hybrid indicators.

This classification can be further refined by considering the granularity of available data:

1. Benchmarks based on the order book information and/or high frequency data; and
2. Benchmarks based on volume and price data recorded at low frequency (hourly or daily).

The first group of benchmarks relies on high frequency transaction data and bid/offer information for both consummated and unconsummated transactions which are not available for most energy markets. The second group of benchmarks is based on lower frequency (mostly daily) closing prices and aggregate volumes.

As indicated above, different measures of market liquidity should be used jointly and assessed using judgment and insights derived from experience, as no single index captures all the dimensions of market conditions at one point in time. The trends are often more important than the specific readings of a given indicator. The inability to calculate one or more of the benchmarks (1) – (4) on the previous page may be the best evidence of extreme market illiquidity.[5]

Our survey of liquidity measures will describe three of these benchmarks: transaction volume-based indicators, spread-based indicators, and hybrid indicators, including their respective applications to the natural gas market.

Transaction Volume - Based Indicators

Market liquidity indicators reflecting the level of trading activity are as follows:

1. Transaction volume per unit of time;
2. The number of market participants trading in a given market;
3. The number of transactions per unit of time;
4. Time elapsed between two successive transactions; and
5. Average transaction size.

Transaction volume, the number of transactions and the number of counterparties present at the market at a given time period are the most obvious and intuitive measures of market liquidity. The appeal of these measures is to a large extent based on the availability of empirical data for most markets (free of charge or available at a fee) and the ease of calculating and reporting relevant statistics without recourse to complicated quantitative models. Transaction volume is calculated as:

$$Vol_t = \sum_{i=1}^{n_t} vol_i \qquad (1)$$

where vol_i denotes the volume of transaction i, n_t – the number of transactions in time period t. In the case of energy markets, transaction volume information available to the public varies from market to market. For example, in the case of the U.S. natural gas and electricity markets, daily volume of Intercontinental Exchange (ICE) transactions used in the calculation of the day-ahead price index (physical transactions) is available from the exchange. The volume is reported as an aggregate daily number with no information about individual underlying transactions. High granularity data may be purchased from the exchange or obtained by the traders by scraping the ICE screens.

The turnover measure combines physical volume information with price information:

$$V_t = \sum_{i=1}^{n_t} vol_i \times p_i \tag{2}$$

where p_i denotes the price at which the *i*th transaction took place.

The volume and turnover indicators are sometimes reported as volume (turnover) duration, the inverse of the volume (turnover) per unit of time (Gouriéroux *et al*., 1999). The latter measure indicates the time required to trade a certain volume (or to reach a certain turnover level.)

Churn factor is defined as the ratio of transaction volume to actual physical deliveries. In other words, this is the number of times each molecule, barrel or electron is re-traded in the market before reaching the final user. The difficulty in calculating the churn factor is related to estimating actual volume underlying a given market and defining the final users. Churn factors are used in European natural gas markets where physical configuration of trading hubs makes determination of actual deliveries easier than in the case of the highly complex U.S. natural gas transportation and distribution network. According to Heather and Petrovich (2017) in an Oxford Institute for Energy Studies paper:

> "Commodity markets are deemed to have reached maturity when the churn is in excess of 10 times. In this one metric all others are, necessarily, reflected: if there are many participants, trading many different products in large quantities, then the churn rate is likely to be high. The churn rate is used by traders as a 'snapshot' of a market's liquidity; some traders will not participate in markets with a churn of less than 10 and many financial players will only participate when the churn is above 12 times."

In 2016, the churn rate in two European natural gas hubs was above 10: 57.1 for TTF [Title Transfer Facility in the Netherlands – GM and VK] and 22.1 for NBP [National Balancing Point in the UK – GM and VK]. Other trading hubs had much lower churn ratios, ranging from 5.7 for CEGH/VTP [Central European Gas Hub AG (CEGH), located in Vienna, Austria, Virtual Trading Point – GM and VK] to 0.1 for PVB [Spanish Punto Virtual de Balance – GM and VK].

The threshold churn level of 10 is rather arbitrary. It seems that market participants learn through experience to establish a certain intuitive confidence level of trading intensity in specific commodity markets, and this can vary by commodity and over time and location. The U.S. market consists of a network of interconnected pipelines with no obvious, well-defined boundaries of different regions. Since the churn index in the U.S. market is difficult to estimate, given its largely reticulated nature, measuring liquidity using a variety of benchmarks is a useful alternative in attempting to ascertain how liquidity varies by natural gas hub.

Another measure of liquidity is market depth, which is defined as the sum of ask and bid volumes available at time t. Calculation of this indicator of market liquidity requires access to information about the outstanding bids and offers which is not available for most markets or to most market participants.

$$Depth_t = Vol_t^A + Vol_t^B \tag{3}$$

where depth of the market at time t is equal to the sum of volumes on the bid and ask sides at the best bid and offer prices (p_t^B and p_t^A).

The variations on this measure, according to Butler *et al.* (2005), include a logarithmic version of (3):

$$Depth_t^{log} = \log(vol_t^A) + \log(vol_t^B) = \log(vol_t^A \times vol_t^B) \tag{4}$$

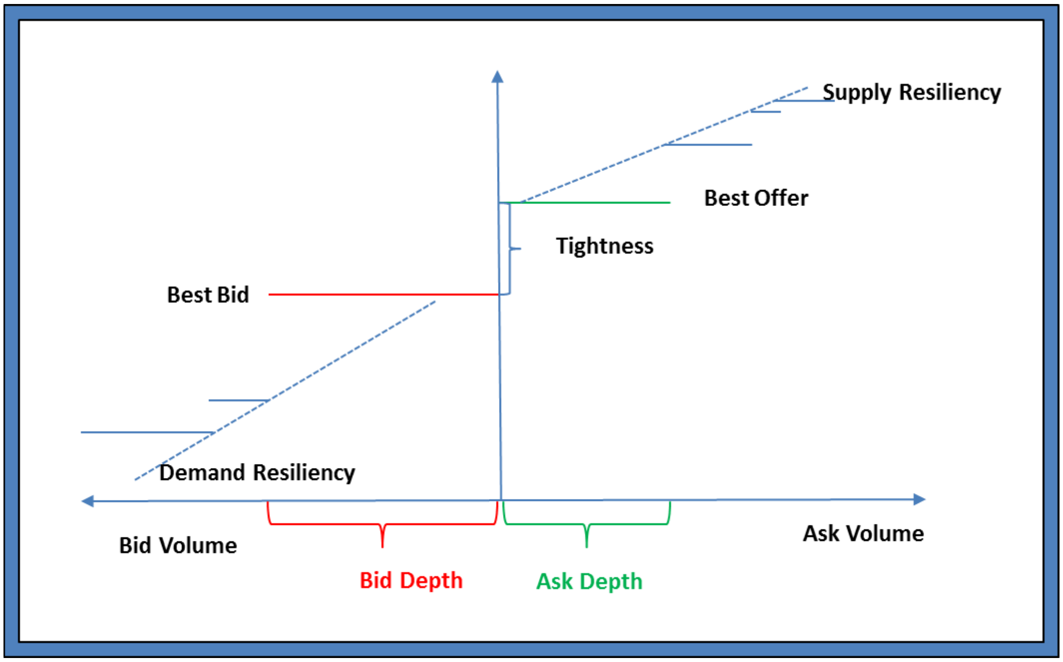
and currency depth (depth expressed in terms of market values)

$$Depth_t^{\$} = \frac{vol_t^A \times p_t^A + vol_t^B \times p_t^B}{2} \tag{5}$$

The logarithmic version (4) has some modeling advantages, related to the probabilistic properties of a product of random variables as opposed to their sum.

Figure 1 illustrates some of the concepts discussed above.

Figure 1
Market Depth



Source: Ranaldo (2001).

Limitations of Trading Volume as a Measure of Liquidity

The volume of transactions can be a misleading measure of liquidity. One could argue that a vibrant, liquid market implies a large transaction volume and a large number of transactions, but the reverse statement is not necessarily true. The following example provides an illustration:

> "On Kentucky Derby day, Bob and Joe invested in a barrel of beer and set off to Louisville with the intention of selling at the racetrack at a dollar a pint. On the way, Bob, who had one dollar left in the world, began to feel a great thirst, and drank a pint of beer, paying Joe the dollar. A little later, Joe yielded to the same desire, and drank a pint of beer, returning the dollar to Bob. The day was hot, and before long Bob was thirsty again, and so, a little later, was Joe. When they arrived at the track, the dollar was back in Bob's pocket, but the beer was all gone." (Robertson, 1922).

The beer market on this specific day seemed to be quite liquid (no pun intended) if assessed by the number of transactions.

Transaction volumes may often reflect artificial activity triggered by many industry specific circumstances or macroeconomic conditions. A few examples from recent history illustrate how misleading volume can be if used as a measure of liquidity to the exclusion of other information.

Enron's early success, driven to a large extent by permissive mark-to-market accounting rules, enticed a number of merchant energy companies (producers, utilities, and midstream companies) to imitate the Houston company, proudly calling itself, "Wall Street away from Wall Street," and enter the energy trading business (through the establishment of specialized, unregulated merchant units), resulting in the creation of a machinery with a scale that exceeded industry needs. The merchant energy companies were chasing relatively immature markets with capacity insufficient to justify the size of the trading operations they had set up, driven by excessively optimistic expectations of market growth. The outcome was a daisy chain of transactions between marketing companies, inserting themselves between end users and producers, often with as many as twenty intermediate steps before molecules and electrons reached final destinations. Given that the volume of transactions became one of the valuation metrics for start-up energy trading firms, in lieu of non-existing profits, some companies sought to artificially inflate their portfolios by engaging in the so-called round trips (wash trades), nearly simultaneous purchases and sales, under identical or almost identical terms. A well-known example is the case of circular trades between Reliant and Enron executed on the platform EnronOnLine in January of 2001.[6]

The number of transactions during a given time period may be equally misleading. A large number of transactions in a given time window is usually considered a manifestation of market liquidity, but this is not always the case. In an illiquid market a trader has to "work the trade," by splitting the transaction into smaller installments in order to avoid detection by predatory traders, who can front run her, and to reduce the market impact of her trades. Some traders wish to execute a transaction in one discrete, big step. For example, a trader buying natural gas for storage injection or selling gas withdrawn from storage does not want to overwhelm the back office, schedulers and accountants with multiple deals, executed at different price levels, requiring multiple time-consuming confirmations and ledger entries. One-stop shopping may be accomplished by offering price concessions to her counterparties.[7] Trading volumes may also be inflated for other reasons, related to cyclicality inherent in the activities of the financial industry.

Spread-Based Liquidity Measures

The logic behind spread-based liquidity measures is very simple: low levels of market liquidity translate into wider spreads between bid and offer prices. The market participants who want to transact have to compensate their counterparties for increased risk. A liquidity provider accommodating a potential buyer (seller) recognizes that in an illiquid market closing the position, i.e., entering into an offsetting transaction, may take time (with a higher risk of a potentially adverse market movement) or may require making price concessions. A higher bid-offer spread is compensation for taking this risk.

In many markets, bid-offer spreads are not observable or are not available to most market participants. The good news is that bid-offer spreads (as documented later in this paper) can be estimated from the consummated transaction prices, as long as the price history is available with reliable time stamps (i.e., the transaction prices can be sorted in chronological order.)

Bid-Ask Spreads

Effective Spread is defined as:

$$ES = 2 \times |\ln(P_i) - \ln(M_i)| \tag{6}$$

where P_i stands for the price at which the *i*th transaction was executed and M_i is the midpoint price at the time of the *i*th transaction. In the financial literature, this spread is often referred to as the TAQ spread after the name of the database Trade and Quote, containing stock market transaction data for NYSE, NASDAQ and regional exchanges.[8] Effective spread is reported as a volume-weighted average over a certain time period (typically a month.)

In Huang and Stoll (1996), realized half-spread is defined as:

$$RHS = P_{t+\tau} - P_t | P_t = p_t^B \tag{7}$$

$$RHS = -(P_{t+\tau} - P_t) | P_t = p_t^A \tag{8}$$

where p^B_t (p^A_t) denotes the bid (ask) price at time t, P_t ($P_{t+\tau}$) denotes price at time t (t+ τ), where τ denotes a chosen time interval (usually a minute or five minutes.) The expression $P_t = p^B_t$ ($P_t = p^A_t$) means that the transaction was executed at the bid (ask) price. In other words, the transaction was either a sell or a buy (a seller or a buyer initiated.) The symbol "|" means that the definition of realized half spread is conditional on the transaction type.

Some recent papers use a modified definition of realized spread:

$$RS = 2 \times (\ln(P_{t+\tau}) - \ln(P_t)) | P_t = p_t^B \qquad (9)$$

$$RS = -2 \times (\ln(P_{t+\tau}) - \ln(P_t)) | P_t = p_t^A \qquad (10)$$

The direction of the trade (buys vs. sells) is determined in practice using the algorithm proposed by Lee and Ready (1991).[9]

An alternative formulation for realized spread is called the Percent Realized Spread:

$$PRS = 2 \times q_i(\ln(P_i) - \ln(M_{i+5})) \qquad (11)$$

where P_i denotes the price of the *i*th trade, M_{i+5} is the midpoint price 5 minutes after this trade occurs. The variable q_i is an indicator variable that equals +1 if the *i*th trade is a buy and -1 if the *i*th trade is a sell.

Percent Quoted Spread (PQS) is another indicator based on bid/offer time series:

$$PQS = \frac{Ask - Bid}{\frac{Ask + Bid}{2}} \qquad (12)$$

where Ask is the best ask quote at a given time window, and Bid is the best bid quote. The PQS indicator is reported as the time-weighted average of indicators calculated for each time window.

Roll Index and Extensions

Roll (1984) proposed a method of estimating the effective spread, s, from low frequency price data. This paper demonstrated that the following relationship holds:

$$Cov(\Delta P_t, \Delta P_{t-1}) = \frac{1}{4} s^2 \qquad (13)$$

$$s = 2\sqrt{-Cov(\Delta P_t, \Delta P_{t-1})} \qquad (14)$$

$$s = 0 \; if \; Cov(\Delta P_t, \Delta P_{t-1}) > 0 \qquad (15)$$

In equation (13), ΔP_t stands for the price increment from period to period, and ΔP_{t-1} is the price increment lagged by one period.[10] $Cov(\Delta P_t, \Delta P_{t-1})$ stands for the covariance between the price increments. The covariance can be estimated using the Ordinary Least Squares (OLS) technique or directly from its definition. Hasbrouck (2004) recommended using Bayesian regression techniques in place of OLS.[11]

It is assumed that s = 0 if the covariance is positive since the square root of a negative number in (14) cannot be calculated. One shortcoming of the original Roll index of liquidity is that the estimated spread would be equal to zero in many cases, which is not a very satisfying result.

The model proposed by Roll was extended and modified by a number of economists who relaxed some of the assumptions of the original model or proposed different estimation techniques.

Modification of the assumption of balanced order flow (equal probability of buy and sell orders) leads to a formula:

$$s = \frac{s_R}{2\sqrt{\eta(1-\eta)}} \tag{16}$$

where s_R stands for the spread calculated according to the Roll procedure and η stands for the probability of receiving a buy order.

Relaxing the assumption that orders are not auto-correlated leads to the following formula for the spread:

$$s = \frac{1}{1-\delta}\sqrt{-Cov(\Delta P_t, \Delta P_{t-1})} \tag{17}$$

where δ = Probability ($d_{t+1} = d_t$).

The assumption that orders carry information leads to an alternative formula for the bid/offer spread:

$$s = 2(\lambda + \gamma) \tag{18}$$

where λ and γ are estimated through a regression equation:

$$\Delta P_t = \lambda d_t + \gamma \Delta d_t + \varepsilon_t \tag{19}$$

where λ captures the adverse selection spread component and γ represents the order processing cost fraction.

High/Low Prices

Corwin and Schultz (2012) proposed a formula for estimating the bid/ask percentage spread from daily high and low prices. The percentage spread is given by:

$$S = \frac{2(e^{\alpha}-1)}{1+e^{\alpha}} \tag{20}$$

where

$$\alpha = \frac{\sqrt{2\beta}-\sqrt{\beta}}{3-2\sqrt{2}} - \sqrt{\frac{\gamma}{3-2\sqrt{2}}} \tag{21}$$

with

$$\beta = \mathbb{E}\{\sum_{j=0}^{1}[\log\left(\frac{H_{t+j}}{L_{t+j}}\right)]^2\} \tag{22}$$

$$\gamma = [\log\left(\frac{H_{t,t+1}}{L_{t,t+1}}\right)]^2 \tag{23}$$

where H_t (L_t) denotes high (low) price for day t. $H_{t,t+1}$ ($L_{t,t+1}$) denotes high (low price) over the period of two days. The symbol $\mathbb{E}$ denotes expectation operator.

Implementation of this formula in the case of energy markets requires a modification. Electricity prices may be negative and, if this is the case, natural logs are replaced with (H/L) - 1 terms under some circumstances.[12]

Thompson-Waller Spread Estimator

As discussed in Thompson and Waller (1988) and in Bryant and Haigh (2002), the Thompson and Waller (TW) nominal bid/ask spread estimator is calculated as follows:

$$TW = \frac{1}{T}\sum_{i=1}^{T}|\Delta p_i| \tag{24}$$

where Δp_i stands for non-zero intraday price changes, and T stands for the number of observations.

A modification of this index has been proposed by Wang *et al.* (1997). Their measure is referred to in the literature as the CFTC liquidity measure (as the CFTC was using this liquidity index at the time (1997).) This measure is similar to the TW index, except that they only use non-zero price changes of opposite direction. In other words, any price change that follows another price change of the same sign is ignored.

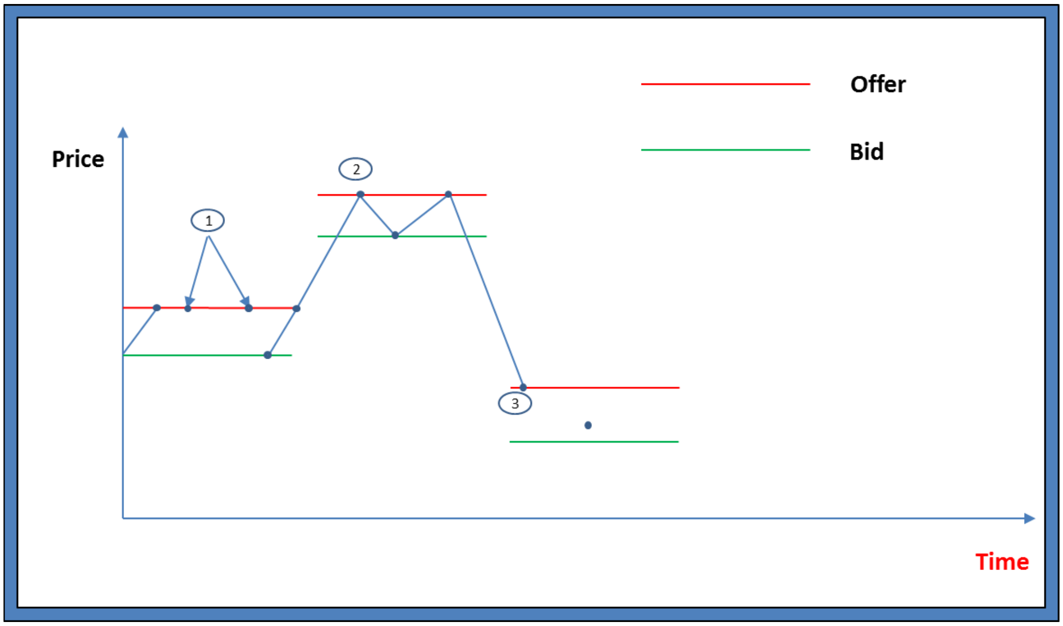
The logic behind the Modified Thompson-Waller Estimator can be illustrated with a graph, as shown in Figure 2 below. Assuming that the equilibrium price established based on market fundamentals remains unchanged, the transaction prices will bounce between bid and offer levels. Transactions that do not represent trend reversals (zero price increments or consecutive increments of the same sign) are, respectively:

- Repeated transactions at the same bid or ask levels (transactions marked as 1);
- Transactions (as, for example, transaction 2) which correspond to a jump to a new equilibrium level following the arrival of new information.

Price increments that correspond to transaction types identified above are removed from the calculation of the spread estimate. Only price increments that correspond to a jump from bid to offer levels, or vice versa, are included.

This very ingenious technique is not without flaws. A price increment that represents a reversal may correspond to a move to a bid (offer) corresponding to a new fundamental equilibrium level (transaction marked as 3.) Such price increments should be eliminated from the spread estimate as they tend to overstate the size of the estimated bid-offer spread. One potential approach to elimination of such price increments from calculations is the use of a filter to prescreen price increments (signed) used in the calculations. The starting point would be a guess of two cut-off points (for example -3, +3 standard deviations) to eliminate outliers from the set of observed price changes. The range of included price increments would next be narrowed in small increments (-2.9, 2.9), (-2.8, 2.8), etc. until the estimated spread stabilizes.

Figure 2
Modified Thompson-Waller Spread Estimator



Another shortcoming of the discussed estimator is that it is based on intuition and is not supported by assumptions about the stochastic process followed by the underlying price. This makes it impossible to deploy the usual artillery of statistical tests to assess the quality of the estimates.

In spite of the shortcomings, the modified Thompson-Waller spread estimator is very popular among practitioners: it is easy to calculate, as long as transaction prices with reliable time stamps are available. The computational burden is low and the technique can be used for a large number of trading locations as well as for the analysis of intra-day liquidity patterns. A more complicated approach (for example, Bayesian regression techniques) would require a time-consuming review of regression printouts and an analysis of regression diagnostics.

Hybrid Liquidity Measures

Amihud (2002) provides a price impact measure that is given by

$$Illiquidity = Average(\frac{|r_t|}{Volume_t}) \tag{25}$$

with r_t being the price return on day t. The Amihud index is usually averaged or summed over monthly periods. Volume in equation (25) is replaced sometimes by turnover (Σpq) or the number of trades in a given time period. The absolute value of price return is, in some versions of this measure, replaced by the square of price increment ($P_t - P_{t-1}$).

A related measure is the Amivest Liquidity ratio:

$$Liquidity = Average(\frac{Volume_t}{|r_t|}) \tag{26}$$

which is defined for non-zero return days.

The logic behind Amihud's index of liquidity is very simple, and this explains its popularity in applied financial economics. The value of the index increases with greater absolute return, i.e., greater market impact, for a given level of volume (turnover.) A higher value for Amihud's index means that the market becomes more illiquid: the price reaction measured by the price return is stronger for a given transaction volume.

An imputed round trip cost measure has been proposed by Dick-Nielsen *et al.* (2012). The intuition behind this measure is the observation that an asset (including in the energy markets) may trade two or three times in a short timeframe. This may happen when a dealer acts as a principal buying from one market participant, warehousing the risk for a short period of time, and selling the underlying to another party.

The imputed round trip cost (IRC) is defined as

$$IRC = \frac{P_{max} - P_{min}}{P_{max}} \qquad (27)$$

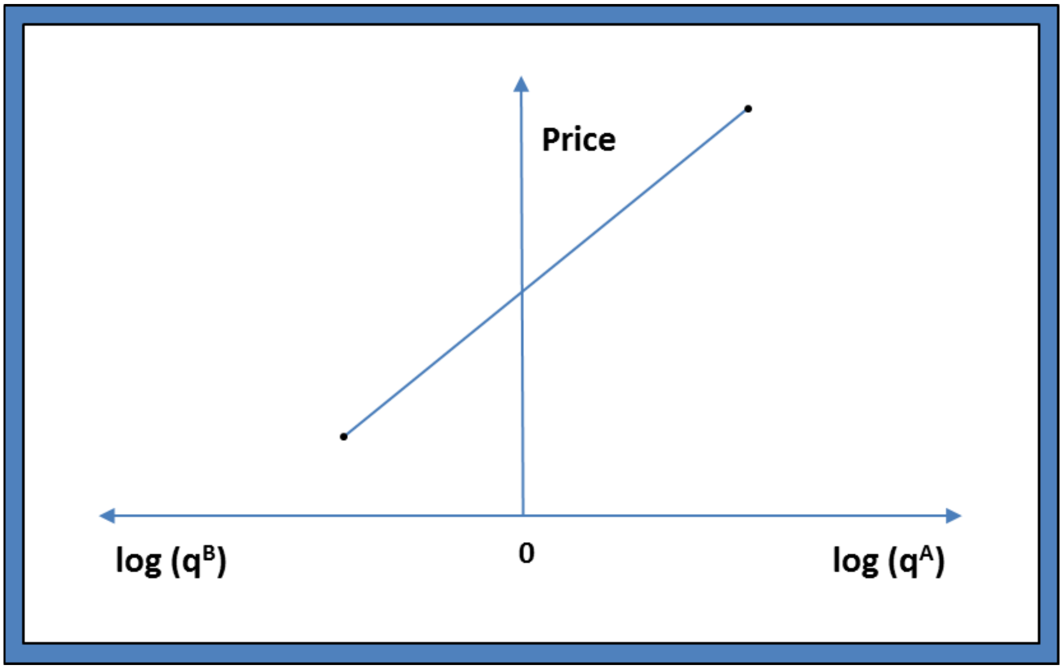
where Pmax (Pmin) are, respectively, the maximum (minimum) price in an identified round-trip set. The IRC is reported as a daily average.

Hasbrouck and Seppi (2001) define the slope of price quote as:

$$QuoteSlope_t = \frac{P_t^A - P_t^B}{\log(P_t^A) + \log(P_t^B)} \qquad (28)$$

This indicator is illustrated below in Figure 3. A higher slope in Figure 3 corresponds to lower liquidity.

Figure 3
Quote Slope



Conclusion

In this article, we examined different liquidity measures and considered their relevance to the natural gas markets. In part 2 of this series, which will appear in the next issue of the *GCARD*, we will provide an expert view on the structure of the U.S. natural gas markets along with an analysis of liquidity conditions in these markets.

Endnotes

1 As noted in Kay (2015), “the word [liquidity] is widely – almost obsessively – used in financial markets, but often without any precise or particular meaning. A casual search of investment dictionaries and encyclopedias for definitions of liquidity will reveal as many definitions as sources.”

2 Transaction costs are defined here as commissions, order confirmation and processing costs, taxes and fees. Sometimes the transaction cost definition is expanded by adding a market impact component.

3 Weather derivatives are an example of a hybrid instrument that combines the features of a derivative and an insurance product. A weather derivatives contract is not exactly an insurance product because the buyer does not have to provide a proof of a loss: the occurrence of a weather event is sufficient.

4 Volatility of prices is the most important input to option pricing models.

5 As pointed out in the literature, different measures of liquidity applied to the same market may produce significantly different results. This is why judgment and trend analysis are so critically important.

6 “On this day [January 31, 2001], 227 trades took place on EOL [EnronOnLine]; more than 75 percent of them were transactions between Reliant and Enron. […] The first transaction, at 8:00 a.m., is an Enron purchase of 10,000 MMBtu at $11.30/MMBtu. The last transaction, at 9:30 a.m., is a sale of 10,000 MMBtu from Reliant to Enron for $15/MMBtu. […] Prices rise slightly during the first hour of trading, from $11.30 to $12. Once Reliant begins actively churning, the price rises quickly and steadily, peaking at $15.30 and closing $3.70 higher than the price at which it opened.” (FERC, 2003).

7 Many traders that we have talked to note that large volume transactions related to storage management, pipeline balancing or power plant fuel acquisition are transacted bilaterally at prices based on a negotiated differential to currently observed ICE prices at a specific location.

8 According to the New York Stock Exchange, “[t]he dataset includes Daily NBBO File, Daily Quotes File, Daily TAQ Master File, Daily Trades File, Daily TAQ Quote Admin Message LULD, Daily TAQ Trade Admin Message LULD, and Daily TAQ CTA & Daily TAQ UTP Admin Messages.” NBBO stands for National Best Bid and Offer, LULD stands for Limit Up-Limit Down. As of June 10, 2019, current information on the dataset is available at https://www.nyse.com/market-data/historical/daily-taq.

9 The shortcomings of this algorithm are discussed in a number of papers, including in Theissen (2001) and in Ellis *et al.* (2000).

10 If t = 10, for example, ΔPt would be the change in price between t = 10 and t = 9. The lagged price increment ΔPt-1 would be the change in price between t = 9 and t = 8.

11 There are several software packages available to implement this approach, including the Markov Chain Monte Carlo procedure in SAS.

12 The natural logarithm of X/Y is roughly equal to X/Y-1, if X and Y do not differ too widely.

The opinions expressed in this paper are solely the authors’, and do not necessarily represent the views of the United States, the Federal Energy Regulatory Commission as a whole, any individual Commissioner, or Commission staff.

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Author Biographies

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Dr. Vincent Kaminski spent 14 years working in different positions related to quantitative analysis and risk management in the merchant energy industry. The companies he worked for include Citigroup, Sempra Energy Trading, Reliant Energy, Citadel Investment Group, and Enron (from 1992 to 2002) where he was the head of the quantitative modeling group. Prior to starting a career in the energy industry, Dr. Kaminski was a Vice President in the Research Department, Bond Portfolio Analysis Group, of Salomon Brothers in New York (from 1986 to 1992).

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Dr. Kaminski holds an M.S. degree in international economics, a Ph.D. degree in theoretical economics from the Main School of Planning and Statistics in Warsaw, Poland, and an M.B.A. from Fordham University in New York. He is a recipient of the 1999 James H. McGraw award for Energy Risk Management (Energy Risk Manager of the Year). Dr. Kaminski has published a number of papers, and contributed to several books, on the energy markets, including the most recent 4th edition of the industry standard textbook, Managing Energy Price Risk (Risk Books).

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Dr. Kaminski’s work on this paper was informed by analyses conducted during his appointment as a Visiting Scholar at the Federal Energy Regulatory Commission from July 2017 to July 2018. Specifically, Dr. Kaminski was in the Office of Enforcement’s Division of Energy Market Oversight.

Practical Considerations for Commodity Investment Analysis

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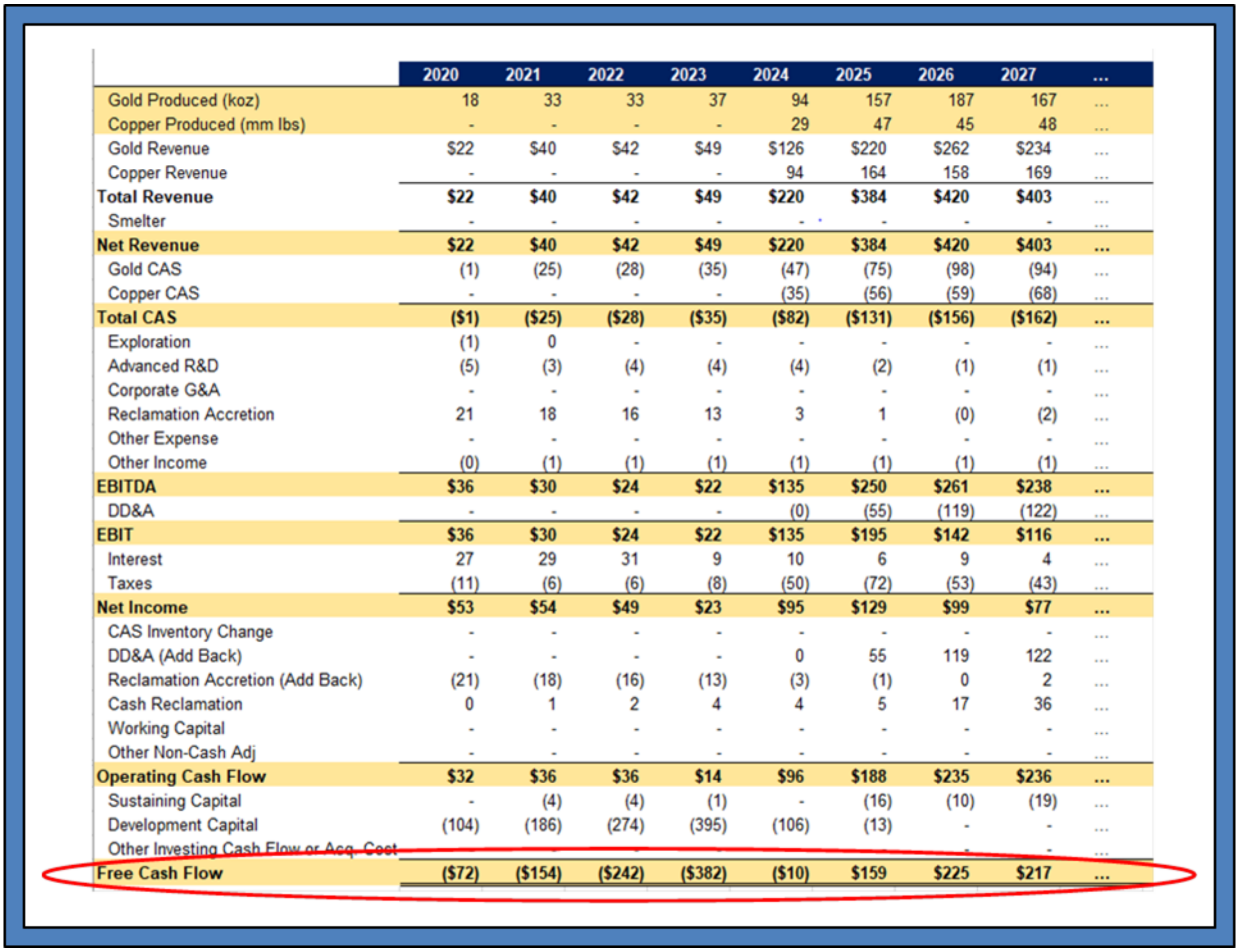
Thomas Brady, Ph.D., Executive Director of the J.P. Morgan Center for Commodities (JPMCC), presenting at the JPMCC's 2nd International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2018.

Introduction

Mining and oil and gas companies face future production profiles that inevitably decline over time, meaning that without further investment, the firm will eventually go out of business. As a result, companies must continually invest to replace production through funding exploration, internal project development and/or merger and acquisition activities. Whether the project or investment is funded internally, through free cash flow (FCF)[1], by issuing additional liquidity via the debt and equity markets or a combination thereof, a key element of the investment decision is the economic evaluation of the investment alternative at hand. Critical to these valuation estimates has traditionally been, and continues to be, the systematic and consistent application of a discount rate to the expected after-tax FCFs of the potential investment. Please see an example FCF model in Figure 1 on the next page.

Figure 1
Example Cash Flow Model (In Nominal Terms)[2]



	2020	2021	2022	2023	2024	2025	2026	2027	...
Gold Produced (koz)	18	33	33	37	94	157	187	167	...
Copper Produced (mm lbs)	-	-	-	-	29	47	45	48	...
Gold Revenue	$22	$40	$42	$49	$126	$220	$262	$234	...
Copper Revenue	-	-	-	-	94	164	158	169	...
Total Revenue	**$22**	**$40**	**$42**	**$49**	**$220**	**$384**	**$420**	**$403**	...
Smelter	-	-	-	-	-	-	-	-	...
Net Revenue	**$22**	**$40**	**$42**	**$49**	**$220**	**$384**	**$420**	**$403**	**...**
Gold CAS	(1)	(25)	(28)	(35)	(47)	(75)	(98)	(94)	...
Copper CAS	-	-	-	-	(35)	(56)	(59)	(68)	...
Total CAS	**($1)**	**($25)**	**($28)**	**($35)**	**($82)**	**($131)**	**($156)**	**($162)**	**...**
Exploration	(1)	0	-	-	-	-	-	-	...
Advanced R&D	(5)	(3)	(4)	(4)	(4)	(2)	(1)	(1)	...
Corporate G&A	-	-	-	-	-	-	-	-	...
Reclamation Accretion	21	18	16	13	3	1	(0)	(2)	...
Other Expense	-	-	-	-	-	-	-	-	...
Other Income	(0)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	...
EBITDA	**$36**	**$30**	**$24**	**$22**	**$135**	**$250**	**$261**	**$238**	**...**
DD&A	-	-	-	-	(0)	(55)	(119)	(122)	...
EBIT	**$36**	**$30**	**$24**	**$22**	**$135**	**$195**	**$142**	**$116**	**...**
Interest	27	29	31	9	10	6	9	4	...
Taxes	(11)	(6)	(6)	(8)	(50)	(72)	(53)	(43)	...
Net Income	**$53**	**$54**	**$49**	**$23**	**$95**	**$129**	**$99**	**$77**	**...**
CAS Inventory Change	-	-	-	-	-	-	-	-	...
DD&A (Add Back)	-	-	-	-	0	55	119	122	...
Reclamation Accretion (Add Back)	(21)	(18)	(16)	(13)	(3)	(1)	0	2	...
Cash Reclamation	0	1	2	4	4	5	17	36	...
Working Capital	-	-	-	-	-	-	-	-	...
Other Non-Cash Adj	-	-	-	-	-	-	-	-	...
Operating Cash Flow	**$32**	**$36**	**$36**	**$14**	**$96**	**$188**	**$235**	**$236**	**...**
Sustaining Capital	-	(4)	(4)	(1)	-	(16)	(10)	(19)	...
Development Capital	(104)	(186)	(274)	(395)	(106)	(13)	-	-	...
Other Investing Cash Flow or Acq. Cost	[illegible]	-	-	-	[illegible]	[illegible]	-	-	...
Free Cash Flow	**($72)**	**($154)**	**($242)**	**($382)**	**($10)**	**$159**	**$225**	**$217**	**...**

Abbreviations
CAS stands for Cost Applicable to Sales;
R&D stands for Research and Development;
G&A stands for General and Administrative expense; and
DD&A stands for Depreciation, Depletion, and Amortization.

This article aims to provide practitioners with practical steps to calculate and communicate discount rates for project valuation, capital budgeting and the many other uses throughout a typical commodity based firm. Traditionally academic and industry professionals have focused on determining "theoretically precise" discount rates. A second objective of this article is to argue that given the inherent uncertainties within the calculation of discount rates themselves and more importantly with the cash flow estimates to which these rates are applied, practitioners should focus on simplification and the consistent application across investment alternatives over a quest for precision.

Discounted Cash Flow (DCF) Analysis

For consistent evaluation and communication across investment alternatives, it is critical to have a consistent economic analysis template (such as in Figure 1.) Whether evaluating an external merger and acquisition (M&A) target or internal development projects, a standard template lends itself to effective capital budgeting.[3] A discounted cash flow (DCF) analysis is used to estimate a potential investment based on the future cash flows. The utility of DCF is that this puts all investment alternatives on a common evaluation basis of handling the time value of money where cash flows are discounted back to the present with a compounded interest rate of return.

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \cdots + \frac{CF_n}{(1+r)^n}$$

where:

CFi = cash flow in year i

n = period (say, a month or a year)

r = country specific discount rate

= (1) WACC + (2) other risk premiums

As shown, discount rates comprise an estimate of the weighted average cost of capital (WACC), which may or may not include other premiums for country risk and/or company size.

Practical Steps to Calculate Discount Rates

The weighted average cost of capital is a calculation of a firm's cost of capital where each source of capital is proportionally weighted. In general, a firm's financing (or sources of capital) come through two sources, equity and debt.[4]

Weighted Average Cost of Capital (WACC)

$$WACC = \frac{E}{V} * k_e + \frac{D}{V} * k_d * (1 - T)$$

where:

k_e = *cost of equity*

k_d = *cost of debt*

E = market value of firm's equity

D = market value of firm's debt

V = total value of capital (firm's equity + debt)

T = corporate tax rate

This section will progress through the steps to estimate the costs of equity and debt with descriptions of how best to communicate resulting discount rates to the many and varying end users of these rates.

Step 1: WACC -- Determine the Cost of Equity

$k_e = R_f + \beta * (R_m - R_f)$ + *other risk premium(s)*

where:

R_f = *risk-free rate (for example, the yield on the 10-Year Treasury bond)*

β = *beta (which is the volatility of the stock price's returns relative to the volatility of the overall market (S&P 500) * the correlation of the stock price's returns with that of the overall market)*

R_m = *market return*

$R_m - R_f$ = *market risk premium (which is the extra yield earned by investing in the market relative to investing in a riskless asset)*

Other risk premiums may be due to firm size and country risk.

The cost of equity can be interpreted as the sum of the risk-free rate and premiums to compensate for risk associated with the overall market (the "systematic risk" inherent with the overall market or the market risk premium) and risks specific to a particular company ("unsystematic risks" that may include risks associated with small companies and/or the country where a potential investment is geographically located.)

Data Sources

To obtain estimates of the various components for the cost of equity, I typically use averages from 2 to 5 years of daily historical data (usually 5 years) rather than current prices and rates. The choice of the data period requires judgment. As examples, if there has been a structural change in the markets of concern (such as the Global Financial Crisis or the widespread use of horizontal drilling/fracking in the U.S. oil segment), I would shift the horizon to only evaluate market conditions following the disruption. For simplicity and communication purposes, I use the same historical period of observations for all variables throughout the WACC calculation. In my experience, one can obtain all necessary historical data required for WACC calculations from widely available sources such as Bloomberg and Thomson Reuters. I have found that in publicly traded firms, internal and external audit personnel will likely be required to review all data and calculations and having notable data sources eases their abilities to complete independent reviews.

Cost of Equity: Risk-Free Rates

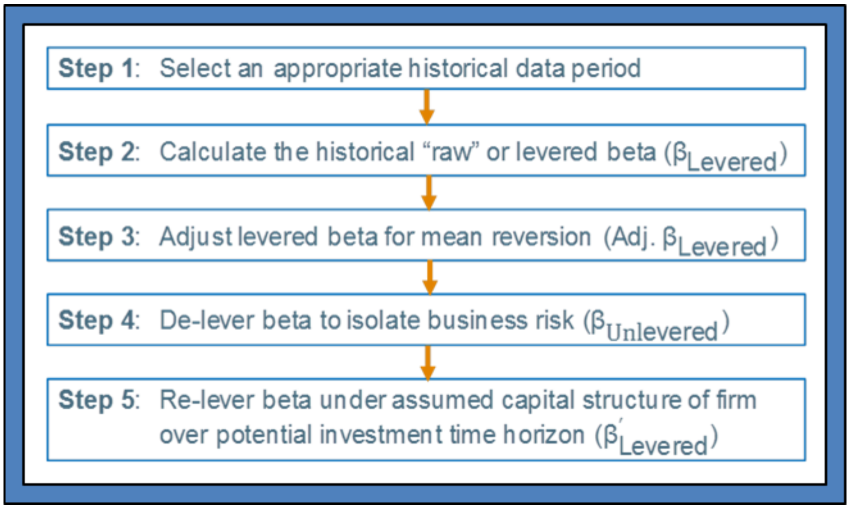
For an asset to be considered "risk free," there can be no default risk, and by definition these can only be government issued securities as governments are the only entities that control a country's money supply. It is generally best practice to match the duration of the risk-free asset with that of the potential investment. Across the commodity sector, investment horizons can span multiple decades. In the U.S., this would mean using the yield on the 30-year Treasury bond and the risk-free rate. However, given that there is traditionally minimal differences between the 30- and 10-year Treasury yields, I use the yields on the 10-year.[5]

It is important that the risk-free rate be consistent with how the free cash flows (such as shown in Figure 1) are defined for a potential investment. For example, if the cash flows are in U.S. dollars then yields on U.S. Treasuries should be used for the risk-free rate. If the cash flows are in Australian dollars, then the yield on an Australian government bond should be used.[6]

Cost of Equity: Calculating an Appropriate Beta

Figure 2 displays the practical steps in calculating a beta to be used in determining the cost of equity piece of the overall WACC calculation. As shown, these steps include determining an appropriate period of time (if a historical period approach is attempted), estimating a "raw" beta, adjusting the raw beta for mean reversion, de-levering the beta (to eliminate the impact that any debt outstanding a firm may have) and finally to re-lever under an assumed capital structure representative of the time horizon of the potential investment.

Figure 2
Determining Beta (β)



Consistent with other WACC estimates, for an appropriate historical data period (Step 1), I tend to use 5 years of daily data. The most straightforward method to estimate a "raw" or levered beta (Step 2) is to regress the daily percentage changes of a stock price on the daily percentage changes of a benchmark index, which is a proxy for the overall market (such as the S&P 500 in the U.S.)

Step 3 involves adjusting the raw beta to account for mean reverting behavior of the beta statistic. While there may be disagreement as to whether or not betas mean revert, my rationale for this adjustment is that the resulting beta is more stable over time, and therefore, this measure is better to apply to investment cash flows that may extend many years into the future.[7] Whether or not a practitioner chooses to include this step, the key is to select the estimation approach, apply it consistently and stick with it over time.[8]

A further complication with both the raw and adjusted beta is that these are levered, meaning these estimates include two components of risk: (1) the company specific business risks and 2) the risk from the firm taking on leverage (or debt.) To isolate the business risk component, an unlevered beta[9] is calculated (Step 4):

$$\beta_{\text{unlevered}} = \frac{\beta_{Levered}}{1+\frac{D*(1-T)}{E}}$$

where:

E = market value of firm's equity

D = market value of firm's debt

T = corporate tax rate

An unlevered beta provides a more accurate picture of a company's operating stability; it is the risk attributed to the company's assets, disregarding the capital structure of that firm.

Step 5 in Figure 2, and the last in the beta calculation process, includes re-levering the beta using the assumed capital structure of the firm over the potential investment horizon:

$$\beta_{Relevered} = \beta_{Unlevered} * \left(1 + (1 - T') * \frac{D'}{E'}\right)$$

where:

E' = assumed market value of firm's equity

D' = assumed market value of firm's debt

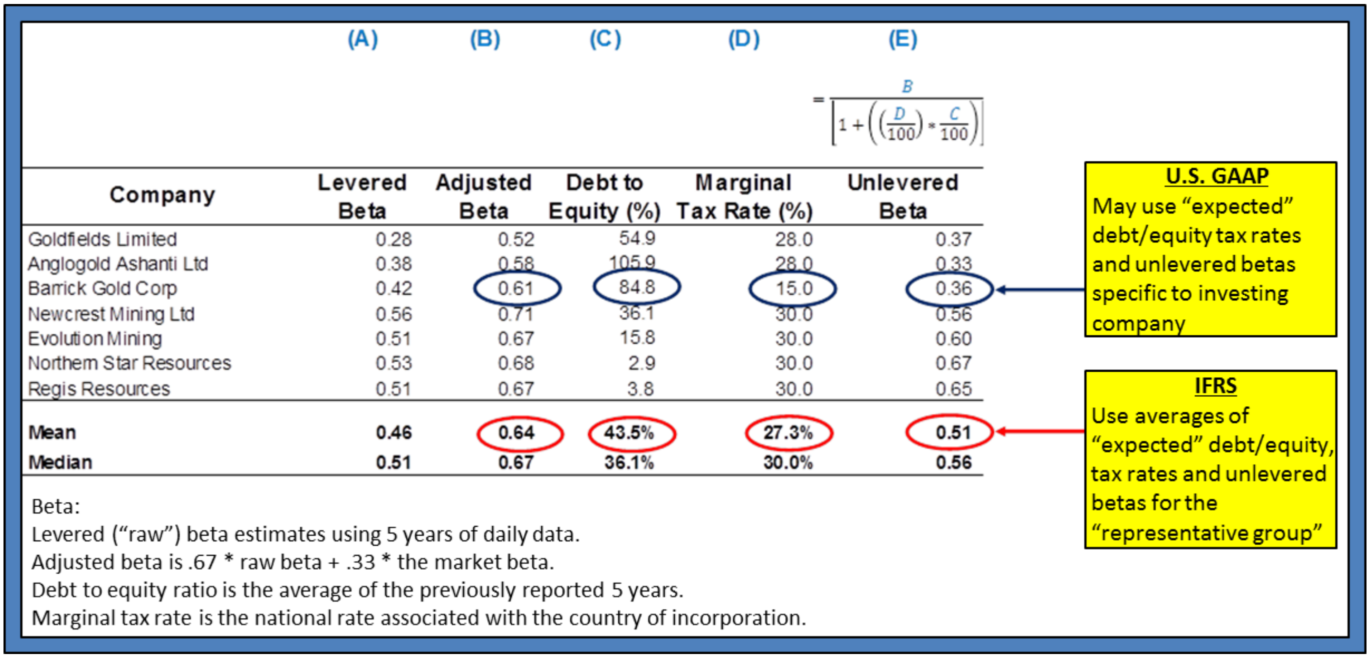
T' = assumed corporate tax rate

For example, assume a firm has a current capital structure of 80% equity and 20% debt. To fund a potential investment, the firm may need to issue additional debt to cover development costs. As such the firm's capital structure may be assumed to migrate to 60% equity (E' in the equation above) and 40% debt (D').

A Note on U.S. GAAP and IFRS Guidelines for Beta Calculations

For Generally Accepted Accounting Principles (GAAP) in the U.S., betas and other WACC inputs may be based on a single company (i.e., the firm actually evaluating the investment.) However, under International Financial Reporting Standards (IFRS), these inputs must be based on a "representative set" of comparable companies. For example, the international reporting of accounting valuations may be subject to IFRS guidelines. Figure 3 summarizes the various beta calculations for an example gold mining project in Australia, both under U.S. GAAP (assuming the individual investing company is Barrick Gold) and under IFRS with a "representative" group of gold mining companies in the country. As shown, under U.S. GAAP, Barrick's unlevered beta is 0.36 whereas under IFRS, the mean of the set of representative companies would be 0.51.

Figure 3
Calculating Beta (β) Under U.S. GAAP and IFRS



	(A)	(B)	(C)	(D)	(E)
					$= \frac{B}{\left[1 + \left(\left(\frac{D}{100}\right) * \frac{C}{100}\right)\right]}$
Company	**Levered Beta**	**Adjusted Beta**	**Debt to Equity (%)**	**Marginal Tax Rate (%)**	**Unlevered Beta**
Goldfields Limited	0.28	0.52	54.9	28.0	0.37
Anglogold Ashanti Ltd	0.38	0.58	105.9	28.0	0.33
Barrick Gold Corp	0.42	0.61	84.8	15.0	0.36
Newcrest Mining Ltd	0.56	0.71	36.1	30.0	0.56
Evolution Mining	0.51	0.67	15.8	30.0	0.60
Northem Star Resources	0.53	0.68	2.9	30.0	0.67
Regis Resources	0.51	0.67	3.8	30.0	0.65
Mean	**0.46**	**0.64**	**43.5%**	**27.3%**	**0.51**
Median	**0.51**	**0.67**	**36.1%**	**30.0%**	**0.56**

Beta:
Levered ("raw") beta estimates using 5 years of daily data.
Adjusted beta is .67 * raw beta + .33 * the market beta.
Debt to equity ratio is the average of the previously reported 5 years.
Marginal tax rate is the national rate associated with the country of incorporation.

U.S. GAAP
May use "expected" debt/equity tax rates and unlevered betas specific to investing company

IFRS
Use averages of "expected" debt/equity, tax rates and unlevered betas for the "representative group"

Cost of Equity: Market Risk Premium

The market risk premium measures risk that affects investments in the overall market (the systematic risks that are not firm specific). This risk is not diversifiable and is measured as the expected market return less the return on a "riskless" asset (or the risk-free rate) and represented as (Rm – Rf) in the above cost of equity equation. There are multiple methods to estimate the market risk premium including surveys (where market participants such as corporate Chief Financial Officers are queried for their expectations on equity returns), other forward-looking techniques where implied risk can be determined from prices in the option (or derivatives) markets or by examining historical return averages. As mentioned, my approach is to average historical daily data over the most recent 5 years to obtain these estimates. My personal view is that the market can migrate through extended periods of over-and undervaluation, as such using historical averages is an adequate path. Again, it is key to be consistent with the approach over time.

Cost of Equity: Other Risk Premiums

Company Size

Smaller companies tend to be more exposed to risk than larger firms, which may result in the need for an additional factor. In other words, the CAPM model may understate risk associated with smaller market capitalized companies. Previous studies have shown there is evidence of a persistent premium associated with smaller companies; however, this is very volatile. Studies of U.K. listed equities imply these premiums are ~4% (Dimson and Marsh, 1986). Surveys in Australia reveal that practitioners in that country apply premiums in the 5% range for companies with market capitalizations of less than $A50M (KPMG, 2017). In the past, I have not applied additional premiums for smaller market capitalized equities due to the past volatility of these estimates. For those analysts who do include this risk factor, I would caution against the potential to "double count" risk such as by including risk premiums for company size as well as for the lack of market liquidity for an equity.

Country Risk

Another key component included in the cost of equity is country risk, which measures the additional risk associated with political and economic conditions in the geographic region of the potential investment. Country risk is included as it is assumed that global markets have some level of significant positive correlation, and these risks cannot be diversified away.[10] There are multiple, practical methods to evaluate country risks including the use of country bond spreads and rankings from public and proprietary sources.

Country Bond Default Spreads

A fairly common approach for estimating country risk is to simply take the difference on the yields from bonds of comparable tenure in a country relative to a developed market such as in the U.S. Under this approach, the yield on a bond in the country of interest (such as the Peruvian 10-year bond) is compared to the U.S. 10-year Treasury yield.

$$Country\ Bond\ Spread_i = Country_i\ Bond\ Yield - Country_{Reference}\ Bond\ Yield$$

Again, using Peru as an example (for *Country*$_i$), the bond spread would be calculated as the yield on the country's 10-year government bond, at say 6.2%, less the yield on the U.S. 10-year Treasury as the reference bond yield for a mature market, at say 2.5%, resulting in a spread of ~3.7%.[11] This country risk premium would be added to the cost of equity for a potential Peruvian investment. A problem with this method is that this measures the risk of default on debt and for completeness, country risk estimates should also include a measure of risk associated with a country's equity market, as in the calculation on the next page.[12]

$$Country\ Risk\ Premium\ (CRP)_i = \ Country\ Bond\ Spread_i * \frac{\sigma_{equity\ market_i}}{\sigma_{govt\ bond_i}}$$

where:

$\sigma_{equity\ market i}$ *is the annualized standard deviation of the equity market in country i*

$\sigma_{govt\ bond i}$ *is the annualized standard deviation of the selected government bond in country i*

For the above Peruvian example, the country's bond spread is modified by the relative volatility of the equity and bond markets (3.7% * 14.2%/12.7%) = 4.1% where 14.2% and 12.7% are the annualized standard deviation of the equity and bond markets, respectively.[13] As shown, under this approach the country risk is slightly higher due to the relatively higher risk associated with the equity market compared to the bond market. At times, I have found that incorporating the relative volatility of equity and bond markets useful in the country risk premium calculation as many of the external audit firms such Deloitte, EY, and KPMG rely on this approach or some close variant to estimate country risk.

A cautionary note in using default spreads is a potential for a lack of data associated with emerging markets that may not have widely traded equity and/or bond markets.

Public and Proprietary Country Risk Indices

Other approaches to measuring country risk are available from both public and private sources including the World Bank, Eurasia Group, IHS Markit, the Economist Intelligence Unit (EIU) and the Fraser Institute, among others. Generally, these sources may provide more comprehensive relative rankings of country risk, typically on a scale of 1 (least risky) to 100 (most). For mining related projects, the Fraser Institute ranks countries and states within key countries in terms of mineral potential (geological attractiveness) and mining policies (transparency of tax and legal systems, enforcement of regulations, and infrastructure.) While mineral specific, a drawback to the Fraser survey is that it only covers ~50 countries. The World Bank, EIU and IHS services cover more countries and generally rank countries over a mix of risk factors including economic, geopolitical stability, security, infrastructure and social risks. Risks in each of these categories are evaluated by combining in-country personnel assessments with publicly available data.[14]

With these sources, my approach is to take the difference between the risk indices for the country of concern and that of a mature market (the U.S.) Noting a definite level of subjectivity, this risk difference (or delta) can then be scaled into an appropriate range of additions to country risk (typically in the range of -1%, 0%, +1%, …, 10%.) Countries such as Syria, Venezuela, and Yemen would be given a country risk factor of 10% whereas those countries deemed less risky than the U.S. (such as Switzerland, Sweden, Norway, and Greenland) would be given a risk factor of -1%.

Applying "Other Risk Factors"

Analysts may apply an estimate of country risk to the cost of equity and the cost of debt. My personal assumption is to only add this premium to the cost of equity under the view that any debt raised for a potential investment will typically be issued in the country where the investee is incorporated and will be priced in accordingly; in my experience this was primarily in the U.S. When including the country risk premium (CRP) in the cost of equity (k_e) calculation, there are different approaches with some adding the premium(s) to the cost of equity while others scale the risk premium by the beta estimate; the two approaches are shown below in equations (a) and (b), respectively.

(a) $k_e = R_f + \beta * (R_m - R_f) + \text{company size} + CRP$

(b) $k_e = R_f + \beta * (R_m - R_f + CRP) + \text{company size}$

My approach has been to use alternative (a) to add risk factors to the cost of equity. Others may scale the country risk factor via the beta estimate (as in alternative (b)), which implies that a company's exposure to country risk is proportional to its exposure to the overall market. From my point-of-view, a more conservative approach is to add other risk factors vs. scaling with a beta estimate since beta measures risk relative to the overall market which, in turn, may not adequately reflect country risk.

Step 2: WACC -- Determine the Cost of Debt

The cost of debt is the return a company provides to the holders of its debt securities. These creditors require compensation for the risk exposures that they take on by lending to the company (the risk that the company may default on its obligations in the future.) There are a few alternatives to calculate the cost of debt, based on whether the debt is publicly and widely traded, the debt has been rated by a credit agency (such as S&P, Moody's, Fitch) or neither.

Yield to Maturity (YTM) Approach

If a firm has publicly traded debt outstanding the current market interest rate on the debt (or the yield to maturity (YTM)) can be used as the cost of debt.[15] This method requires a liquid trading market for the corporate debt that is representative of the debt of the firm. With these conditions met, the cost of debt (k_d) calculation is both accurate and timely:

$$k_d = \left(\frac{d_1}{D} * i_1 + \frac{d_2}{D} * i_2 + \cdots + \frac{d_n}{D} * i_n\right) * (1 - T)$$

where:

i_i = the YTM of the i^{th} outstanding debt instrument

d_i = the market value of the i^{th} outstanding debt instrument

D = total market value of debt outstanding by the firm

T = corporate tax rate

Here the cost of debt is the weighted YTM for a company's outstanding debt. A limitation of this approach may be the availability and trading liquidity on longer-term bonds that relatively match the long investment horizons of potential investments in the commodity space. For example, if a firm has a 20- or 30-year bond outstanding, is the trading of this bond liquid enough that the YTM is representative?

Debt Ratings Approach

If a company's debt is not publicly traded (i.e., market price information is not available or is difficult to obtain), the cost of debt may be estimated via ratings from credit agencies, provided these agencies have rated the debt. Under this approach, the cost of debt is calculated as a default spread over a selected risk-free rate, representing the compensation the firm has to pay creditors for the risk of defaulting on their financial obligations.

$$k_d = \left(R_f + Default\ Spread\right) * (1 - T)$$

where:

R_f = *risk-free rate*

Default spread = spread over a riskless asset

T = corporate tax rate

The default spread is based on other bonds rated similarly by the credit agencies that are publicly traded over a risk-free rate.[16] In essence, the approach estimates a proxy cost of debt based on the credit rating on firm's debt. For example, the default spread on a corporate bond with the highest credit rating (Aaa by Moody's and AAA by S&P) may have spreads well below 1% (typically in the 0.4% to 0.8% range.) Under this approach, bonds rated Aaa/AAA would be assigned this default spread. Bonds with moderate risk (Baa/BBB) will have higher default spreads (usually in the ~2% to 3% range) where the poorest quality issues (rated as C category) may have ratios well above 10%.[17]

A limitation of this approach is that different bonds issued by a company may have different credit ratings. As such taking an average across all bonds will not be as accurate or timely as the previous YTM method.

Financial Ratios Approach

If a firm does not have any debt outstanding and is unrated by a credit agency, a synthetic rating can be estimated based on the firm's financial ratios, specifically the interest coverage ratio:

$$Interest\ Coverage\ Ratio = \frac{EBIT}{Interest\ Expenses}$$

where:

EBIT = earnings before interest and taxes

Under this approach, firms with higher interest coverage would receive higher credit ratings and thus lower default spreads. The calculated interest coverage ratio may then be translated into credit ratings and default spreads using the same methodology described in the *Debt Ratings Approach* discussed on the previous page.[18]

In the past, I have predominately used the YTM approach to estimate the cost of debt. While many calculate a weighted YTM based on all outstanding bonds for a company, I typically obtain the YTM on the bond outstanding with a tenor that most closely matches the time horizon of the potential investment. For mining projects, this usually translates into obtaining the longest tenured debt as the estimate. For example, the longest dated bond for Newmont Mining is due in 2042, from which I obtain the current YTM for use as the cost of debt.

Cost of Debt: Corporate Tax Rates

Within the calculations to un-lever and re-lever betas and to calculate the cost of debt, there are multiple alternatives to estimate the tax rates to be used. While I have used various approaches over my career, for ease I tend to utilize the marginal tax rate of the country in which the company is incorporated. This assumes that the income generated abroad will eventually be repatriated to the country of incorporation, at which point the company will pay the marginal rate. As shown in Figure 3, the national marginal tax rate is 15% in Canada (where Barrick is incorporated), 30% in Australia and 28% in South Africa.

For multinational firms, it is possible to calculate a weighted average of marginal rates for the relevant countries where income generating operations are present. A downside to this approach is that the calculated average rate may change as the operating portfolio of a company evolves. While there are multiple alternatives as to which tax rates to use, again I focus on simplicity and using the marginal rates is generally more conservative. Another alternative is to use a company's effective tax rate. Effective rates are the actual taxes paid as a percentage of reported income and are typically lower than marginal tax rates due to the use of accelerated depreciation, tax credits, deferrals, and tiered tax rates. A complication of using effective rates is that these tax "deductions" typically cannot be assumed to remain effective in perpetuity.

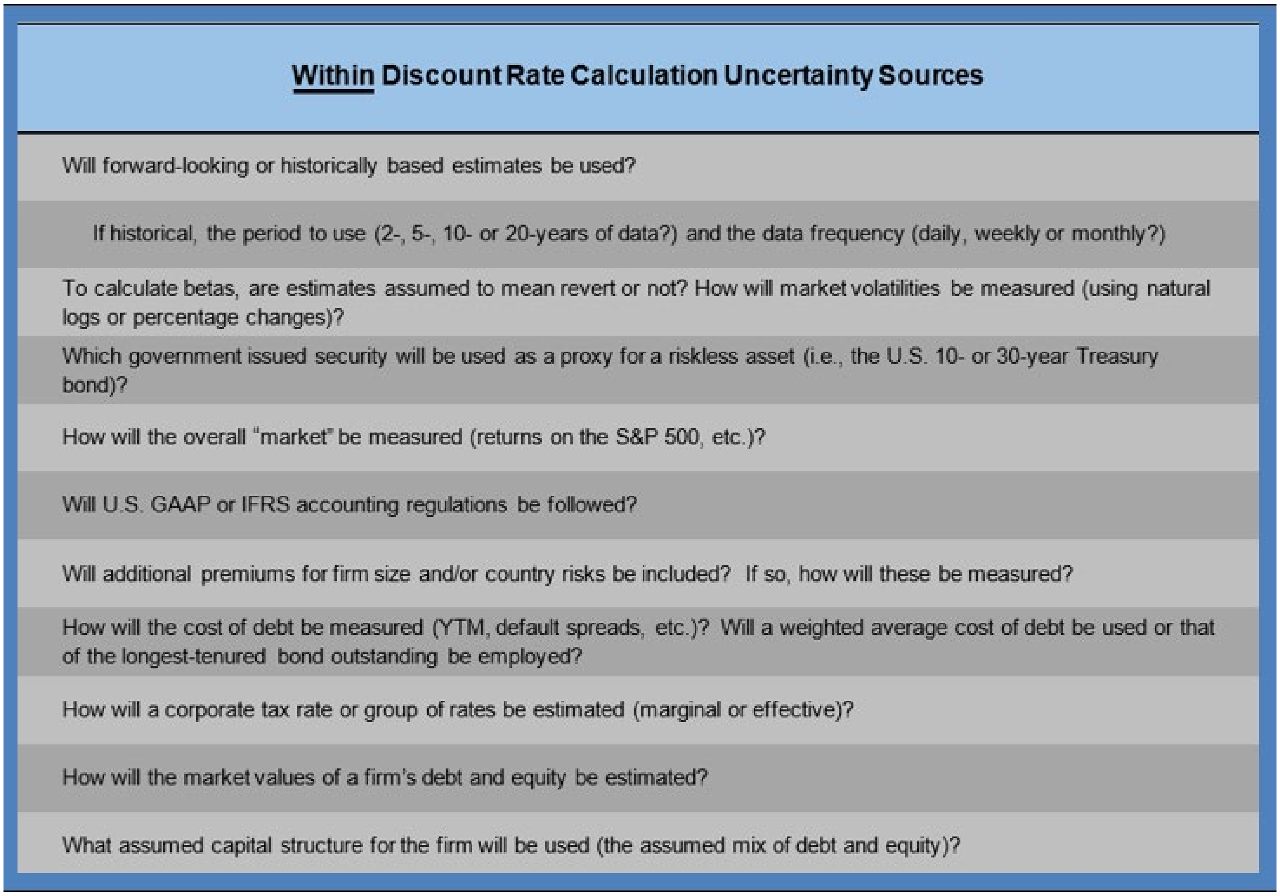
WACC: Market Value of Debt and Equity

Once the cost of equity and debt are estimated, these need to be weighted by the firm's capital structure, the split of the firm's value attributable to equity and to debt. For publicly listed companies, the market value of equity is the diluted shares outstanding multiplied by the share price where my approach has been to use the current share price. As described above, for those companies that have public debt, this cost should reflect the yield to maturity (YTM) on the firm's long-term debt, which is generally sourced from applications such as Bloomberg. For those firms that do not have observable market values or that do not have obtainable debt information, these may be evaluated using comparable company analysis and/or the aforementioned default spreads (or financial ratios.)

Communicating Discount Rates

The previous section provided practical steps to calculate discount rates. This section reviews the sources of uncertainty within the calculations of these rates and provides my recommendation on how to communicate and use these rates. To review, the previous section aims to provide practical steps toward calculating discount rates. An additional goal is to provide readers with an appreciation of the many sources of uncertainty inherent within the estimation of these rates. Figure 4 provides a summary of these various sources of uncertainty.

Figure 4
Sources of Uncertainty within a Discount Rate Calculation

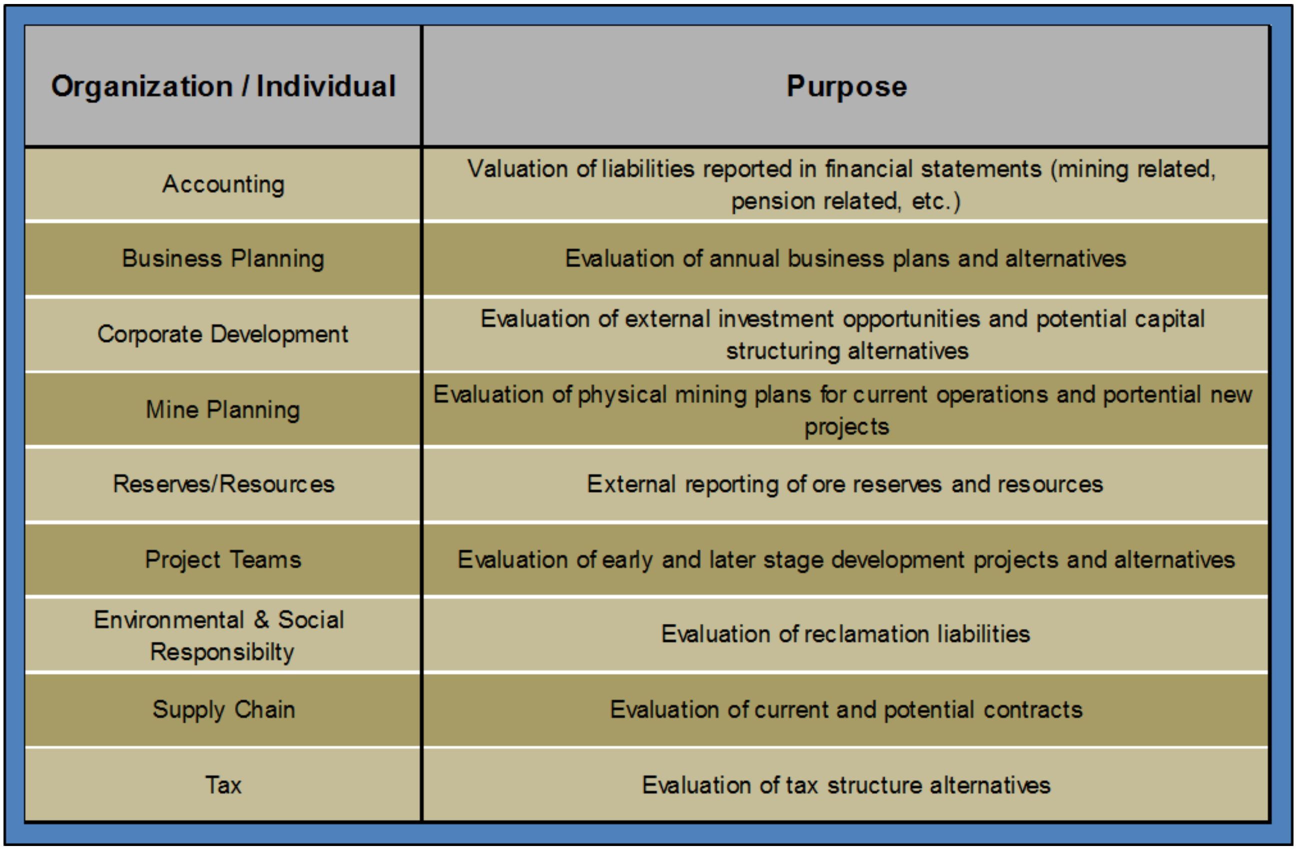


Within Discount Rate Calculation Uncertainty Sources
Will forward-looking or historically based estimates be used?
If historical, the period to use (2-, 5-, 10- or 20-years of data?) and the data frequency (daily, weekly or monthly?)
To calculate betas, are estimates assumed to mean revert or not? How will market volatilities be measured (using natural logs or percentage changes)?
Which government issued security will be used as a proxy for a riskless asset (i.e., the U.S. 10- or 30-year Treasury bond)?
How will the overall "market" be measured (returns on the S&P 500, etc.)?
Will U.S. GAAP or IFRS accounting regulations be followed?
Will additional premiums for firm size and/or country risks be included? If so, how will these be measured?
How will the cost of debt be measured (YTM, default spreads, etc.)? Will a weighted average cost of debt be used or that of the longest-tenured bond outstanding be employed?
How will a corporate tax rate or group of rates be estimated (marginal or effective)?
How will the market values of a firm's debt and equity be estimated?
What assumed capital structure for the firm will be used (the assumed mix of debt and equity)?

Figure 5 on the next page displays the many representative groups/personnel within a company who may require the use of discount rates (from Accounting to mine and business planning teams, for example.) The objective is to have a consistent application of rates across the company. If an external M&A opportunity is being evaluated in Ghana for example, it should be using the same discount rate that a potential internal development project in that country is using; that is, the same rate a Ghanaian supply chain team is using to evaluate a potential contract (if this requires discounting.)

For effective capital budgeting across a company, having a single source for these rates is critical. If varying teams are allowed to set their own discount rates, effective capital budgeting across the entire portfolio of potential investments of a company cannot be achieved. A further argument is the varying monetary incentives that may exist within a firm. In many companies, project development and corporate development teams may be financially rewarded for the eventual funding and completion of their projects. Having these teams set their own discount rates is very problematic and a definite conflict of interest.

Figure 5
Example Users of Discount Rates within a Firm

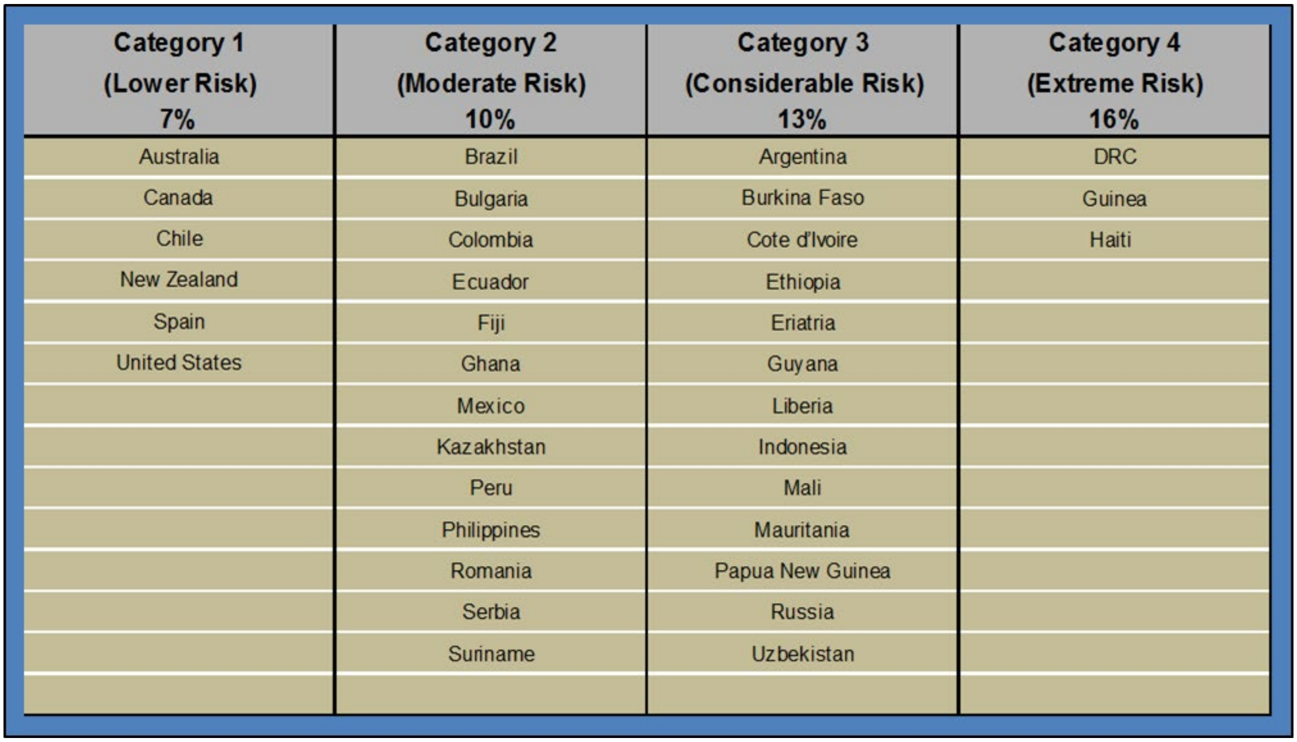


Organization / Individual	Purpose
Accounting	Valuation of liabilities reported in financial statements (mining related, pension related, etc.)
Business Planning	Evaluation of annual business plans and alternatives
Corporate Development	Evaluation of external investment opportunities and potential capital structuring alternatives
Mine Planning	Evaluation of physical mining plans for current operations and portential new projects
Reserves/Resources	External reporting of ore reserves and resources
Project Teams	Evaluation of early and later stage development projects and alternatives
Environmental & Social Responsibilty	Evaluation of reclamation liabilities
Supply Chain	Evaluation of current and potential contracts
Tax	Evaluation of tax structure alternatives

Driven by all the uncertainties inherent within discount rate estimation and within the cash flow models themselves (as reviewed in the next section) as well as the vast number of varying individuals who may use these rates, my recommendation is simplification over the false assumption of precision. As shown in Figure 6 on the next page, my approach is to segment various country specific discount rates into a small number of distinct buckets, four in this case. Notice that associated with each category is a discount rate that is rounded to the nearest whole number (again no false assumed precision with multiple decimal points.) All countries within a given category use the same discount rates.

Simplification greatly assists with communication across a wide variety of users and enforcing a proper "portfolio approach" to capital allocation across a firm. As an example, prior to the above estimation and communication approach, I remember a 15-minute investment review meeting with a Chief Executive Officer and the project team on the prospect for continued investment in a Canadian development project. For 13 of the 15 minutes, the conversation centered on discount rates versus a proper discussion on the specific steps that the team was going to complete in order to ensure the economic viability of the project. It is noted that any individual communicating discount rates under this approach is very likely to get significant pushback from various groups, including those that may have personal financial interests. An example pushback is of the nature: "How can you possibly assign the same discount rate in Ghana as in Mexico?" Again, given all of the uncertainty with rate and cash flow estimates, in my view this is a valid approach.[19] It is also recognized that the level of simplification presented in Figure 6 may not be appropriate for all uses (specifically for mineral and business appraisers tasked with determining fair market values for assets.) However, it is anticipated that this article provides readers tasked with these responsibilities further understanding of the uncertainties within these assignments.

Figure 6
Example Nominal Discount Rates



Category 1 (Lower Risk) 7%	Category 2 (Moderate Risk) 10%	Category 3 (Considerable Risk) 13%	Category 4 (Extreme Risk) 16%
Australia	Brazil	Argentina	DRC
Canada	Bulgaria	Burkina Faso	Guinea
Chile	Colombia	Cote d'Ivoire	Haiti
New Zealand	Ecuador	Ethiopia	
Spain	Fiji	Eriatria	
United States	Ghana	Guyana	
	Mexico	Liberia	
	Kazakhstan	Indonesia	
	Peru	Mali	
	Philippines	Mauritania	
	Romania	Papua New Guinea	
	Serbia	Russia	
	Suriname	Uzbekistan	

Nominal and Real Discount Rates

It is critical that discount rates and the cash flows to which they are applied are aligned in terms of including the impacts of inflation (or are in nominal terms) or exclude inflation (in real terms.) Nominal cash flows are the actual cash flows that are expected to be received or paid out in the future whereas real cash flows are in today's or current terms and do not include the impact of inflation. By intention or not, it is not uncommon for practitioners to mix the application (applying a real discount rate to a nominal cash flow model or a nominal rate to real cash flows.)

The example discount rates in Figure 6 (7%, 10%, 13%, and 16%) are in nominal terms, designed to be applied to cash flows that include the impact of inflation. Given the significant time horizons of investment projects in the commodity space, I advocate using models and rates in nominal terms. As a further incentive, having cash flow models include inflation may also assist the firm in enforcing cost and capital discipline. In many instances, however, real rates may be required. For example, under various accounting regulations, certain liabilities such as reclamation and pension contracts may need to be publicly reported in real terms.

For investment projects where the majority of the spending is in U.S. dollars, in order to adjust nominal cash flows and/or discount rates to real terms, I rely on inflation rates implied by prices of Treasury Inflation Protected Securities (TIPS) to assist with the conversion.[20] Specifically, by taking the difference between the yields on the U.S. 10-year Treasury bond (2.5%, for example) and the U.S. 10-year TIPS (0.5%, for example) implies inflation expectations of roughly 2% (2.5% - 0.5%) over the next 10 years. In the examples on Figure 6, real rates would be estimated at 5% (7% - 2% expected inflation) for Category 1, 8% for Category 2, and 11% and 14% for Categories 3 and 4, respectively.

Cash Flow Model Uncertainties

As mentioned previously, my contention is that the many uncertainties within discount rate calculations are significantly outweighed by the uncertainties within the cash flow models to which these rates are applied. As an example, and which will be discussed in this section, there are huge amounts of uncertainty in the very first line of a typical commodity investment cash flow model: the expected production (let alone the many other lines in a cash flow model that have uncertainty such as the costs and capital estimates.) This section provides a very high-level view of how production estimates are obtained within the gold mining sector as an example. In particular, this section progresses from exploration through geostatistical modeling to mine plan development, from which estimates of metal production are derived. The goal is to provide an introductory understanding of the uncertainties inherent in each step.

Exploration

Mineral exploration is the search for an ore deposit and typically starts with reconnaissance. Reconnaissance is the preliminary examination of the overall geological factors and characteristics of a region. Activities during this phase include geophysical surveys, widespread geochemical and geophysical sampling. Geophysical methods measure the earth's magnetic conditions such as the resistance to electric current. As shown in Figure 7a on the next page, magnetometers can be used on the surface or in small airplanes to generate magnetic/gravity maps of an area. As an example, these maps may reveal the existence of minerals with high iron content (deep purple areas on the figure.)[21] Given the geology, this may indicate the presence of gold and other potentially profitable metals such as copper.

If remote sensing surveys reveal positive indicators, activities to more closely examine a region may follow. At this point, geologists will typically be on the ground, mapping geological characteristics of the region of interest, including rock types and structures such as faults. Geochemical sampling will also occur that consists of analyzing the mineral content of soils, plants and water as these may provide indications of what lies beneath the earth's surface; please see Figure 7b.

Figure 7a
Aerial Geophysical Surveying

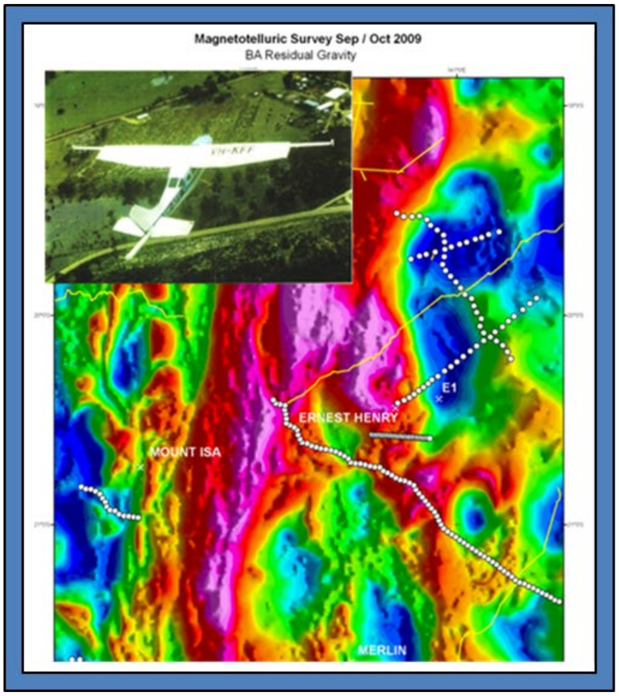


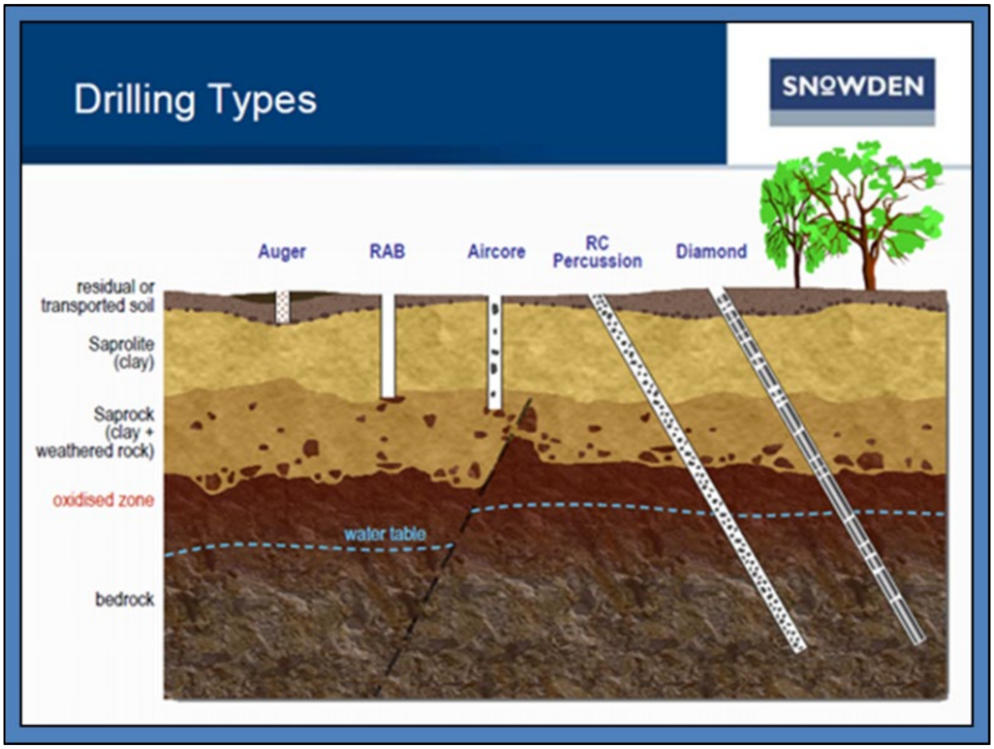
Figure 7b
Geophysical Sampling

Sources include Newmont Goldcorp Exploration.

If the mineral potential is high enough in a region following reconnaissance activities, subsurface evaluation may follow (if the mining company has funds available in exploration budgets.)

Figure 8 displays various drilling methods that may be employed. Selection of the drilling technique or the combination of methods is a trade-off of speed, cost, environmental concerns and the resulting sample quality.

Figure 8
Exploration Drilling Methods



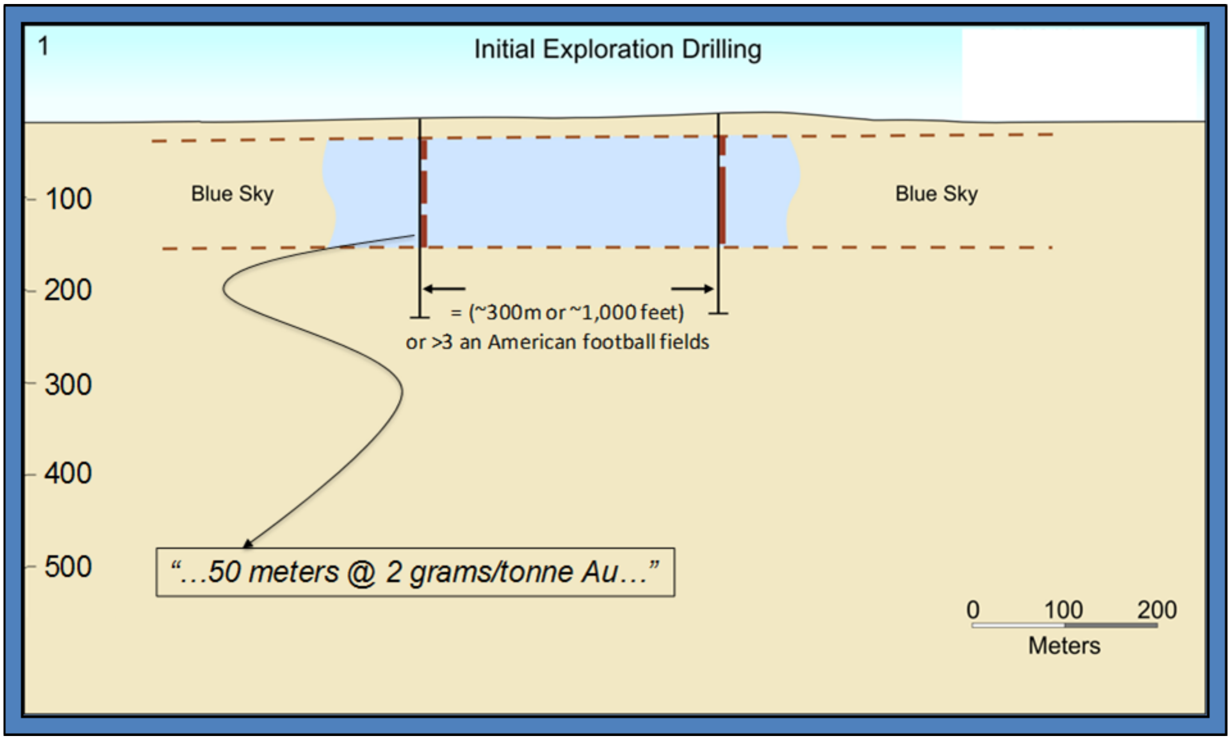
Source: "Geology for Non-Geologists" Professional Education by the Snowden Group.

As shown in Figure 8, methods range from fast and inexpensive Auger and Rotary Air Blast (RAB) techniques to diamond drilling, which can be extremely expensive but generates the highest quality geological information. Reverse Circulation (RC) and diamond drilling can generate samples that are very deep from ~1,600' to nearly 6,000' below the surface, respectively. The biggest advantage of diamond drilling is the resulting generation of a solid rock core that can be subsequently logged and geologically mapped. At Newmont Mining, the average diamond drill hole was ~500', costing ~$125,000 each. It is important to note that the cost as exploration budgets are limited, particularly when metal prices and company revenues are low. As such, there is a trade-off between how much drilling can be afforded and the need for information to eventually build cash flow models.

Continuing with the discussion on exploration, the example on Figure 9 displays a cross section of a geological area of interest (depicted in light blue) with two exploratory drill holes, each over 250 meters in depth (over 800 feet.) As highlighted in the red areas of each drill area are notable drill intercept results (found by the subsequent analysis of the drill cores.) In this case, a mining company might issue a press release stating, "…drill intercept of 50 meters in length at 2 grams/tonne gold." Also note the distance between these two drill holes of ~300 meters (or 1,000' or the equivalent of over three American football fields.)

Figure 9

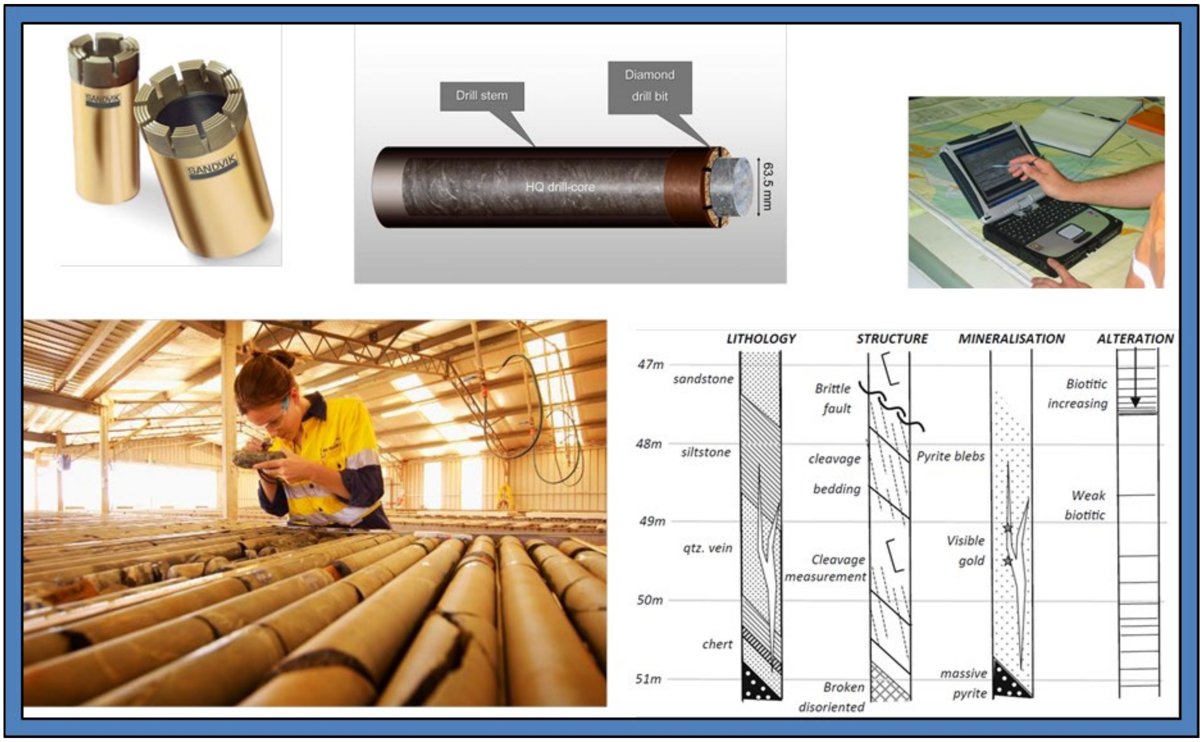
Example Early Stage Exploration Drilling (Cross Section)



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

As depicted in Figure 10, diamond drilling generates a solid rock core by the use of a hollow, rotating bit, studded with industrial diamonds. With the resulting drill core, geologists complete logging (or identifying the attributes of the sample) that may include the grade, the structure and the physical characteristics of the rock. This information is recorded onto tablet computers from which eventual geological models are created.

Figure 10
Diamond Drill Core Logging



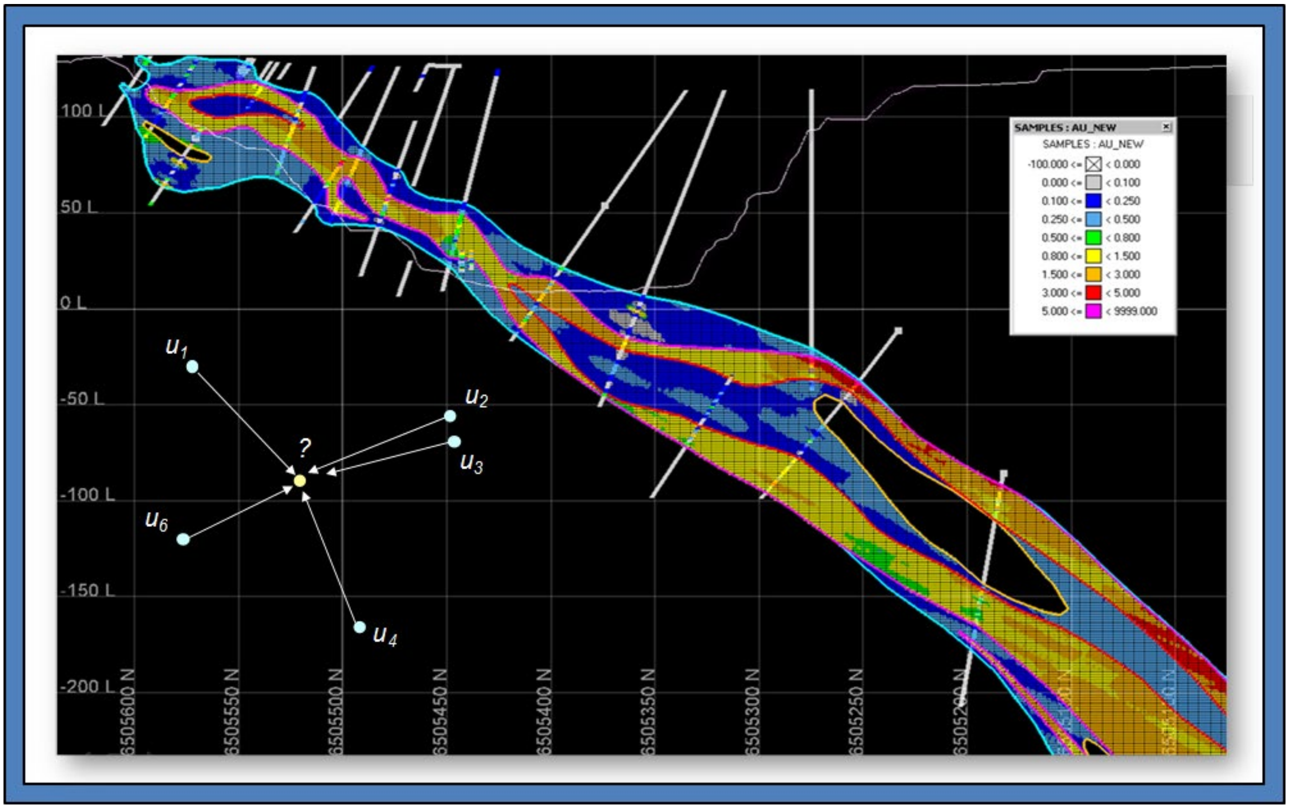
Sources include Newmont Goldcorp Exploration.

Once drill information is logged, the information is then handed over to geologic modeling teams whom utilize geostatistical models to estimate a potential mineral resource.

Figure 11 on the next page provides an example of a 3D image of a computer-generated block model that assigns a mineral grade to each individual block in the resource based on information from drilling samples. Within the figure, individual drill holes are shown as the white lines. Through geostatistical (or spatial) modeling, known grade information from the drill holes is used to interpolate potential grades in areas between the drill holes with the blue through yellow to purple colors indicating blocks with increasingly higher ore grades. As such, these models generate better (i.e., less uncertain) estimates the closer the drill holes are to each other, thus requiring lower degrees of interpolation.

A simple version of an interpolation routine within these models is shown in the lower left of Figure 11 where the goal is to estimate the grade at a given location (depicted with "?") from 6 available drill samples (labeled u1 to u6.) As a reminder, the example initial drill holes discussed in Figure 9 were ~1,000' apart: this is a huge amount of space to interpolate a resource, but it is what mining companies will generally start with for metal production estimates as initial cash flow models are developed.

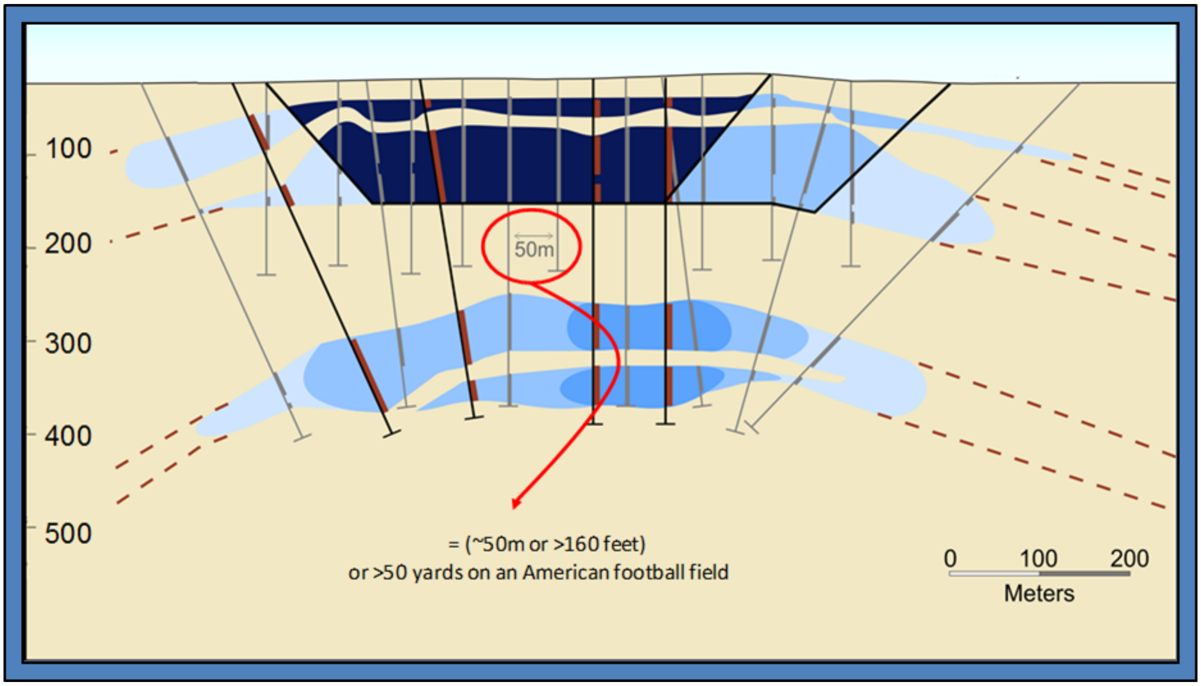
Figure 11
Geostatistical Modeling of a Potential Resource



Source: Newmont Goldcorp Technical Services.

As corporate and exploration budgets and personnel permit, if a resource has significant potential, more drilling can be completed as shown in Figure 12, which is a continuation of the previous example. As shown, additional drilling on the resource has been completed to the point that the spacing between the holes has been reduced from 300 meters in Figure 9 to 50 meters (~150' or 50 yards on an American football field.) As mentioned previously, this added information greatly improves geostatistical and mine planning models, but does not eliminate uncertainty. Further, with spacing of ~50 yards, typical levels of uncertainty of estimated production would be +30% (or if annual production is expected to be 100,000 gold ounces, with a down- and upside of 70,000 to 130,000 ounces, respectively.) As the company drills and spends more studying a given resource, the uncertainty may be reduced to +15%. However, even with this level of uncertainty, a faulty quest for discount rate "precision" can be swamped by uncertainty with attempting to estimate production estimates (let alone the many other elements of a cash flow model needed to estimate FCF.)

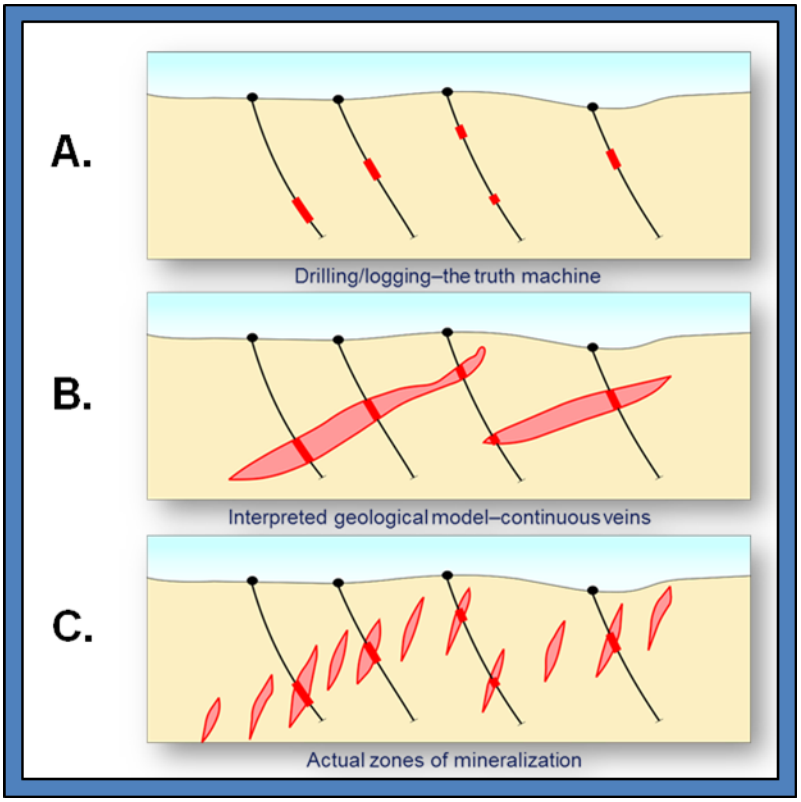
Figure 12
Continuing Exploration Drilling



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

As a further example, even with best intentions, geologic modeling carries uncertainty. Consider the schematic in Figure 13 on the next page which, while simple, definitely occurs in the exploration for and modeling of metal deposits. In this example, through exploration, the mining company has completed four drill holes (Part A of the figure) with varying intercepts of higher-grade material (again identified in red.)

Figure 13
Geologic Modeling Uncertainty



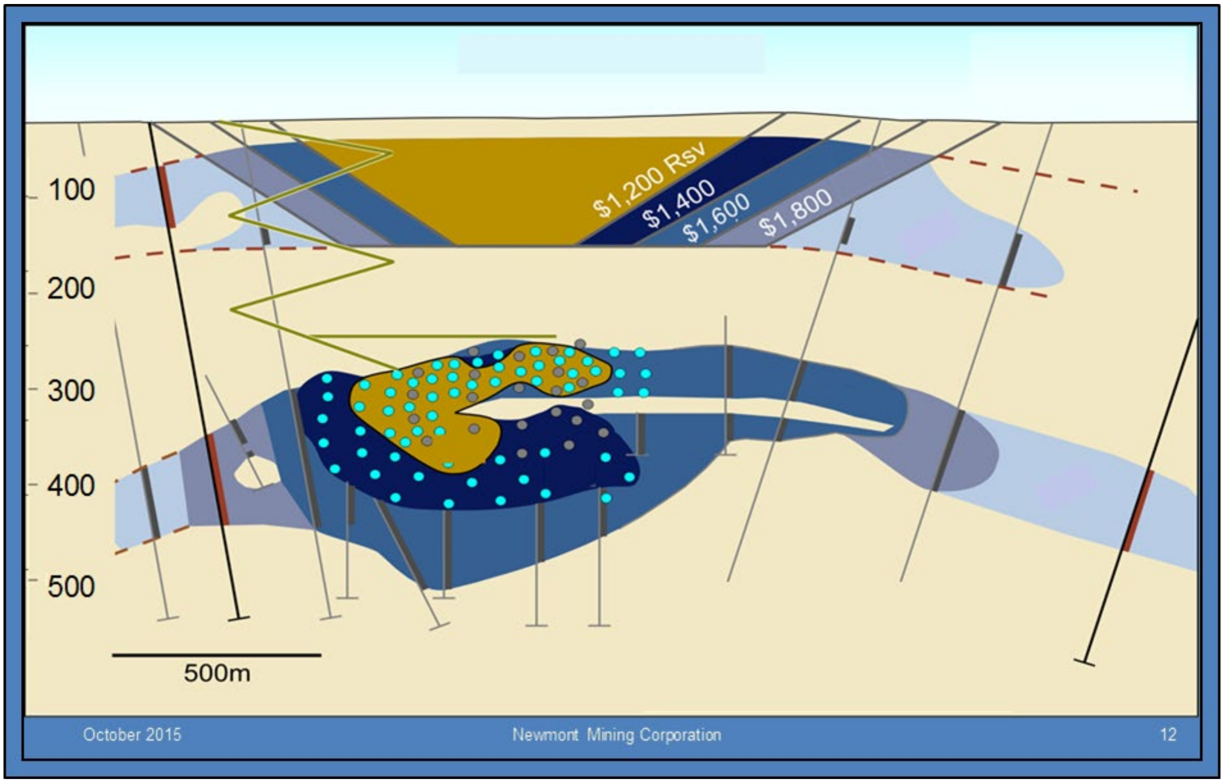
Source: Newmont Goldcorp Technical Services.

As previously described, with the core information from the four drill holes, the geologic modeling team interpolated a mineral resource that through modeling was thought to be relatively contiguous (as shown in Part B.) However, after the mining company fully invested in the development of the project, the actual mineral resource resembled Part C with drastically fewer gold ounces that could be profitably mined.[22]

Other Sources of Uncertainty

To this point, we have reviewed the uncertainties inherent in cash flow modeling associated with expected production due to the levels of interpolation that occur in resource modeling. Uncertainty from required interpolation can be extended by uncertainty with metal prices as shown in Figure 14 on the next page. As shown in this figure, the gold shaded areas represent areas of a potential mine that a representative company is highly confident that can be profitably mined at gold prices of $1200 per ounce. As shown, the number of mined ounces that have a high level of confidence of being profitably mined increases with the metal price (at prices of $1,400, $1,600, and $1,800.) As another reason to not become overly concerned with discount rate precision, trying to predict metals prices in the next 3 months, let alone over multiple decades, has quite uncertain success.[23]

Figure 14
Estimated Mine Production at Various Gold Prices



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

Conclusion

This article attempts to provide distinct, practical steps for estimating, applying and communicating discount rates to the many users throughout a firm. The article demonstrates the multiple sources of uncertainty that lie within any discount rate calculation. These risks, however, are outweighed by the uncertainties inherent in the cash flow estimates to which these rates are applied. For investment analysis, capital budgeting and other applications for discount rates across the commodity sector, the methods presented in this article provide an appropriate mix of theory and practice.

We welcome feedback on this article; accordingly, comments and suggestions can be emailed to gcard@ucdenver.edu.

Endnotes

1 As a reminder, FCF is the cash that a project or investment may generate from inflows of money (for example, from gold or copper sold) less the necessary outflows (cash operating and other costs, interest, taxes and capital expenditures) as well as non-cash items (including depreciation and amortization). FCF represents the discretionary funds that a firm may use to pay dividends, repay debt, buyback shares or to fund growth.

2 Nominal prices and rates include the effects of inflation (and are discussed in the article.)

3 A further benefit is that with standard templates, multiple models may be combined to evaluate investments with a portfolio view.

4 Equity may include common shares outstanding and as applicable, preferred shares outstanding.

5 In addition, trading liquidity on the 10-year is significantly higher than on the 30-year.

6 Damadoran (2008) provides a nice write up on using risk-free rates.

7 Additionally, EY (2018) suggests using adjusted betas (mean reverting betas) as this tendency has been shown for industrial firms.

8 Damadoran (1999) also describes the use of adjusted betas.

9 Specifically, the equation is the Hamada formula and is used to separate financial risk of a levered firm from its business risk. Note: if a firm has no debt outstanding then the levered beta is equal to the unlevered beta.

10 These positive correlations increase significantly during times of financial and economic stress (as during the Asian and Global Financial Crises in 1998 and 2008/9, respectively.)

11 Again, due to the volatility in these markets, I typically use 5-year historical averages for these bond yields.

12 For further details on this approach, see Damadoran (2003).

13 To annualize an estimate, multiply by the square root of 252 ($\sqrt{252}$) if using daily data (there are 252 trading days in a year) or by the square root of 12 ($\sqrt{12}$) if using monthly averages.

14 At Newmont Mining, we worked with both IHS Markit and the EIU to create mining specific risk indices that included the availability of water, mineral rights, and access to land.

15 YTM is the interest rate at which the current market price of the bond is equal to the present value of all future cash flows of the bond.

16 Professor Aswath Damodaran of the Stern School of Business at New York University suggests matching the tenor of the government bond used for the risk-free rate to that of each bond analyzed. However, for simplicity I generally use the 10-year Treasury yield. However, as mentioned later in the article, for simplicity I typically do not analyze all bonds outstanding for a company and instead use the longest dated bond as a proxy.

17 The best free online source for default spreads that I have found is provided by the National Association of Insurance Commissioners.

18 Damadoran (2019) provides a table to translate interest coverage to default spreads.

19 As an aside, in my experience if and when project teams become overly concerned with discount rates, tax rates, this throws up a potential red flag as to the eventual economic value of the project for the firm.

20 For projects outside of the U.S. with the majority of the initial and continuing spending in local currencies, many markets may not have inflation-protected bonds. In these instances, I would rely on the farthest dated inflation forecasts that one can find such as from the IMF, World Bank, and Bloomberg in an attempt to be as consistent as possible across countries.

[21] Specifically, these types of deposits are iron oxide copper gold (IOCG) and have relatively simple metallurgy and high ore grades.

[22] Unfortunately the mining company spent multiple billions of dollars to develop this resource: mining is a tough and uncertain business!

[23] One of my responsibilities as Chief Economist at Newmont Mining was to provide commodity price and FX rate forecasts throughout the firm. Rather than attempting precision, I typically estimated multiple structured forecast scenarios.

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Prior to being named the Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School, Dr. Thomas Brady was the Chief Economist at Newmont Mining Corporation where he was responsible for generating key commodity price, foreign exchange and other financial assumptions used throughout the company. In this role, Dr. Brady also developed methods to effectively quantify and communicate the economic impact of Newmont's operations to host communities and countries. Prior to this position, Dr. Brady led Newmont's Strategic Planning function that developed and implemented portfolio modeling analytics. Before Newmont, Dr. Brady was a Senior Manager at Risk Capital Management, a consultancy that advised energy and natural resource companies on financial risk, valuation and commodity hedging. He has also worked with CQG, Inc. where he developed a suite of automated trading systems for commodity futures contracts using the company's short-term, price and volume charting methods.

Dr. Brady is also a member of the J.P. Morgan Center for Commodities' Research Council at the University of Colorado Denver Business School. He holds a Ph.D. in Mineral Economics with research emphases in commodity markets from the Colorado School of Mines. In addition, Dr. Brady holds a Master's degree in Mathematics, also from the Colorado School of Mines.

The Relationship between Oil Prices, Exchange Rates and Interest Rates

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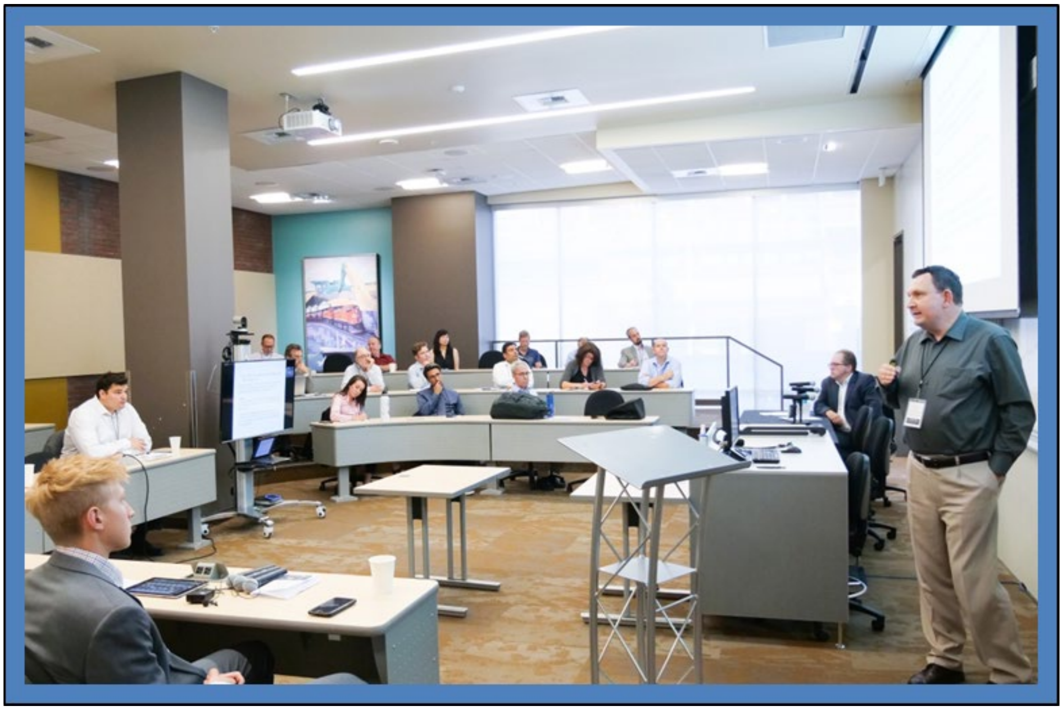


The co-author of this paper, **Dr. Lutz Kilian**, Ph.D., Senior Economic Policy Adviser, Federal Reserve Bank of Dallas, presented on "Oil Prices, Exchange Rates and Interest Rates" during a session on "Economics and Policy Issues on Energy Markets" at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019. Seated at the panel table is the chair of the session, Dr. Robert Vigfusson, Ph.D., Assistant Director and Chief, Trade and Quantitative Studies Section, International Finance, Board of Governors of the Federal Reserve System (Washington, D.C.). Both Dr. Kilian and Dr. Vigfusson are members of the JPMCC's Research Council.

Introduction

There has been much interest in the relationship between oil prices, exchange rates and interest rates since the 1980s. Even today, this relationship remains poorly understood, however. The challenge is that variation in any one of these variables tends to coincide with variation in the other variables, making it difficult to determine the ultimate cause of these fluctuations.

One popular argument in the literature has been that the real price of oil through its effect on the terms of trade is a primary determinant of the U.S. trade-weighted real exchange rate (Backus and Crucini 2000; Mundell 2002), but this conjecture has not been rigorously tested.

At the same time, the exact opposite argument has been made that exogenous fluctuations in the real exchange rate are driving the real price of oil. For example, there is a folk wisdom in the financial press that a depreciation of the dollar is associated with rising oil prices. The same sentiment is shared by many academics. Notably, Brown and Phillips (1986) conjectured that an exogenous appreciation of the U.S. real exchange rate in the early 1980s lowered the demand for oil outside the United States and stimulated the supply of oil, contributing to the fall in the real price of oil. Likewise, the sustained surge in the real price of oil in the 2000s has been attributed in part to the declining real value of the dollar.

A third argument, exemplified by Frankel (2014), is that fluctuations in the U.S. real interest rate affect the real price of oil not only by directly shifting the incentives for oil storage and production, but also by shifting the real exchange rate. This point is significant because it suggests that the real appreciation of the dollar and the decline in the real price of oil in the early 1980s may have been caused by higher U.S. real interest rates. Similarly, it has been suggested that the sustained surges in the real price of oil in 1979/80 and in the 2000s may be explained in part by low U.S. real interest rates, possibly caused by exogenous shifts in U.S. monetary policy.

Finally, to further complicate the analysis, it has been shown that the U.S. real interest rate responds to exogenous shifts in the demand for and supply of oil and, hence, so does the U.S. real exchange rate (Kilian and Lewis, 2011; Bodenstein *et al*., 2012). Thus, we cannot treat changes in the U.S. real interest rate as exogenous with respect to the real exchange rate and the real price of oil.

As this review illustrates, the three variables of interest are jointly and simultaneously determined. Thus, attempts to attribute causal effects to any one of these variables based on reduced-form correlations are doomed. Understanding cause and effect in the relationship between the real price of oil, the U.S. trade-weighted real exchange rate, and the U.S. real interest rate requires a structural model.

Generalizing the Workhorse Structural Oil Market Model

A recent study of ours proposes a novel approach to disentangling the causal effects of oil demand and oil supply shocks from the causal effects of shocks to the U.S. real exchange rate and the U.S. real interest rate (see Kilian and Zhou (2019)). In this study, we generalize the workhorse structural model of the global oil market, as discussed in Zhou (2019), to incorporate the trade-weighted U.S. real exchange rate and the U.S. real interest rate.

The model exploits three new insights. The first insight is that there cannot be feedback from exogenous variation in the U.S. exchange rate to the price of oil within the same month because, if there were, the price of oil would have a strong and statistically significant response to U.S. macroeconomic news much like the response found in the U.S. exchange rate. Kilian and Vega (2011) showed this not to be the case. The second insight is that longer-term market interest rates likewise are not contemporaneously affected by demand and supply shocks in the global oil market, which may be established in a similar manner. The third insight is that U.S. real market interest rates do not respond to exogenous changes in the real exchange rate on impact because expectations of inflation and output tend to be insensitive to exchange rate fluctuations in the short run.

Imposing these three restrictions on an otherwise standard model of the global oil market allows us to disentangle the causal effects of traditional oil demand and oil supply shocks from the causal effects of exogenous variation in the real exchange rate and the real interest rate without restricting the lagged interaction of the model variables.

The second co-author of this paper, **Dr. Xiaoqing Zhou**, Ph.D., Economist, Federal Reserve Bank of Dallas, also presented at the JPMCC's 3rd Annual International Commodities Symposium. Seated at the panel table is Dr. Zhou's co-author, Dr. Lutz Kilian, who, in turn, chaired the symposium's "Commodities Matter Everywhere" session.

Responses to U.S. Real Interest Rate Shocks

Our model allows us, for the first time, to quantify the effect of unexpected increases in the U.S. real interest rate on the real price of oil, building on the work of Frankel (2014). Some of the key implications of Frankel's model of real commodity prices may be summarized as follows:

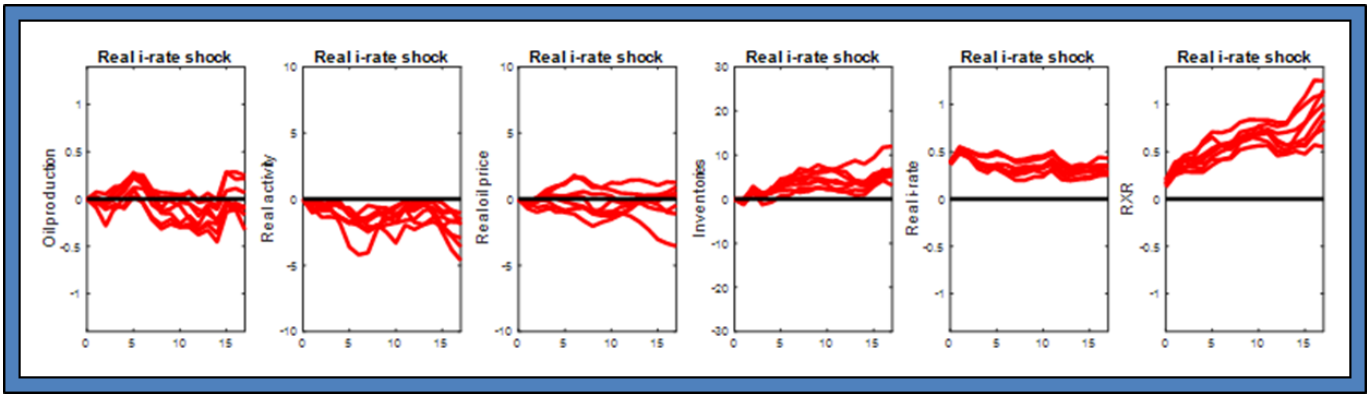
- An exogenous increase in the U.S. real interest rate stimulates global oil production by raising the opportunity cost of keeping oil below the ground. Frankel's model does not allow for the fact that higher U.S. real interest rates raise the capital cost of future oil extraction and hence may lower future oil production, however, which renders the sign of the oil production response ambiguous in practice, so we do not restrict this sign in our empirical analysis.

- Global real economic activity falls, as the value of the dollar appreciates in response to higher U.S. real interest rates.

- Finally, an exogenous increase in the U.S. real interest rate lowers oil inventories, as the opportunity cost of carrying inventories rises. Since the reduction in global real activity caused by higher U.S. real interest rates is likely to cause an accumulation of oil inventories, however, the sign of the inventory response is uncertain and hence is left unrestricted in our empirical work.

Thus, only the signs of the responses of the real exchange rate and of global real economic activity in Frankel's model are likely to be robust. Imposing the latter two sign restrictions on the structural model allows us to quantify the response of the real price of oil, in particular, to an exogenous increase in the U.S. real interest rate, as shown in Figure 1.

Figure 1
Responses to an Exogenous Increase in the U.S. Real Interest Rate



Notes: RXR stands for the trade-weighted U.S. real exchange rate and the real interest rate refers to the U.S. real market rate of interest. Real activity refers to global real economic activity and inventories to the level of global oil inventories.

Frankel's model implies that the real price of oil should fall in response to higher U.S. real interest rates. Figure 1 shows that the real price of oil indeed declines in the short run, as predicted, but at longer horizons the response is indistinguishable from zero. Thus, the response pattern is consistent with Frankel's model, allowing for the inherent ambiguity of the sign of the responses of oil production and oil stocks. However, even the most negative response of the real price of oil that is consistent with the data is small. This conclusion is robust to any additional restrictions one may impose.

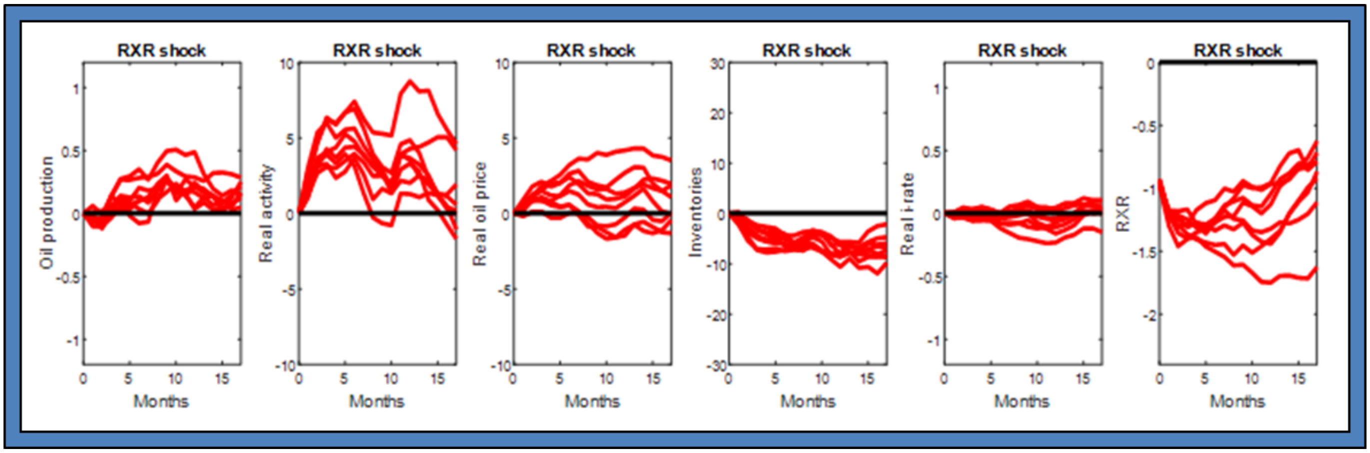
Responses to U.S. Real Exchange Rate Shocks

Next, we consider the responses to an exogenous real depreciation of the dollar in the same model. Figure 2 on the next page shows that the real price of oil tends to increase in the short run, as expected, but the magnitude of the response at longer horizons is indistinguishable from zero. Global real activity increases at least in the short run. The response of global oil production tends to be slightly positive with some delay, while that of the U.S. real interest rate and of oil stocks tends to be slightly negative. The latter three responses are again indistinguishable from zero.

Thus, from the point of view of the global oil market, real exchange rate shocks must be interpreted primarily as oil demand shocks. A real depreciation of the dollar, for example, makes it less expensive for countries other than the United States to import oil and other industrial commodities, raising global real activity and the real price of oil. A real appreciation, in contrast, tends to lower the real price of oil.

Our analysis provides direct evidence in support of a transmission of real exchange rate shocks to the real price of oil. In contrast, the responses of the U.S. trade-weighted real exchange rate to oil demand and oil supply shocks that raise the real price of oil are indistinguishable from zero in general (and hence are not shown), indicating that this link is weak and subject to great uncertainty.

Figure 2
Responses to an Exogenous Real Depreciation of the U.S. Dollar



The Key Determinants of the Variability in the Model Variables

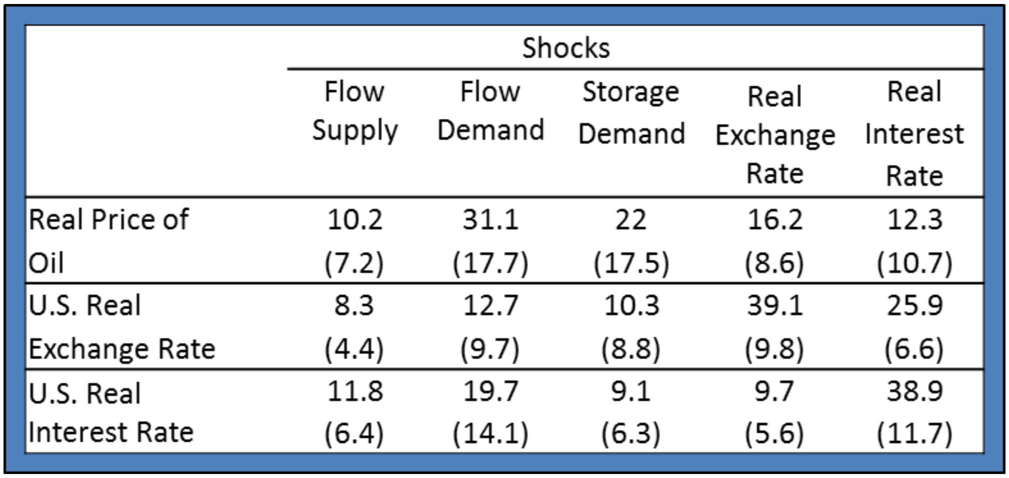
Our structural model estimates shed light on a number of questions that have been debated in the literature for a long time. For example, Backus and Crucini (2000) conjectured that much of the variability of the real exchange rate reflects variability in the real price of oil, which traditionally had been viewed as being driven primarily by exogenous oil supply shocks. We are in a position to quantify the importance of exogenous oil demand and oil supply shocks for the variability of the U.S. real exchange rate (see Table 1 on the next page).

Our analysis provides no support for this conjecture. It reveals that exogenous oil supply shocks account, on average, for only 8% of the variability in the U.S. real exchange rate and all oil demand and oil supply shocks combined explain only about one third of the variability in the U.S. real exchange rate. The other two thirds are explained by exogenous variation in the real exchange rate (39%) and by exogenous variation in the U.S. real interest rate (26%).

The latter result supports the view that exogenous variation in the U.S. real interest rate is an important determinant of the real exchange rate (and hence of real commodity prices). Our model attributes about 10% of the variability in the real price of oil to exogenous U.S. real interest rate shocks and 16% to exogenous real exchange rate shocks, compared with 53% for traditional oil demand shocks and 10% for oil supply shocks.

The variability in the U.S. real interest rate, in contrast, is driven mainly by real interest rate shocks (39%) with real exchange rate shocks (10%) playing a lesser role. The relatively large contribution of oil demand shocks (29%) does not mean that the oil market is driving the U.S. real interest rate, but that both the oil market and the U.S. real interest rate are responding to the same global economic conditions.

Table 1
Variance Decompositions (Percent)



	Shocks				
	Flow Supply	Flow Demand	Storage Demand	Real Exchange Rate	Real Interest Rate
Real Price of Oil	10.2 (7.2)	31.1 (17.7)	22 (17.5)	16.2 (8.6)	12.3 (10.7)
U.S. Real Exchange Rate	8.3 (4.4)	12.7 (9.7)	10.3 (8.8)	39.1 (9.8)	25.9 (6.6)
U.S. Real Interest Rate	11.8 (6.4)	19.7 (14.1)	9.1 (6.3)	9.7 (5.6)	38.9 (11.7)

Note: Posterior mean (with posterior standard error in parentheses).

What Happened in the Early 1980s?

As we have already shown, much of the variation in the U.S. real exchange rate is exogenous with respect to the real price of oil. In fact, there is evidence of a large, but slow-moving cycle of exogenous real appreciations and real depreciations of the U.S. dollar. Thus, one would not expect real exchange rate shocks to explain sudden large increases or decreases in the real price of oil. Indeed, exogenous exchange rate shocks contributed only 1% to the surge in the real price of oil from 1979.1 to 1980.9, for example.

We establish, however, that the cumulative effect of real exchange rate shocks over several years can be sizable. Of particular interest in this context is the extent to which the prolonged exogenous real appreciation of the dollar in the early 1980s contributed to the decline in the real price of oil after 1980. Brown and Phillips (1986), among others, conjectured that this contribution was important. Our model shows that these shocks explain a cumulative decline in the real price of oil of 16% between 1980.10 and 1985.3, suggesting that Brown and Phillips (1986) had a valid point, although the quantitative importance of that point is perhaps less than one might have conjectured.[1]

The early 1980s are by no means a historical exception in this regard. Between 2002.1 and 2008.3, for example, exogenous real exchange rate shocks cumulatively raised the real price of oil by 42%, as the U.S. dollar depreciated over an extended period.

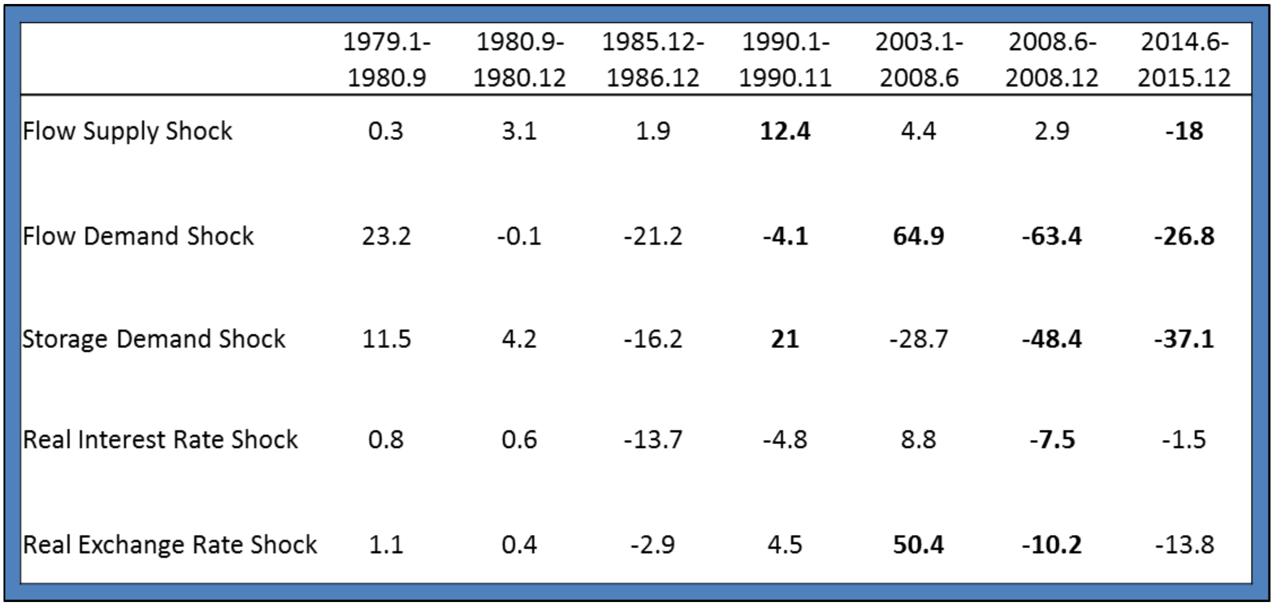
Revisiting the Historical Narrative of the Ups and Downs of the Real Price of Oil

As we have noted, even a small response of the real price of oil to a one-time shock may be consistent with substantial cumulative effects of this shock over time. Thus, we investigate in detail whether allowing for additional shocks to the U.S. real exchange rate and the U.S. real interest rate in the global oil market model changes the historical narrative of what caused the ups and downs in the real price of oil since the late 1970s.

Table 2 focuses on historical episodes of major oil price fluctuations including the Iranian Revolution (1979.1-1980.9), the outbreak of the Iran-Iraq War (1980.9-1980.12), the collapse of OPEC (1985.12-1986.12), the invasion of Kuwait (1990.1-1990.11), the oil price surge of the 2000s (2003.1-2008.6), the Great Recession (2008.6-2008.12), and the most recent major oil price decline (2014.6-2015.12). For each episode, it shows the cumulative effect of selected structural shocks on the real price of oil in the absence of other structural shocks.

Table 2

The Cumulative Effect of Selected Shocks on the Real Price of Oil by Episode (Percent)



	1979.1-1980.9	1980.9-1980.12	1985.12-1986.12	1990.1-1990.11	2003.1-2008.6	2008.6-2008.12	2014.6-2015.12
Flow Supply Shock	0.3	3.1	1.9	**12.4**	4.4	2.9	**-18**
Flow Demand Shock	23.2	-0.1	-21.2	**-4.1**	**64.9**	**-63.4**	**-26.8**
Storage Demand Shock	11.5	4.2	-16.2	**21**	-28.7	**-48.4**	**-37.1**
Real Interest Rate Shock	0.8	0.6	-13.7	-4.8	8.8	**-7.5**	-1.5
Real Exchange Rate Shock	1.1	0.4	-2.9	4.5	**50.4**	**-10.2**	-13.8

Notes: Posterior median. Boldface indicates precise estimates.

Table 2 shows that the main difference from earlier studies is the large cumulative effect of exogenous real exchange rate shocks during the oil price surge between 2003.1 and 2008.6. In fact, this is the only episode when these cumulative effects are both large and precisely estimated. While it remains true that flow demand shocks explain the bulk of this increase, as evidenced by a cumulative increase of 65%, higher demand for oil from the exogenous depreciation of the U.S. dollar explains an additional 50% cumulative increase in the real price of oil, making it the second most important determinant of the real price of oil. In traditional oil market models these shocks are conflated and virtually all of the increase in the real price of oil is attributed to flow demand shocks (Zhou, 2019).

In either case, however, the importance of oil demand shocks in this episode is much larger than that of oil supply shocks. Thus, extending the oil market model by including the U.S. real exchange rate and the U.S. real interest rate yields a more nuanced, but substantively similar conclusion about what happened during 2003.1-2008.6.

With this qualification, the substantive results are quite similar to earlier studies. For example, the surge in the real price of oil in 1979/80 was mainly caused by a combination of flow demand and storage demand shocks. The decline in the real price of oil in 1986 mainly reflected lower flow demand, as the global economy slowed, and lower storage demand, as OPEC's impotence to control the price of oil was revealed. The oil price spike of 1990 was caused by an oil supply disruption and a surge in storage demand, reflecting expectations of future shortages of oil. The sharp decline in the real price of oil in the second half of 2008 mainly reflected lower flow demand, as the global economy entered a recession, and lower storage demand, and the decline after June 2014 reflected a combination of positive oil supply shocks and negative oil demand shocks.

Monetary Policy and Commodity Prices

An important question for policymakers is whether the U.S. Federal Reserve was partially responsible for the surge in oil prices in 1979/80 and in the 2000s. One view has been that the U.S. Federal Reserve contributed to the commodity price boom between 2003 and 2008 by allowing the real interest rate to remain low for too long. Our model allows us to formally evaluate and reject this conjecture. Although real interest rate shocks in Table 2 account for a 9% increase in the real price of oil, that increase is dwarfed by the cumulative effect of flow demand and real exchange rate shocks of 115% combined over the same period. Moreover, the 68% credible set suggests that the cumulative effect of real interest rate shocks could be anywhere between -13% and +28%. Thus, there is no credible evidence that monetary policy was responsible for the sustained surge in the real price of oil after 2002. In contrast, the contribution of other structural shocks is larger and more precisely estimated. Likewise, Table 2 shows no support for the hypothesis that the 1979/80 oil price increase was caused by earlier unexpected reductions in the real interest rate.

Concluding Remarks

Modeling the relationship between oil prices, exchange rates and interest rates raises some interesting identification challenges. Recent research shows how the workhorse structural oil market VAR model may be modified to overcome these challenges. The resulting structural model sheds light on common conjectures about the determinants of the variability of the real exchange rate, the real price of oil, and the U.S. real interest rate. The model estimates provide a more nuanced understanding of historical oil price fluctuations, but substantively agree with earlier historical narratives. They reveal no evidence in support of a link from shifts in U.S. monetary policy to real oil price fluctuations. They do provide, however, for the first time, direct empirical support for some of the effects highlighted in Frankel's (2014) model of real commodity prices.

Endnotes

1 It should be noted that in a structural model omitting the real interest rate shock one would have obtained a much higher estimate of 32% for the cumulative decline in the real price of oil explained by exogenous exchange rate shocks, illustrating the importance of jointly modeling the real exchange rate and the real interest rate.

Dr. Kilian presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Economics and Policy Issues on Energy Markets" session on August 12, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

The views in this article are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Dallas or the Federal Reserve System.

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Author Biography

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Lutz Kilian received his Ph.D. in Economics from the University of Pennsylvania and his M.A. in Development Banking from The American University. Before joining the Federal Reserve Bank of Dallas in 2019, he was a Professor of Economics at the

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Speculative Pressure

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Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3279425

This article examines the information content of futures markets speculators' net positions. It shows that long-short portfolios based on speculative pressure capture attractive premia in commodity, equity and currency futures markets. The thus formed speculative pressure factors are able to explain the cross-sectional variation in futures returns after controlling for tradeable (carry, momentum and value) factors and non-tradeable global macroeconomic factors. The results are robust to transaction costs, liquidity concerns, alternative signals and portfolio weighting schemes, and sub-periods. These findings do not extend to fixed income futures markets. The key message is that an efficient hedgers-to-speculators risk transfer mechanism is at play in commodities, equity and currency futures markets but is not manifested in fixed income futures markets.

Introduction

The hedging pressure hypothesis of Cootner (1960) and Hirshleifer (1988) represents one of the cornerstones of the modern literature on commodity futures pricing. Under this theoretical framework, the price of a commodity futures contract is expected to rise as maturity approaches in a market when speculators are net long in order to reward them for providing price-fluctuation insurance to the net short hedgers. Vice versa, the futures price is expected to fall with maturity in a market when the speculators are net short in order to reward them for matching off the net long hedging demand. However, the extant empirical evidence offers mixed support for the hedging pressure hypothesis.[1]

The authors measure at each portfolio formation time t the price pressure effect dictated by the net demand for futures contracts of hedgers. To do so they employ data on the net positions of speculators (the supply side) and refer to the resulting measure as the *speculative pressure* SP_{it} signal; a positive SP_{it} (negative SP_{it}) indicates that the speculators are net long (short) in the ith futures contract.

The paper contributes to the literature by examining the extent to which long-short portfolios of futures contracts based on SP as a sorting signal are able to capture a premium not only in commodity markets but also in financial (equity, currency and fixed income) markets. Further, it deploys tests to assess the

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This digest article was written by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Cass Business School, City, University of London (U.K.).

ability of the corresponding futures class-specific and "everywhere" speculative pressure factors to price the broad cross-section of futures against well-documented risk factors within futures class and across futures classes such as momentum, value and carry (Asness *et al*., 2013; Koijen *et al*., 2018) and global macroeconomic risk factors. Finally, it addresses the question of whether there are common drivers of the commodity, equity index and currency speculative pressure premia.

Relevance of the Research Question

The long-short portfolio analysis conducted in this paper is important, first, to re-assess the Cootner (1960) and Hirshleifer (1988) hedging pressure theory in the context of a rich sample of data for a broad "universe" of commodity, equity index, currency and fixed income futures contracts over an updated time period that includes important landmarks such as the late 2000s Global Financial Crisis, and post Dodd-Frank Wall Street Reform and Consumer Protection Act period *inter alia*. Being able to confirm (or otherwise refute) with this updated sample the presence of an efficient risk transfer mechanism from commodity hedgers to speculators has important implications for policymakers and regulators of commodity futures markets. Furthermore, by investigating the presence of an analogous risk transfer mechanism in financial futures markets, the paper aims to fill a void in the futures markets literature.

Second, the specific research questions tackled in the paper are important to inform the literature on futures pricing within each asset class and cross-class, and are also potentially useful to long-short portfolio managers interested in practical investment solutions within and across futures markets.

Data, Speculative Pressure Signal and Portfolio Construction

The paper uses the weekly open interest (OI) of large non-commercial futures traders as compiled by the Commodity Futures Trading Commission (CFTC) in its Futures-Only Legacy Commitments of Traders (COT) report for 84 futures contracts (43 commodities, 11 currencies, 19 equity indices and 11 fixed income and interest rates) from September 1992 to May 2018 to measure the *speculative pressure (SP)*:

$$SP_{i,t} = \frac{1}{W}\sum_{w=1}^{W}\frac{L_{i,t-w} - S_{i,t-w}}{L_{i,t-w} + S_{i,t-w}}$$

where t denotes each portfolio formation time, $L_{i,w}$ and $S_{i,w}$ are the week *w* long and short open interest of large non-commercial traders on the *i*th futures contract, and W is the length (in weeks) of the lookback window ($W = 52$). The trading signal is standardized by calculating $\omega_{i,t} \equiv (SP_{i,t} - \overline{SP}_t)/\sigma_{SP,t}$ with $\overline{SP}_t$ and $\sigma_{SP,t}$ denoting the cross-sectional mean and standard-deviation of SP at time t, respectively.

The corresponding daily settlement prices of each futures contract are obtained from *Thomson Reuters Datastream*. Futures returns are measured as the logarithmic price changes of the front-end contracts up to one month prior to delivery when the positions are rolled to the next nearest contract.

As implied by the hedging pressure hypothesis, the portfolio strategy takes long (short) positions in the futures contracts with $\omega_{i,t} > 0$ ($\omega_{i,t} < 0$). The weights of the long and short portfolio constituents are given by the magnitude of the SP signal, $\omega_{i,t}$, appropriately scaled so as to ensure full investment. The long-short SP portfolio is held for one month on a fully-collateralized basis, before rebalancing takes place. Alternative weighting schemes and ranking-holding periods are also considered later in the paper as robustness checks on the main findings.

Results

The analysis reveals that over the period, October 1993 to May 2018, the long-short speculative pressure portfolios capture attractive annualized mean excess returns of 4.12% per annum (statistically significant as borne out by a t-statistic of 2.62) in commodity futures markets, 2.51% ($t = 2.45$) in currency futures markets and 4.03% p.a. ($t = 2.29$) in equity index futures markets. In contrast, the fixed-income futures markets behave differently, yielding an unappealing SP return of -0.74% ($t = -1.49$).

By regressing the excess returns of the long-short speculative pressure portfolios on the excess returns of a long-only portfolio of futures, and long-short momentum, carry and value portfolios, the authors provide evidence to suggest that speculators predominantly pursue momentum and carry strategies.

Second, the evidence from cross-sectional pricing regressions suggests that the class-specific SP risk factors and “everywhere” SP risk factors have significant pricing ability for the broad cross-section of 84 futures contracts, after controlling for the corresponding class-specific and “everywhere” Long-Only, Momentum, Value and Carry factors, and for traditional global business cycles variables such as the change in industrial production, the default spread, the term spread, the Kilian index of global real economic activity, market liquidity shocks, funding liquidity shocks, and volatility shocks.

The aforementioned findings from the portfolio and cross-sectional analyses remain unchallenged in additional tests that: i) use data from alternative Commitment of Traders (COT) reports from the CFTC such as short and long positions of hedgers instead, futures and options combined and the disaggregated COT reports, ii) employ different portfolio construction techniques as regards the number of constituents of the long and short portfolios, and their weights, and the ranking and holding periods, iii) take into account futures contracts’ transaction costs and liquidity, or iv) different sub-periods.

Conclusions

This paper supports the theoretical notion of an efficient risk transfer mechanism from hedgers to speculators in futures markets beyond commodities by showing that long-short speculative pressure portfolios earn attractive premia in commodity, currency and equity index futures markets. Speculative risk factors constructed within commodity, currency and equity index futures markets have significant pricing ability for a broad cross-section of futures returns after controlling for tradeable momentum, value and carry factors, and global macroeconomic risks.

The aforementioned risk transfer mechanism is not revealed in fixed income markets. The authors argue that this might be because agents choose to manage interest rate risk through other means such as adopting immunization strategies or simply by temporarily changing the modified duration of their portfolios. Further research is warranted to shed light on this seeming anomaly, for instance, by defining better the entities that really are hedgers (versus non-hedgers) in the fixed income derivatives market.

Endnotes

1 A *positive* relation between the net short (long) positions of hedgers (speculators) and commodity futures returns has been documented by Cootner (1960, 1967), Chang (1985), Hirshleifer (1988, 1989), Bessembinder (1992), de Roon *et al*. (2000), Dewally *et al*. (2013), and Basu and Miffre (2013), whereas in sharp contrast, Rouwenhorst and Tang (2012), Gorton *et al*. (2013), Daskalaki *et al*. (2014), and Szymanowska *et al*. (2014) find no evidence of a significant relation**.**

Dr. Fuertes is a member of the Editorial Advisory Board of the *Global Commodities Applied Research Digest.*

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Keywords

Performance measurement, commodity trading advisors, CTA, alternative risk premia.

Demystifying Commodity Futures in China

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Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3124223

Amid an increasingly liberalized economy and substantial growth in investor interest, the authors examine systematic investment strategies in the Chinese commodity futures market. In light of unique institutional settings, their results indicate that momentum and term structure strategies generate statistically significant profits across the futures curve in the most liquid markets and randomly selected sectors. The observed profits are not subsumed by market risks, transaction costs and data snooping. Instead, the authors argue that liquidity, anchoring and regulation-induced "limits-to-arbitrage" provide a partial explanation. In addition, the paper presents a head-to-head comparison of the important institutional settings with the U.S. market.

Introduction

This paper devotes considerable effort to address the question: can alternative risk premia strategies generate statistically significant profits in Chinese commodity futures? The literature on commodity risk premia has seen substantial developments in the past decade. Studies have identified various risk premia that provide investors with distinct sources of returns in commodity futures. Despite being one of the fastest-growing markets globally, the literature on Chinese commodity futures appears to be in its infancy. Contrasting with the U.S., the authors first provide a comprehensive overview of the institutional background in Chinese futures markets. In the presence of barriers-to-entry, excessive speculation and strict position limits, they examine 12 systematic long-short strategies in a broad sample of 30 commodities traded across all major exchanges in China. Furthermore, a comparative analysis is conducted based on a matched sample of U.S. and Chinese commodities.

Why the Paper's Research Questions are Important

China's socialist market economy has spurred unprecedented economic growth over the past decades. To fuel the continuous expansion of the world's second largest economy, China's colossal demand for commodities is quietly changing the balance of the global commodities trade. From 2001 to 2010, the trading volume of Chinese commodity futures soared from a mere 3 trillion to 227 trillion RMB. Products such as soybean meal and steel rebar have now become the world's most actively traded instruments. Consequently, the once extraneous market is beginning to show signs of influence on the pricing of global commodities. As Chinese authorities continue to open up the economy and the access to its capital markets, this paper makes a timely contribution to both the academic literature as well as the investment management industry. The paper addresses the debate on commodities risk premia by

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This digest article was written by John Hua Fan, Ph.D., Senior Lecturer in Finance, Griffith Business School, Griffith University (Australia).

conducting tests in a segmented market, where the price discovery mechanism likely differs from a developed futures market such as the U.S., due to unique institutional settings. For practitioners, by "demystifying" the commodity futures market in China, this paper highlights the potential trading opportunities, particularly for commodity trading advisors and hedge funds seeking diversification.

Dr. John Hua Fan, Ph.D., Senior Lecturer in Finance at Griffith Business School (Australia), presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

Data Description

The data employed in the paper are obtained from Datastream International. The dataset consists of 30 commodities covering grains, oilseeds, industrials, metals and energy sectors, traded on the Dalian (DCE), Shanghai (SHFE) and Zhengzhou (ZCE) exchanges, respectively. The raw dataset contains more than 4,000 individual contracts and maturities spanning from 1993 to 2017. The cleaning process results in a final sample from February 2004 onwards. Investors are assumed to hold the m^{th} (where m = 1, 2, 3, 4) nearest contracts until the last trading day of the month prior to expiration. For the matched sample, data on 14 U.S. commodities are obtained from the Commodity Research Bureau (CRB). Furthermore, position data are obtained from the CFTC's Commitments of Traders report. For macroeconomic and financial variables, the authors employ the RMB effective exchange rate, unexpected inflation and industrial production, the CSI 300 Index and Barclays China Aggregate Bond Index from Bloomberg.

Methodology

The authors evaluate 12 systematic long-short strategies designed to exploit information on the term structure (Gorton, Hayashi and Rouwenhorst, 2013), hedging pressure (Garcia, Leuthold and Zapata, 1986; Basu and Miffre, 2013), cross-sectional and time-series momentum (Miffre and Rallis, 2007; Moskowitz, Ooi and Pedersen, 2012), volatility (Szymanowska, de Roon, Nijman and van den Goorbergh, 2014), open interest (Hong and Yogo, 2012), liquidity (Marshall, Nguyen and Visaltanachoti, 2012; Szymanowska *et al*., 2014), exchange rate and inflation (Erb and Harvey, 2006), skewness (Fernandez-Perez, Frijns, Fuertes and Miffre, 2018) and value (Asness, Moskowitz and Pedersen, 2013).

For each strategy, commodities are sorted into quartiles based on the respective signal. The strategy then takes long and short positions in commodities within the highest and lowest quartiles. The long-short portfolios are equally weighted and rebalanced monthly. For risk-adjusted performance, the authors employ standard market risk metrics (Moskowitz *et al*., 2012), commodity-specific risk metrics (Bakshi, Gao and Rossi, 2019), behavioral measures (Bianchi, Drew and Fan, 2016) and liquidity risk factors (Amihud, 2002).

Results

The analysis of the institutional settings reveals three distinct characteristics. First, the market is dominated by the presence of individual investors, who account for more than 95% of the total trading accounts by 2017. Second, the nearest-to-delivery contracts are subject to strict regulatory constraints and, therefore, are not the most liquid contracts. Instead, the 3rd nearest contracts exhibit the highest trading volume on average. Third, non-Chinese investors without the (RMB) Qualified Institutional Investors (RQFII) quotas are restricted from trading the vast majority of the commodities (at the time when the digest article was written.) However, this is changing rapidly, as the recently launched crude oil contract on the Shanghai International Energy Exchange (INE), and the recently prescribed PTA (on ZCE) and iron ore contracts (on DCE) are now open for overseas investors.

The paper presents several empirical findings. First, long-only investments in the Chinese commodity futures market fail to generate statistically significant profits, where certain sectors in fact report significant losses during the sample period. These results are robust to time and sector specifications or weighting schemes employed. The authors posit that the poor performance of the broad market explains the absence of investment vehicles in China. Second, among the 12 long-short strategies examined, term structure and momentum yield statistically significant economic profits, robust across the futures curve, in most liquid markets and randomly selected sectors. Using the 3rd nearest contracts (i.e., the most liquid market on average), the momentum strategy delivers 16.71% per annum on average, whereas the term structure strategy generates 13.79% and the hedging pressure strategy reports 8.11%. The authors argue that due to the position limits on the nearest contracts, the profitability on the front contracts is likely “inflated” by the regulation-induced limits-to-arbitrage, as implementing such strategies on thinly traded contracts is difficult.

Third, the authors demonstrate that long-short strategies offer promising diversification benefits for stocks and bonds in China. The hedging pressure and momentum strategies report negative (-0.17) and low (0.04) correlations with the CSI 300 Index. These findings remain consistent after time-varying correlations and different market conditions are considered. Lastly, in a matched sample of U.S. and Chinese commodities, their results suggest the two markets are not homogeneous and are likely driven by different pricing dynamics. They state that such comparison is necessary because more than half of the 30 commodities sampled are not listed on U.S. exchanges. Furthermore, the authors confirm the recent deterioration of momentum profits and the persistence of the hedging/speculative pressure and value strategies in the U.S. Finally, regression analyses reveal that the profits documented cannot be explained by commodity-specific risk factors, standard risk adjustments and market sentiment measures. However, liquidity risk and anchoring bias provide a partial explanation for some observed profits.

Conclusion

In summary, this article points to the conclusion that profitable trading opportunities exist in the emerging commodity futures markets of China. Evidence of market segmentation does not prevent the profitability of systematic investment strategies. In the presence of strict position limits and excessive speculation, momentum and term structure strategies consistently deliver strong risk-adjusted performance. This paper is of particular interests to global asset managers seeking portfolio diversification. A string of new policies introduced in 2019 signals the Chinese government's commitment to further open up the economy and reduce market access restrictions on foreign investors. Significant foreign investment flows into Chinese futures should help further boost the liquidity and efficiency in these markets.

Endnote

Dr. Fan presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Commodity Derivatives Trading and Financialization" session on August 12, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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Keywords

China, RQFII, commodity futures, position limits, momentum, term structure, hedging pressure, open interest, liquidity, diversification, limits-to-arbitrage.

On Commodity Price Limits

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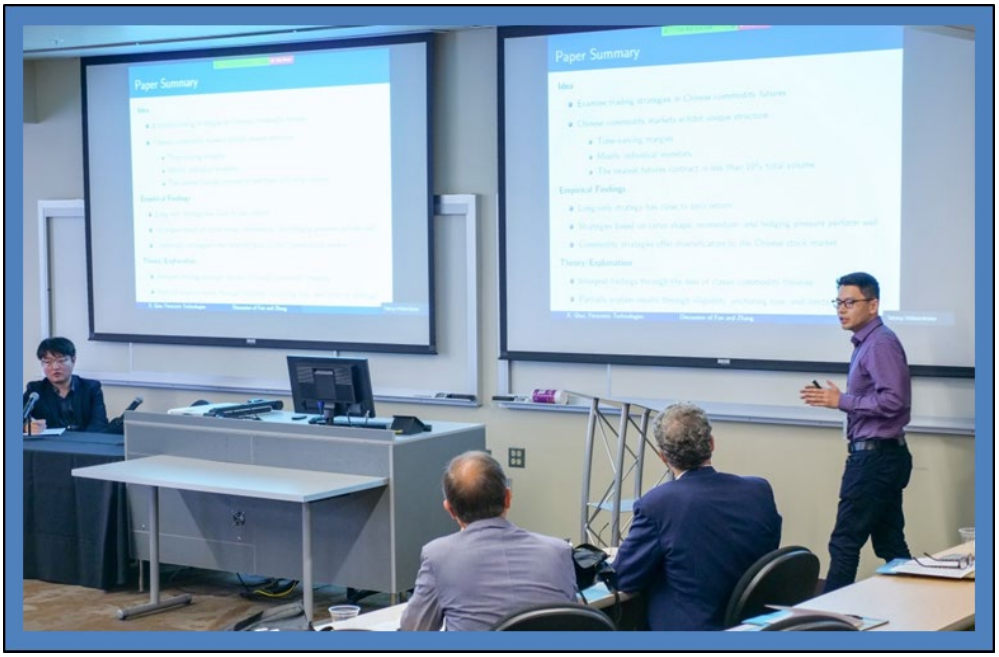
Published in: *Journal of Futures Markets*: *Special Issue from the JPMCC International Commodities Symposium*, 2019, Vol. 39, No. 8, August, pp. 946-961.

This paper examines the behavior of futures prices and trader positions around price limits in commodity futures markets. The authors ask whether limit events are the result of shocks to fundamental volatility or the result of temporary volatility induced by the trading of non-commercial market participants (speculators). The authors find little evidence that limit events are the result of speculative activity, but instead are associated with shocks to fundamentals that lead to persistent price changes. When futures trading halts, price discovery migrates to options markets, but option prices provide a biased estimate of subsequent futures prices when trading resumes.



The author of this digest article, **Dr. Xiao Qiao**, Ph.D. (right) of Paraconic Technologies US Inc., is shown here presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019. On the far left is Dr. John Hua Fan, Ph.D., Senior Lecturer in Finance, Griffith Business School (Australia). Dr. Fan, in turn, also contributed an article to this issue of the *GCARD*.

This digest article was written by Xiao Qiao, Ph.D., Co-Head of Research at Paraconic Technologies US Inc.

Introduction

Exchanges use different methods to curb volatility, such as circuit breakers, price controls, and price limits. In commodity futures markets, price limits are used to restrict price movements from rising above or falling below preset levels. Historically, price limits are viewed as a tool to reduce volatility caused by speculation. An alternative view is that price limits curb volatility induced by news about fundamentals and postpone inevitable price changes to slow down price discovery.

On the one hand, if price limits reduce speculation, speculative activity is expected to decrease around limit events. Speculators ought to cut their long positions after a limit up and reduce their short positions after a limit down occurs. Price changes are likely to reverse and volatility is likely to decrease after limit events as speculation wanes (Ma *et al.*, 1989).

On the other hand, if price limits are driven by fundamental volatility, speculators are not expected to change their trading behavior on limit days compared to non-limit days. Following limit events, prices are likely to continue in the same direction and volatility should not decrease.

The two views presented above are not necessarily mutually exclusive; volatility may contain both speculative and fundamental components. The net impact of price limits on market participants, as well as the behavior of prices and positions, is an empirical question. It is against this background that the authors investigate the behavior of price limits through three research questions. They use a large sample of more than 5,000 limit events in 12 commodity futures markets over a 25-year period.

Why the Paper's Research Questions are Important

The authors attempt to answer three questions. First, do price limits mitigate speculative activity of market participants? This is an old question that is often used to justify the existence of price limits. This paper provides an independent evaluation across 12 commodity markets. Second, what causes limits to occur? The answer to this question relates to the effectiveness of price limits. Third, do price limits affect price discovery in futures markets? If market participants can easily switch between commodity futures and other financial instruments, price discovery is expected to migrate to other related markets when participants cannot trade futures.

All three questions can help market participants improve their understanding of market microstructure so they can make more informed trading decisions, especially around price limits. The research questions also shed light on the efficacy of the current implementation of price limits and have implications of how futures markets could potentially be better regulated. It is in the interest of policymakers and regulators to understand the answers to these questions.

Data Description

The authors gather price limits occurrences for 12 commodities: soybean oil, corn, cotton, feeder cattle, Kansas City wheat, live cattle, lean hogs, oats, rough rice, soybean, soybean meal, and soft red winter wheat. Price data are from Bloomberg. The sample is from January 1991 to May 2016.

Price limits information is from the CME Group. Exchange price limits are compared to close-to-close price changes to identify limit days. Options data are from the Commodity Research Bureau (CRB). Commitments of Traders (COT) and Disaggregated COT (DCOT) reports of market participant positions are from the Commodity Futures Trading Commission (CFTC).

Methodology

To uncover the trading behavior of market participants, the authors use the change in positions from the CFTC COT reports. In particular, non-commercial traders are commonly associated with providers of speculative capital (Bessembinder, 1992; De Roon *et al*., 2000; Moskowitz *et al*., 2012). The change in non-commercial positions is taken as a proxy for change in speculative positions.

Changes in non-commercial positions around limit events are used to understand whether price limits dampen speculation. Changes in non-commercial positions before limit events are used to test whether speculation leads to price limits. Panel regressions allow for statistical tests of position changes while controlling for confounding factors such as past position changes or past returns, as well as latent differences across limit events with fixed effects.

Several other variables shed light on the effect of price limits. The shape of the futures curve - whether the front end is in backwardation or contango - reveals information about storage. If the curve is in backwardation, stock out risk is likely to be higher (Deaton and Laroque, 1992) than if the curve is in contango. By comparing the curve shape with limit occurrences, the authors can relate fundamentals of storable commodities to limits. Implied volatility and returns around limit events can inform whether these key quantities are affected by limits. If limits dampen speculation, implied volatility likely decreases and returns reverse after limit events. If limits slow down price discovery, implied volatility should not change and returns continue after limit events.

Put-call parity (Black, 1976) can be used to relate the price of options and futures. The authors compute the option-implied futures prices using put-call parity. They run Mincer and Zarnowitz (1969) forecasting regressions - forecasting subsequent futures prices using option-implied prices. The regressions are done in return space to avoid spurious relationships from regressing one price on another.

Results

The authors find that limits do not appear to curb speculation. The CFTC positions data provide direct evidence against reduced speculation after price limits: non-commercial traders do not change their long positions following limit up events. Instead, they reduce their short positions, which lead to an increase in their *net* long positions. Following limit down events, non-commercials do not change their short positions and they reduce their long positions, resulting in an increase of net short positions. In both instances, net positions increase in the direction of the limit, thereby amplifying the speculative pressure.

There is little evidence that limit events are the result of speculative activity. Elevated volatility around limit events does not appear to be associated with higher speculation, as the change in non-commercial positions does not lead to limits. Long and short positions of non-commercials do not materially change before limits happen. High price volatility appears to be related to low levels of physical inventories. Just before limit events, the front end of the futures curve is often in steep backwardation, reflecting low inventories (Deaton and Laroque, 1992). These results suggest limit events are mostly driven by fundamental rather than speculative volatility. A further implication of these results is that price limits prevent futures prices from fully reflecting information when large shocks to fundamentals occur - a time when price efficiency arguably matters the most.

Price discovery in futures markets partially migrates to options markets when price limits are hit. A comparison of option-implied futures at the time of limit events with subsequent prices when trading reopens in the underlying futures markets shows that option-implied futures prices are biased but informative predictors of subsequent futures prices. A 1% increase in the return calculated from the limit-day closing price to the option-implied price is associated with a 0.80% increase in the close-to-open futures returns. Furthermore, the open interest in options markets increases relative to the open interest in futures market after limit events, adding to the evidence that price discovery moves from the futures to the options markets.

Conclusion

The historical justification for the existence of price limits is to curb speculation. The authors re-examine the role of price limits by studying trader positions and price behavior around limit events for 12 commodities over a 25-year period. They offer three main findings. First, limits do not appear to be effective in reducing speculative trading behavior. Second, price limits are mostly driven by elevated fundamental volatility, rather than speculation. Third, price limits hamper price discovery. Normal price discovery in futures markets moves to options markets following price limits.

These findings are important for both policymakers and market participants in commodity futures markets. Policymakers may incorporate the findings for their own thinking when designing future policies, whereas market participants could use these ideas to refine their trading.

Endnotes

The views expressed herein are those of the individual authors and do not necessarily reflect official positions of SummerHaven Investment Management, LLC (“SummerHaven”) or Paraconic Technologies US Inc. (“Paraconic”) nor are the views endorsed by SummerHaven or Paraconic. This paper is not an offer to sell, or a solicitation of an offer to buy any investment product or services offered by SummerHaven or Paraconic. Neither SummerHaven nor Paraconic guarantee the accuracy or completeness of the information contained herein and any information provided by third parties has not been independently verified by SummerHaven or Paraconic.

Dr. Qiao is a member of the Editorial Advisory Board of the *Global Commodities Applied Research Digest*.

Dr. Qiao’s co-author, Professor K. Geert Rouwenhorst, presented a version of this paper at the JPMCC’s 2nd International Commodities Symposium during the “Commodity Futures Trading and Regulation” session on August 14, 2018. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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Keywords

Commodity futures, price limits, speculation, commodity options, circuit breakers, speculative trading.

How to (Potentially) Weather the Storm in Risk Premia Strategies in the Commodity Markets

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Ms. Hilary Till, the Contributing Editor of the *Global Commodities Applied Research Digest* (*GCARD*), presenting on a futures industry case study in Chicago.

A 2018 *Financial Times* article described how commodity risk premia strategies had caused a "boom in trading volumes on exchanges" with estimates of $60 to $80 billion eventually going into these types of strategies (Meyer, 2018). With "risk premia strategies[,] investors systematically place bets based on so-called factors such as momentum, volatility and the pattern of prices for future delivery," explained Meyer (2018).

In this article, we describe risk premia strategies more broadly and note how commodity risk premia strategies are an extension of ideas that originated in the equity markets. We then cover various techniques which attempt to minimize the inevitable losses that can arise from such strategies. Lastly, we conclude with several hypotheses on why commodity risk premia strategies have historically earned high average returns; we do so by identifying the risk exposures that investors are taking on and for which they need to be compensated.

Introduction to Risk Premia Strategies and Factor Investing

In risk premia strategies, an investor or speculator takes on an exposure that other market participants would prefer to lay off and from which an investor earns a return not conditioned on manager skill. These strategies involve the risk of loss and/or underperformance. The underlying idea is that some investors can achieve extra returns by in effect selling insurance to other investors (Cochrane, 1999). One does not classify these strategies as being due to market inefficiencies.

Risk premia strategies can also be referred to as factor investing. As noted by Hixon *et al.* (2018), this type of investing "has become mainstream, but most approaches still focus on equities." Further, "these strategies are all derived from the same idea: go long (or overweight) assets with high values in a particular metric and short (or underweight) assets with low values in the same metric," explain Hixon *et al.* (2018). Researchers also attempt to identify what particular risk is being taken on which allows structural returns for these strategies. So for example, an investor who systematically buys stocks based on value considerations and sells stocks based on growth considerations would be taking on business cycle risk that most investors would desire to avoid since their jobs would also be at risk then (Cochrane, 1999).

There is now a burgeoning body of academic and practitioner research on applying factor investing to commodities, along with attempting to identify the specific risk factor that may give rise to a strategy's backtested returns.

We will now consider how to weather the storm during the inevitable losses that occur in commodity risk premia strategies.

Fundamental Analysis

A modicum of fundamental knowledge on commodity markets is advisable when employing commodity risk premia strategies. In all commodity markets, the key fundamental variable is the storage or inventory situation. The existence of storage can act as a dampener on price volatility since it provides an additional lever with which to balance supply and demand. If there is too much of a commodity relative to demand, it can be stored. In that case, one does not need to rely solely on the adjustment of price to encourage the placement of the commodity. If too little of a commodity is produced, one can draw on storage; price does not need to ration demand.

But when inventories for a commodity become quite tight, the price can become "non-linear" since in the absence of adequate inventories only price can balance supply and demand. After all, one cannot draw from inventories that do not exist. In treatments of the economics of price volatility, one typically sees that at low levels of inventories, a commodity's price can become exponentially large at ever lower levels of inventory.

Arguably, incorporating fundamental knowledge of the commodity markets can help in mitigating potential losses in commodity risk premia strategies. Till (2019b) advocated this position in noting that an examination of the prevailing natural gas inventory situation could have helped OptionSellers.com avoid its catastrophic blow-up in November 2018.

In crude oil, a further fundamental variable besides above-ground inventory is the level of excess spare capacity. Spare capacity is the volume of production that can be brought on within 30 days and sustained for at least 90 days. OPEC spare capacity has historically provided an indicator of the world oil market's ability to respond to potential crises that reduce oil supplies.

There are times when OPEC spare capacity is the most important factor for driving oil prices. When above-ground inventory levels are sufficient, the cushion provided by OPEC spare capacity does not become material. But at sufficiently low levels of inventory, an examination of data over the last 20 years shows that the amount of OPEC spare capacity becomes crucial (Till, 2016). In the absence of being able to draw on inventories *or* exploit surplus capacity, price is the only lever that can balance supply-and-demand in such a scenario.

With both natural gas and corn, being aware of the timing of potential adverse weather events is also crucial, as noted in Till (2019a). Natural gas positions can be strongly impacted by potential heat waves, hurricanes, and cold shocks, especially if the cold shocks occur during the end of winter when inventories are drawn down. The advantage of being a commodity trader, unlike a commercial market participant, is that one does not have to always have a position on. One can decide which pitches to swing at. For certain structural trades in the natural gas markets, one can choose to not include these trades during times of potentially extreme weather.

The advantage of trading corn over natural gas is that one has a much longer dataset with corn over which to run risk-management studies as compared to natural gas, which only started trading in 1990. July is a key time during corn's growing season that determines corn yields. Adverse weather then can have a large impact on corn prices. But over many decades of trading, one can see what the potential impact is and what trade constructions are robust to weather-related price spikes.

In summary, a grasp of key commodity market fundamentals should be included in the design of commodity risk premia strategies in order to mitigate potential losses.

Active Management of Risk Premia Strategies

There are a number of other decisions to incorporate in the design of commodity risk premia strategies. One must decide how much to leverage the strategy, how many reserves to set aside in the event of a catastrophic event, and whether to give up any returns by hedging out some of the strategy's extreme risks. These decisions all impact the ability of an investor to withstand a potential storm in returns in commodity risk premia strategies.

Tactical Allocation Based on Risk-Cheapness Metrics

As is done in tactical asset allocation, one can also use statistical rich-cheapness analyses in deciding which commodities to incorporate in a risk premia strategy.

In an International Monetary Fund working paper, Nozaki (2010) advised such an approach in order to avoid crash risk when carrying out a currency carry strategy. In a currency carry strategy, an investor takes "a short position in a currency with a low interest rate and a long position in a currency with a high interest rate," as explained by Nozaki (2010). The IMF researcher created a *fundamental valuation metric* for foreign currencies (relative to the U.S. dollar) based on (1) each country's "commodity-based terms of trade" and (2) each country's "relative GDP per capita relative to its trading partners." The author advocated a trading strategy of investing in the carry strategy unless the undervaluation or overvaluation of a foreign currency was beyond a threshold level. At that point, one would toggle into owning a currency based on the fundamental metric. Nozaki (2010) found that this strategy offered "some insurance against crash risk without sacrificing a high risk-adjusted average return achieved by the carry … strategy."

How might this idea apply to a commodity strategy?

In commodities, inventories matter and with crude oil, spare capacity matters. Specifically with crude oil, when spare capacity has been quite low, the market can be at risk to oil prices spiking higher, creating demand destruction, followed by the price of oil subsequently crashing. By toggling out of crude oil during pinch-point levels in spare capacity, the distribution of crude oil returns has historically been positively skewed rather than negatively skewed (Till, 2015).

Long-Only Programs: Diversification with Financial Assets

For an investor who is solely in long-only commodity strategies, that investor is taking on the risk of debt-deflationary spirals. And if the commodity strategy is heavily weighted to crude oil, then the investor is also at risk to the possibility of oil-market price-share wars. In both of these scenarios, only financial assets can diversify and dampen these risks.

In examining data since 1876, HSBC found that "[t]umbling oil prices … [have been] a bonanza for global stock markets, provided the chief cause has been a surge in crude supply rather than a collapse in economic demand," wrote Evans-Pritchard (2014). But if oil prices are undergoing a dramatic decline because of "the forces of global recession," this can overwhelm "the stimulus or 'tax cut' effect for consumers and non-oil companies of lower energy costs," summarized Evans-Pritchard (2014). Under that scenario, a Treasury hedge has been the most effective hedge for petroleum complex holdings.

Long-Short Strategies Can Potentially Hedge Out the Commodity Beta

Where long-short strategies are permissible, one can hedge out the commodity beta and therefore not need to diversify with financial assets. And one can potentially further limit drawdowns by diversifying across commodity factors that are implemented as long/short strategies.

Fernandez-Perez *et al.* (2017) discuss harvesting commodity styles by equally weighting them in a portfolio. The chosen styles had previously been found to be associated with high average returns when one formed portfolios based on high and low values of each style's metric. The authors' commodity styles included roll-yield, hedgers' net short positions, speculators' net long positions, momentum, value, and skewness, amongst others.

Their study was from 1992 to 2016. The annualized excess returns were about 8% with a drawdown of -17%. This drawdown figure is strikingly low, showing the potential of diversifying across commodity styles.

Tolerance for Fluctuations in Returns

In weathering the storm in commodity strategies, an investor may find it a challenge to be able to tolerate fluctuations in returns. Taleb (2001) explained why it is such a challenge for traders and investors to follow a disciplined investment process. He provides an example of a return-generating process that has annual returns in excess of T-bills of 15% with an annualized volatility of 10%. At first glance, one would think it should be trivial to stay with a strategy with such superior risk and return characteristics.

But Taleb (2001) also notes that with such a return-generating process, there would only be a 54% chance of making money on any given day. If the investor felt the pain of loss say 2.5 times more acutely than the joy of a gain, then it could be potentially exhausting to carry out this superior investment strategy.

Behavioral Challenges for Quantitative Funds

Risk premia strategies are betas (specifically, alternative betas and definitely not alphas.) In practice, the standalone strategies have experienced at best mid -20% drawdowns.

According to Wiggins (2019), "owning quant funds is not easy," which apparently was particularly the case in 2018. The author noted that there are specific behavioral challenges in holding a quant strategy, particularly when performance is poor. For example, one can never have complete certainty "why a particular factor has delivered a premium … [and one] can never be sure as to whether it will continue to work. … [V]alid factors can struggle for long spells and it is difficult … to decipher whether these are the result of a structural shift extinguishing the factor premium or a 'temporary' phenomenon."

In addition, "[e]ven a strategy with a high Sharpe ratio [that invests] … in proven factors is prone to experience drawdowns that can be multiples of long-term expected volatility," explained Wiggins (2019). The author therefore recommended that "investors … need to be aware of the distinct behavioral challenges that arise from owning systematic strategies and be prepared to manage them if they are to successfully invest in such strategies."

Economic Rationale for Returns

Given the behavioral challenges that arise from investing in quantitative strategies, investors need to be reasonably secure that a strategy has an economic rationale and therefore is not just an artifact of a lot of backtesting. The more confidence that an investor has that a factor is economically grounded, the more likely that investor should be able to stay with that investment during adverse times.

Some of the commodity factors that have been found to have high average returns and have a plausible economic story include momentum, basis or carry, negative skewness, and basis-momentum (Sakkas and Tessaromatis, 2018).

Momentum

Over many decades, momentum has worked across asset classes, including commodities. Hurst *et al.* (2012) noted that momentum's long-term profitability may be due to "long-standing behavioral biases exhibited by investors, such as anchoring and herding, as well as due to the trading activity of non-profit seeking participants such as central banks and corporate hedging programs."

Carry

With the basis or carry factor, one invests in portfolios of commodities based on the commodity futures curve shape. Gorton *et al.* (2013) showed that when the front-month price of a futures contract is at a premium to the deferred contract (which is known as backwardation), this is correlated to when the commodity has relatively low inventories. When the front-month price is at a discount to the deferred contract (which is known as contango), this is correlated to when the commodity has relatively high inventories. In the commodity carry strategy, one overweights backwardated commodity futures contracts and underweights commodity futures contracts that are in contango. According to Bakshi *et al.* (2019), this factor delivers low returns in periods when global equity volatility increases.

Negative Skewness

Regarding another commodity factor, portfolios sorted on overweighting negatively (or lowly skewed) commodities and underweighting positively (or more highly) skewed commodities have also done well, indicating that one should include skewness as an alternative risk factor, as shown by Fernandez-Perez *et al.* (2015). One possible explanation for this effect is that there is a preference for "lottery-like payoffs" (which depresses the returns of positively skewed commodities relative to commodities that have the opposite feature.)

Basis-Momentum

Recently Boons and Prado (2019) proposed a "basis-momentum" factor. Basis-momentum is measured as the difference between momentum in first- and second-nearby futures contracts. The authors found that returns to portfolios sorted on high values of this factor increased with aggregate commodity volatility. The authors inferred that times of heightened volatility would be when the market-clearing ability of speculators would become impaired and so speculators would have to at least partly resort to spread positions to manage risk taken on from commercial hedgers. During these times, speculators would have to be well-compensated to take on spread positions with the compensation needing to be even greater for taking on riskier outright positions.

The Drawdowns

A key reason for bringing up the explanations for why various commodity strategies may be earning risk premia is that when these strategies have drawdowns in the order of -20% to -30%, it may be easier for investors to remain with these strategies if they understand their return rationale along with the risks that they are assuming.

Conclusion

Meyer (2018) noted that inflows into commodity risk premia strategies have been even greater than those into commodity hedge funds. It remains to be seen how various newly discovered commodity risk factors will perform once documented, understood, and invested in. One advantage for commodity futures traders and researchers alike is that one can monitor the relative participation of commercials versus non-commercials through the U.S. Commodity Futures Trading Commission's (CFTC's) Commitments of Traders Reports. Why would these CFTC reports be useful? One can potentially use these reports to detect whether an imbalance of speculative capital emerges relative to commercial hedging needs, which could thereby have a dampening impact on returns of commodity risk premia strategies over time.

Endnotes

This article is based on the "Weathering the Storm in Risk Premia Strategies in the Commodity Markets" session at UBS' Risk Premia Conference, which was held at the New York Stock Exchange on February 4, 2019. The session's participants were the author and UBS' John Kowalik, who is also a member of the *GCARD*'s Editorial Advisory Board.

A version of this article was originally published as an EDHEC-Risk Institute Working Paper where the author is a Research Associate.

It should be added that this article is provided for educational purposes only and should not be construed as investment advice or an offer or solicitation to buy or sell securities or other financial instruments. The information contained in this article has been assembled from sources believed to be reliable, but is not guaranteed by the author. Any (inadvertent) errors and omissions are the responsibility of Ms. Till alone.

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Hilary Till is also a principal of Premia Research LLC, which designs investment indices that are calculated by S&P Dow Jones Indices. Prior to Premia, Ms. Till was the Chief of Derivatives Strategies at Putnam Investments where she oversaw the strategy development and execution of about $90 billion annually in exchange-traded and over-the-counter derivatives; and before Putnam, Ms. Till was a Quantitative Analyst at the Harvard Management Company, the university's endowment firm. Ms. Till's additional academic affiliations include her membership in the North American Advisory Board of the London School of Economics and her position as a Research Associate at the EDHEC-Risk Institute (France.)

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Ms. Till has presented her analyses of commodity futures markets to the following institutions: the U.S. Commodity Futures Trading Commission, the International Energy Agency, and to the (then) U.K. Financial Services Authority. She has been a panel member at both the U.S. Energy Information Administration's workshop on the "evolution of the petroleum market and [its] price dynamics" and the Bank of Canada's joint roundtable with the International Energy Forum on "commodity cycles and their implications." With Joseph Eagleeye, she is also the co-editor of the bestselling Risk Book (London), Intelligent Commodity Investing.

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Oil in the Long Term

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Executive Director, Head of Global Oil Market Research & Strategy, J.P. Morgan

Dr. Abhishek Deshpande, Ph.D., of J.P. Morgan, participated in an industry panel on the commodity markets at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019. This panel session was held in the university's CoBank Lecture Hall.

Introduction

- The global energy basket has diversified significantly since 2000 with oil and coal losing share to gas and renewables. In this article we argue that the factors relevant to oil prices in the long term are not just demand but also supply-side variables.

- According to the International Energy Agency's New Policies Scenario (NPS) the share of fossil fuel powered by demand growth will slow down as renewables penetrate the energy sector. A major structural shift is expected to emerge in the transportation sector where electricity is seen making headways as the Electric Vehicle (EV) market expands.

- According to our JPM models, oil demand would track IEA's NPS oil demand at a trend GDP growth within JPM Demand Estimates Case 1 scenario. In this scenario the demand does not peak until 2040. However, oil demand is expected to peak in the early 2020s and decline gradually thereafter in all other scenarios defined later in this article.

- Given the uncertainty around global oil balances in the long term, investors in general remain wary of investing in oil especially if returns are likely to be challenged by the peak demand theory, or low-cost shale production in the medium term, or oil producers shifting their extraction of resources ahead of any pre-announced climate-based policy implementation. Such negative sentiments in the industry, along with depressed deferred prices along the forward curve driven by U.S. shale supply, have inadvertently impacted investment decisions since 2014 and will likely continue to do so in the medium term. We argue that a lot of assumptions around demand growth and implementation of climate-based policies are untested.

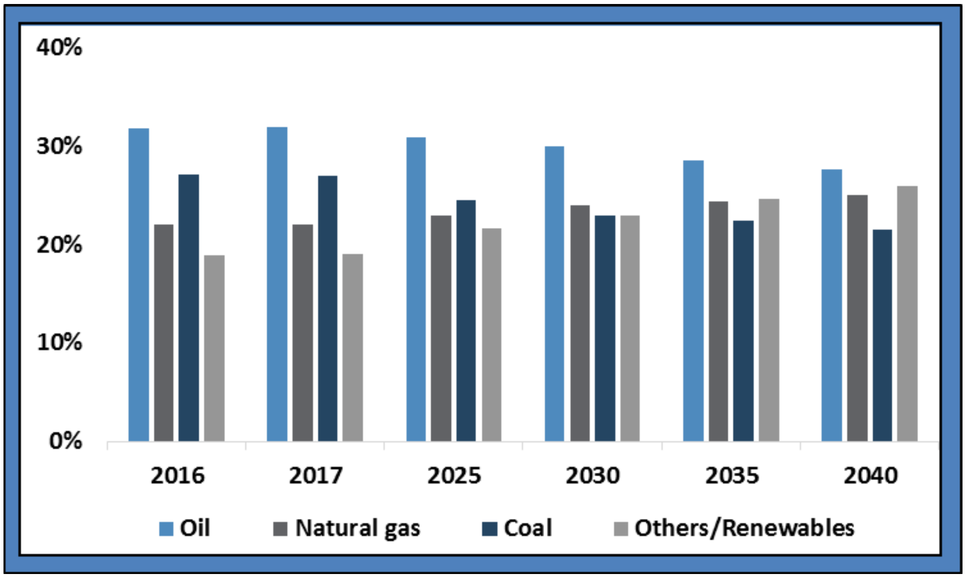
- Currently most Environmental, Social and Governance (ESG) and climate change investors are underweighting or completely avoiding investments in oil and coal. But given the lack of investments in the sector and demand for oil being driven predominantly by non-OECD economies where population growth is on the rise, oil as an asset class should end up providing positive returns and these investors could miss out on this opportunity. Additionally geopolitics will always be core to oil at least in the next decade.

The global energy basket has diversified since 2000 as the share of oil and coal declined whilst the share of natural gas and renewables rose. In this article we have tried to find the factors relevant to oil prices in the long term and argue it is not just demand but also supply-side factors that one needs to consider along with investor appetite for fossil fuels. We have constructed an optimization model to estimate what key swing producers, such as Saudi Arabia, need to consider when targeting oil price maximization. This is relevant from both investment decisions, but also from long-term price scenario perspectives.

Energy Diversification

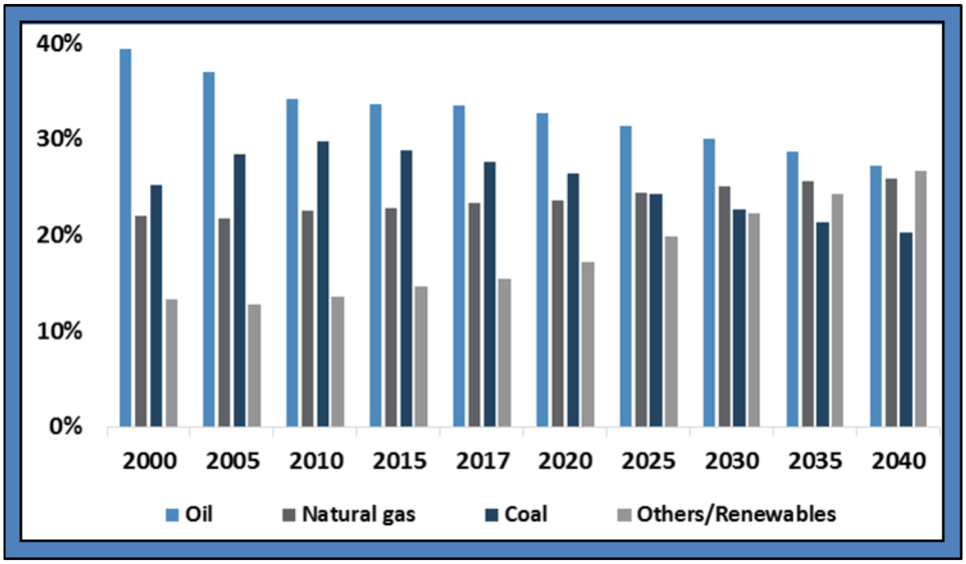
According to the International Energy Agency's New Policies Scenario (IEA NPS), the share of fossil fuel-powered demand growth will slow down as renewables penetrate the energy sector. A major structural shift is expected to emerge in the transportation sector where electricity is seen making headways as the electric vehicle (EV) market expands. Electricity consumption for transportation is expected to grow at a CAGR of 7.2% between 2017 and 2040 versus oil, at a CAGR of 0.6%. On the industry front which includes manufacturing facilities, while the outlook remains optimistic until 2025, its contribution falls after this point in time owing to a slowdown in Chinese demand as the Chinese economy sees a structural shift towards a more service-based economy. **While renewables take a larger share of the global energy basket in the future, the impacts of cleaner sources, along with energy efficiency, are already visible in the energy intensity of GDP, which has come down by a third between 1990 and 2015.** It is expected to continue declining in the future as noted by the IEA in its latest World Energy Outlook (WEO) 2018.

Figure 1
IEA NPS Energy Basket Diversification (2000-2040)



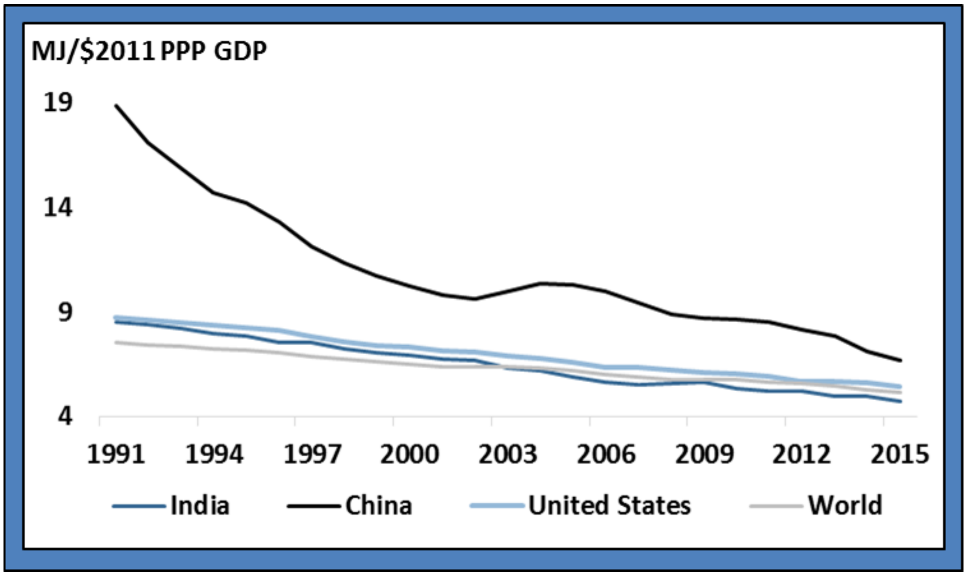
Sources: J.P. Morgan Commodities Research, IEA WEO 2018.

Figure 2
BP Energy Basket Diversification (2000-2040)



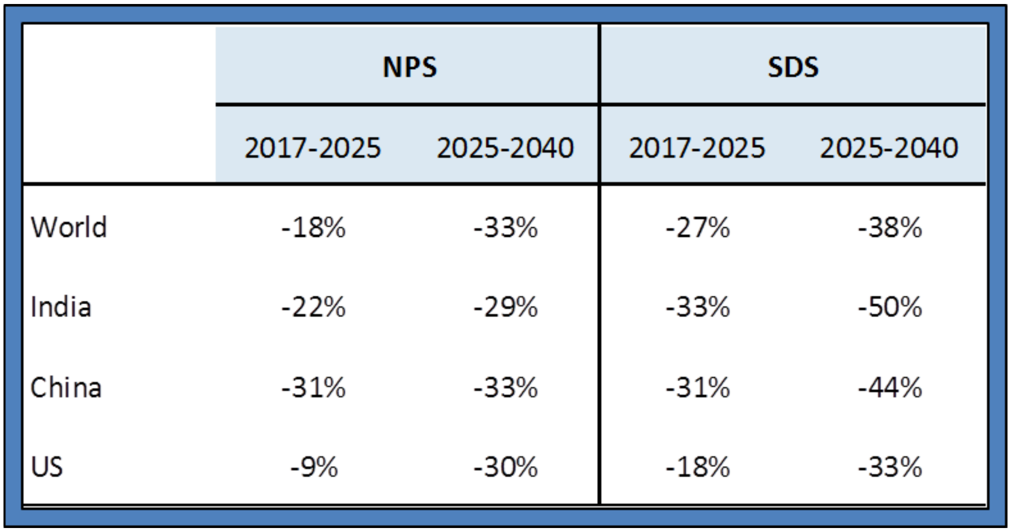
Sources: J.P. Morgan Commodities Research, BP.

Figure 3
Energy Intensity



Sources: J.P. Morgan Commodities Research, World Bank.

Table 1
IEA Change in Energy Intensity under NPS and SDS Scenarios (% change)



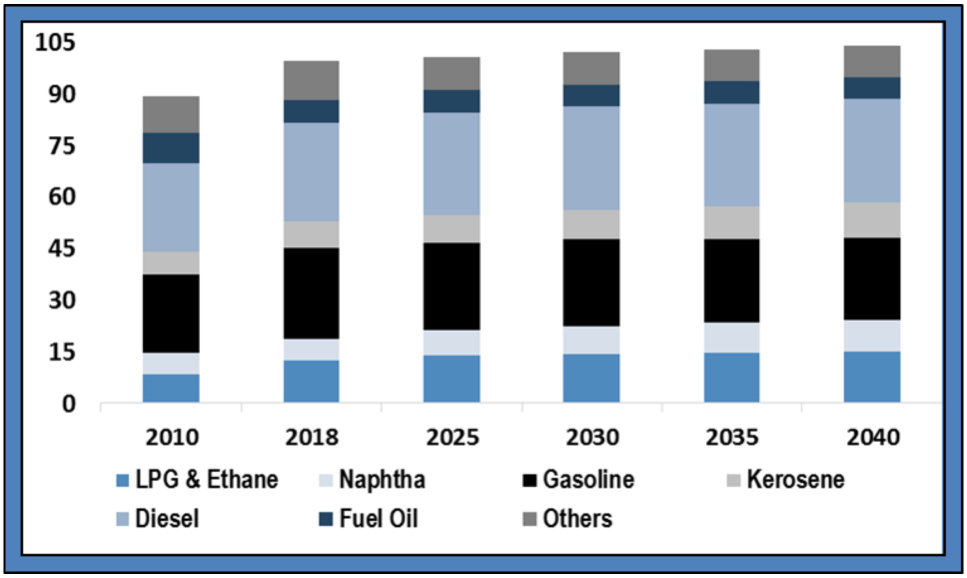
	NPS		SDS	
	2017-2025	2025-2040	2017-2025	2025-2040
World	-18%	-33%	-27%	-38%
India	-22%	-29%	-33%	-50%
China	-31%	-33%	-31%	-44%
US	-9%	-30%	-18%	-33%

Sources: J.P. Morgan Commodities Research, IEA.
NPS = New Policies Scenario
SDS = Sustainable Development Scenario

Oil Products Demand

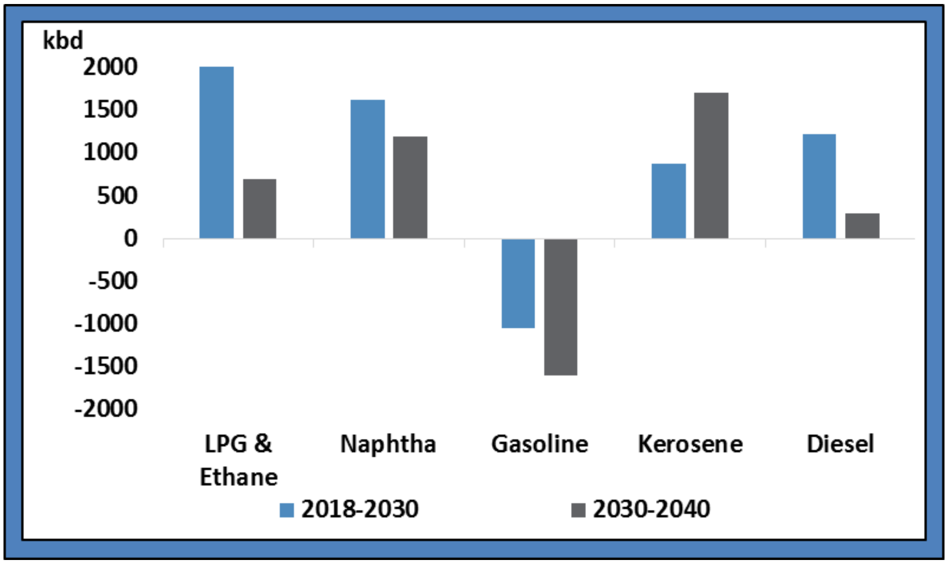
Oil products demand has changed significantly since 2010 with growth dominated by light ends such as gasoline and liquefied petroleum gas (LPG) including ethane and diesel. **Total oil demand has increased by 1.2 mbd per annum on average between 1990 and 2018 and by 1.3 mbd per annum between 2010 and 2018.** However, with the advent of EVs and technological efficiencies, the demand for gasoline is expected to drop by 2.6 mbd between 2018 and 2040 according to the IEA. Fuel oil demand, which has weakened since 2010, is also expected to drop further by 0.4 mbd by 2040 from 2018. The implementation of a global limit on sulphur in bunker fuel by the International Maritime Organization beginning on 1 Jan 2020 (IMO2020) is one of the main drivers for this expected decline alongside the substitution of fuel oil for power generation. IEA predicts that the largest increment in demand will be in naphtha and LPG, including ethane. These products are mainly used in the petrochemical sector. Jet kerosene is another product that will substantially increase in demand. Additionally, energy efficiency will be a strong driver for lower demand for products in energy-intensive industries.

Figure 4
IEA NPS Oil Products Demand 2010-2040



Sources: J.P. Morgan Commodities Research, IEA WEO 2018.

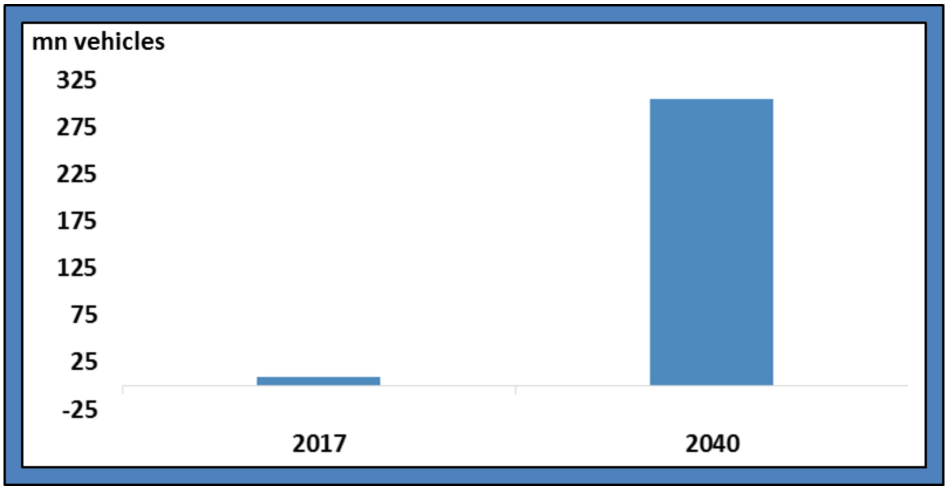
Figure 5
Oil Products Demand Change



Sources: J.P. Morgan Commodities Research, IEA WEO 2018.

The growth in demand for oil is being hotly debated at present as alternate energy sources and EVs pose a threat to the demand for the commodity in the future. **Today there are ~1.1 billion cars on the road globally, nearly all fueled by oil. Electric cars account for just 1% of current annual car sales.** Under the IEA's NPS, the global car fleet expands by 80% by 2040. **Yet global oil demand for passenger cars barely changes, from 21.4 mbd today to just over 23 mbd in the late 2020s and ending just above today's level by 2040.**

Figure 6
Global Electric Vehicle Fleet



Sources: J.P. Morgan Commodities Research, IEA.

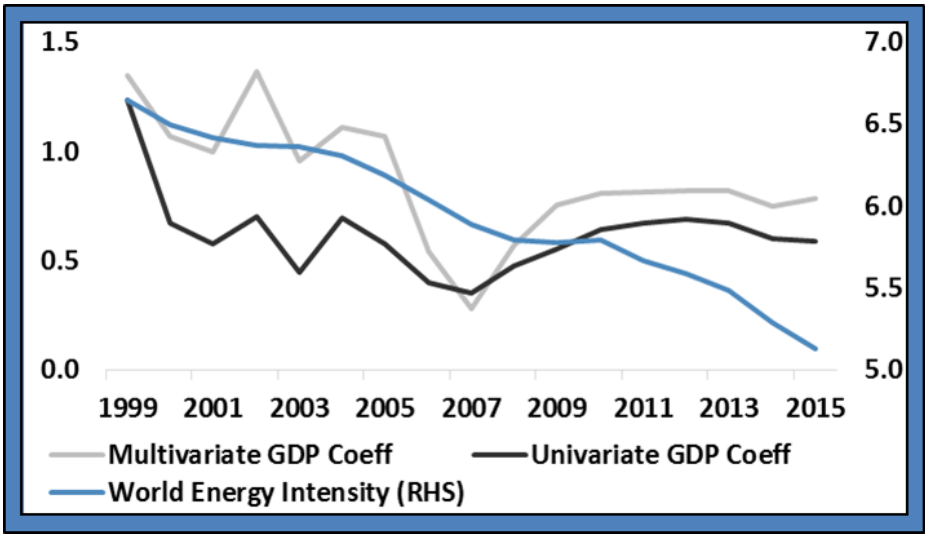
Modeling Different Scenarios for Oil Demand

IEA has identified multiple scenarios that shape the diversification of our energy requirements. The New Policies Scenario takes into account targets announced by countries as of mid-2018 and the commitments made in the Nationally Determined Contributions under the Paris Climate Agreement, setting energy-related CO2 emissions on a slow upward trend to 2040. Under its NPS, IEA expects electricity, renewables, and efficiency gains to cap the growth in coal consumption. The policy assumes demand growth in oil to come predominantly from petrochemicals, trucks, planes and ships and that would more than offset the decline in oil demand from cars, which is expected to peak in the mid-2020s.

The Sustainable Development Scenario (SDS) of the IEA is aimed at delivering on the Paris Agreement. The Paris Agreement's aim is to limit the increase in global average temperatures to "well below 2°C above pre-industrial levels." To achieve these set climate goals, SDS assumes the use of low-carbon technologies to change global energy consumption patterns. This scenario hinges on renewable energy technologies.

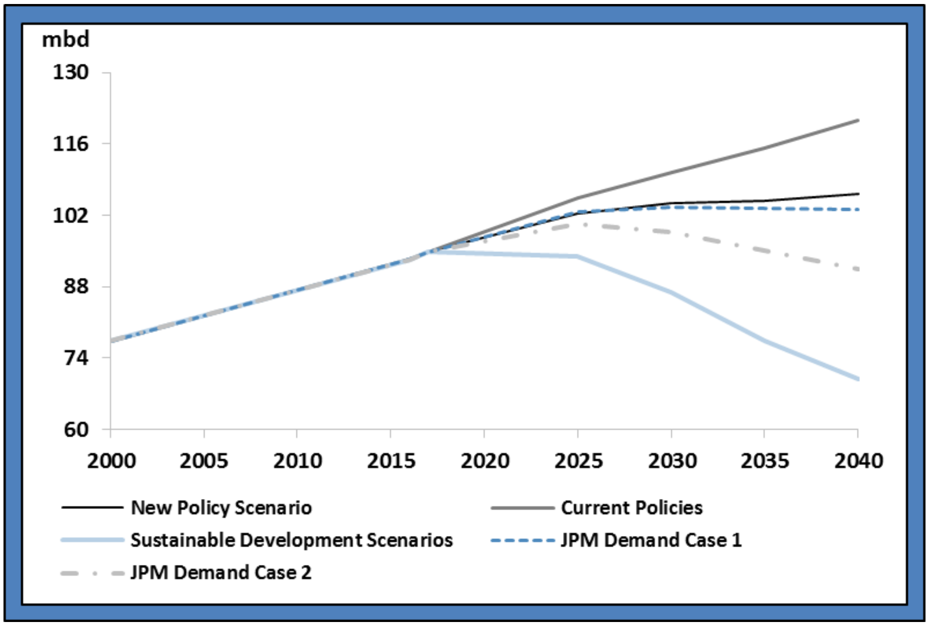
Figure 7

World Energy Intensity versus GDP Coefficient in Multivariate and Univariate JPM Demand Models



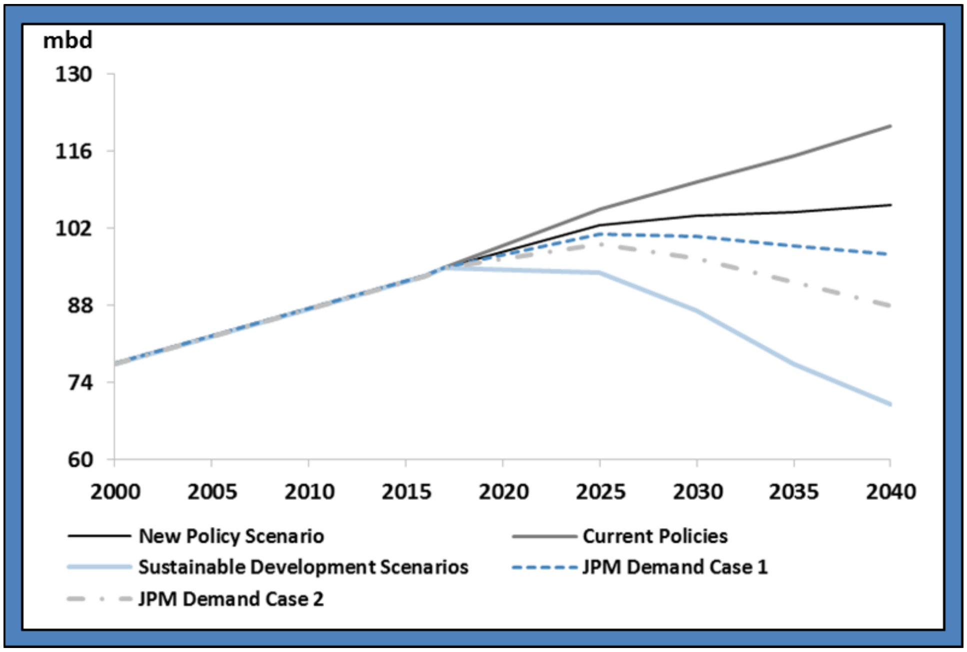
Sources: J.P. Morgan Commodities Research, World Bank.

Figure 8
Global Oil Demand - JPM Estimates with Trend GDP Growth



Sources: J.P. Morgan Commodities Research, IEA.

Figure 9
Global Oil Demand - JPM Estimates with Below Trend GDP Growth



Sources: J.P. Morgan Commodities Research, IEA.

In addition to the two scenarios above we have also plotted IEA's current policy scenario which acts as a yardstick for comparison purposes as it assumes no change in policies from 2018 leading to an increased strain on demand for all forms of energy and a major rise in energy-related CO2 emissions. We have also modeled J.P. Morgan scenarios for oil demand growth at trend global GDP growth of 2.4% and below-trend global GDP growth of 2% owing to structural shifts in the Chinese economy.

The GDP coefficient in our demand model averages 0.84 for the period 2011-2018, with the 2018 coefficient being 0.89.

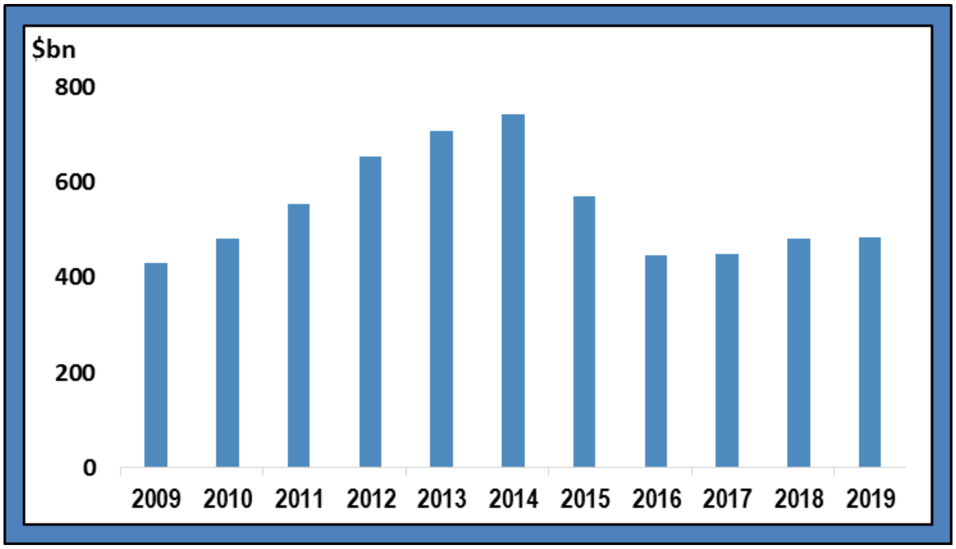
JPM Demand Estimates Case 1: We fixed the coefficients at 0.8 and 0.7 for 2021-2030 and 2031-2040, respectively, as we assumed limited energy intensity (as a function of GDP elasticity) change and the continuation of present demand conditions in the future.

JPM Demand Estimates Case 2: We assumed the GDP coefficient to be 0.6 for the period 2021-2030 and 0.4 for 2031-2040 for both trend and below trend GDP growth rate. This scenario implies a larger impact from climate policy and energy efficiency on the energy intensity of GDP.

According to our models, oil demand would track IEA's NPS oil demand under a trend growth scenario within JPM Demand Estimates Case 1. In this scenario, the demand does not peak until 2040. However, oil demand is expected to peak in the early 2020s and decline gradually thereafter under the below-trend growth scenario for JPM Demand Estimates Case 1 and for both trend as well as below-trend scenarios for JPM Demand Estimates Case 2. In the absence of another commodities super cycle, we expect demand growth to peak early as the Chinese economy slows structurally and energy efficiency improves at a faster pace during 2030-40 versus in 2020-30. The continued decline in the energy intensity of GDP, diversification towards EVs, and other sources of energy will put significant pressure on oil products demand growth.

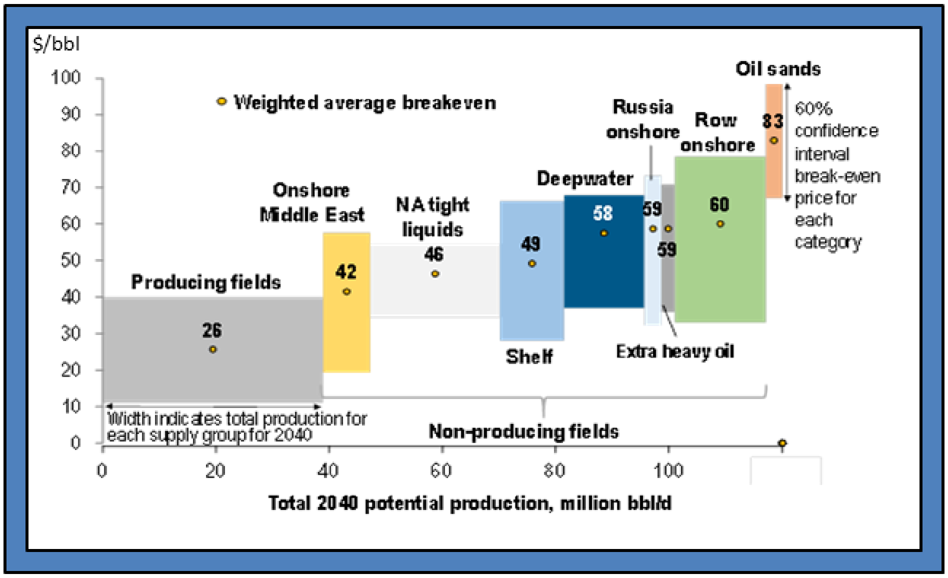
While there is still great uncertainty around the rate of slowdown in demand growth and which of the JPM or IEA scenarios listed above will materialize in the future, this uncertainty in the industry has kept investments in the sector in check as noted in global oil and gas (O&G) capex since 2014. One could argue that lower investments are partly driven by lower costs as costs have come down especially with technological advancement in the O&G sector in the aftermath of the oil price collapse that was led by U.S. shale resurgence. However the lack of clear direction for demand growth in the future and price elasticity of supply, especially supported by the short investment cycle in U.S. shale, has disincentivized producers globally to invest significantly in deep offshore development unlike in the past. A larger proportion of spending in non-OPEC continues to be dominated by the investment in the U.S. This was raised several times by producers, especially OPEC members, in the past couple of years as an upside risk to oil prices; however, such a risk has yet to materialize, and oil prices have found a new cap from U.S. shale in the near term and floor from OPEC+ actions in Dec 2016. It is becoming increasingly important for OPEC to work closely alongside their non-OPEC partners as it tries to help rebalance the markets that have remained imbalanced for the last five years largely due to supply-side issues. Looking ahead, the key question is how do oil-producing countries, especially those with high fiscal break-evens but low operating costs, try to maximize profits in a scenario where there is a potential risk not only to demand growth but also to supply growth (both to the upside and downside).

Figure 10
Global Oil and Gas Upstream Capex



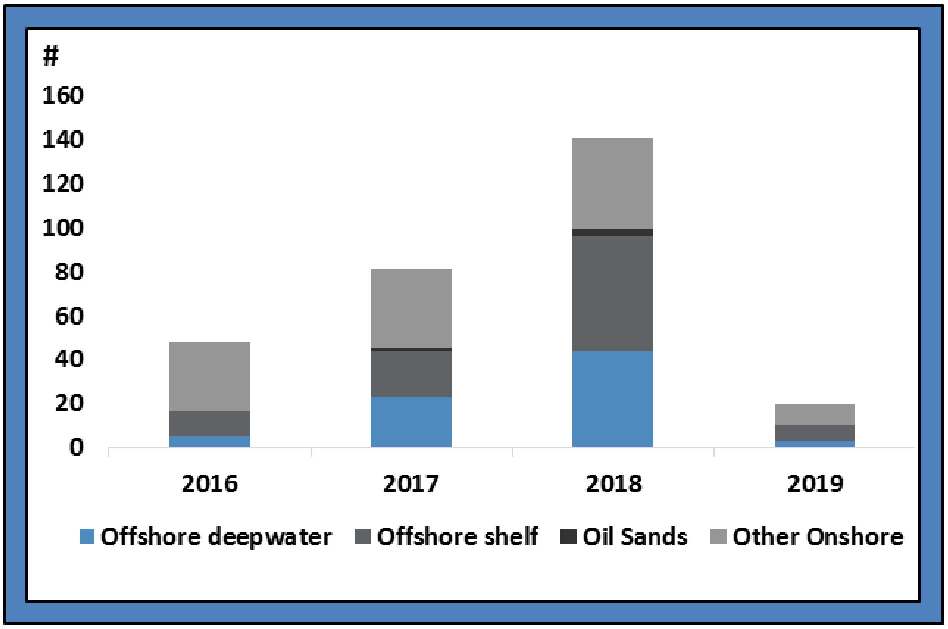
Sources: J.P. Morgan Commodities Research, Rystad Energy.

Figure 11
Real Brent Break-Even Price



Sources: J.P. Morgan Commodities Research, Rystad Energy.

Figure 12
Total Final Investment Decisions (FIDs)



Sources: J.P. Morgan Commodities Research, Rystad Energy.

Optimization of Oil Price and Demand for Profit Maximization: Saudi Arabia

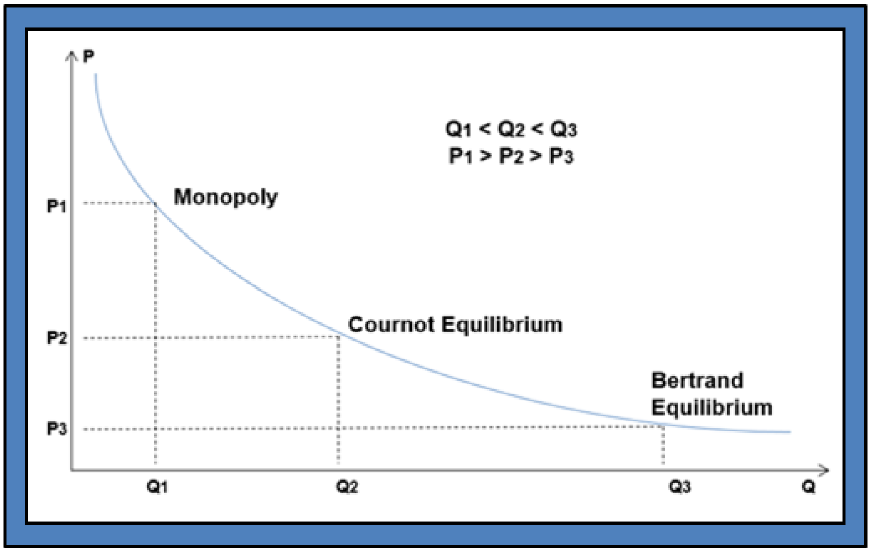
Producers such as Saudi Arabia are caught between a rock and a hard place when it comes to risk of oil demand from technology and alternate energy sources and also price elasticity of supply from short-term investment cycles. A model to optimize price would be prudent especially over a longer timeframe if it wants to maximize profits.

Cournot versus Bertrand Theory of Market Competition

In a typical monopoly, the sellers of oil would benefit from their strong and unique position in the market. Impediments such as high costs to new entrants give them the highest possible price to meet demand. However with OPEC, which is essentially acting as an oligopoly, producers need to also take into account the decisions and actions of their competition outside of the cartel when making pricing decisions. There are two basic models in the formal study of oligopoly: Cournot and Bertrand. In **Cournot analysis**, market demand equals the total amount on offer with an assumption that sales are determined by the firm whereas the price is arrived at by some unspecified factor. In **Bertrand analysis**, firms have a responsibility to meet customer demand after a firm determines the price at which it sells its output. (See Judd (1996).)

Bertrand theory of price competition would argue for potentially larger volumes sold at a given price (lower than the Cournot model), a price which would disincentivize EV transition or shale supply growth. However that is not a given as the transition to EV is not just driven by price but also by consumer spending trends and preferences. Additionally, shale production is also a function of technology. Essentially one could suggest a Cournot model for pricing would be an ideal solution for Saudi Arabia, which means that the Kingdom continues to stay in the cartel to maximize its profits and address the risks from marginal producers outside of OPEC. However, this is likely to work for the next 10 years (assumption). After this 10-year period, it may not be correct to assume if the Cournot model will still work as producers may want to maximize their production to increase resource utilization if we were to reach a peak demand scenario or a demand slowdown scenario causing markets to move from a Cournot to Bertrand model in the next two decades.

Figure 13
Cournot and Bertrand Equilibrium



Source: J.P. Morgan Commodities Research.

In the model below we have tried to assess the optimum price for Saudi Arabia in the long term. While the model is price-driven to meet a given demand in the market, it assumes OPEC and its non-OPEC partners will work together to address the issue of threat from demand decay, as well as supply from unconventional sources.

Oil Price Maximization

$$\max_{wrt\,\{P_t\}} \pi = \sum_{t=1}^{50} (P_t Q_t - cQ_t)$$

P_t is price at time *t* and c is cost, Q_t is demand for Saudi oil

1.)
$Q_t = w_t \widetilde{Q_t}$; where $\widetilde{Q_t}$ is global oil demand

2.)
$\widetilde{Q_t} = g(EV, P);\ g_1 < 0\ ;\ g_2 < 0\ ;$
EV: Electric Vehicles

3.)
$EV = h(P);\ h_1 > 0$

Combining 2 and 3:

4.)
$\widetilde{Q_t} = g(h(P), P);\ \frac{dQ}{dP} < \frac{dQ}{dP}_{EV}\ ;$

5.)
$w_t = f(US\ shale,\ RoW\ supply); U.S. shale\ supply\ and$ *Rest of World (RoW) Supply*

5. a.)
U.S. shale = $k(P); k_1 > 0$

5.b.)
RoW supply = $r(P); r_1 > 0$

Combining 5, 5.a and 5.b

6.)
$w_t = f\big(k(P), r(P)\big) = \check{f}(P);\ \frac{dw}{dP} < \frac{dw}{dP}_{US\ shale} < 0$

Combining 1, 4 and 6

7.)
$Q_t = f\big(k(P), r(P)\big)g(h(P), P) = \tau(P)$

$\frac{dQ}{dP} < 0$

$$\max_{wrt\ \{P_t\}} \pi = \sum_{t=1}^{50} \left(\frac{P_t Q_t}{(1+\gamma)^t} - \frac{\mathrm{c}Q_t}{(1+\gamma)^t}\right)$$

OR

$$\max_{wrt\ \{P_t\}} \pi = \sum_{t=1}^{50} \left(\frac{(P_t - \mathrm{c})Q_t}{(1+\gamma)^t}\right)$$

OR

$$\max_{wrt\,\{P_t\}} \pi = \sum_{t=1}^{50}\left(\frac{(P_t - \mathrm{c})f\big(k(P), r(P)\big)g(h(P), P)}{(1+\gamma)^t}\right)$$

Hotelling's Rule and Green Paradox

A paper by Jensen *et al.* (2015) discusses the unintended consequences of climate policies. **The authors suggest that the green paradox arises due to the supply response from fossil fuel producers/resource owners due to climate policies such as carbon taxes. It tends to increase emissions for a short period of time.** Given the economic scarcity of fossil fuels, the price they command tends to be higher than the cost of extraction. Hence according to Hotelling's rule, the price net of marginal cost must rise at the rate of interest in non-renewable resource markets. However, the climate change externality invalidates the simple Hotelling's rule. In order to account for carbon costs, owners of non-renewable resources would bring forward their extraction of resources in a pre-announced global carbon tax.

Investor Paradox

Long-term investors remain wary of investing in oil especially if returns are likely to be challenged by the peak demand theory, or low-cost shale production in the medium term, or oil producers shifting their extraction of resources ahead of any pre-announced climate-based policy implementation. Such negative sentiments in the industry, along with depressed deferred prices along the forward curve driven by U.S. shale supply, have inadvertently impacted investment decisions since 2014 and will continue to do so in the medium term. We argue that the assumption of demand peaking due to energy efficiency and energy basket diversification from emerging economies is untested, and even if the eventual direction of the industry towards a low-carbon economy is assumed to be true, the jury is still out on the timing of such a change. It is precisely due to this uncertainty, the path towards higher volatility in oil prices is far more certain than the change in oil prices in the medium to long term. We also need to take note of the success rate of fully implementing climate-based policies around the world in the foreseeable future and the potential for another commodities super cycle led by other emerging economies such as India.

Currently most Environmental, Social and Governance (ESG) and climate change investors are underweighting or completely avoiding investments in oil and coal. But given the lack of investment in the sector and demand for oil being driven predominantly by non-OECD economies where population growth is on the rise, oil as an asset class should end up providing positive returns and these investors could miss out on this opportunity. Additionally geopolitics will always be core to oil at least in the next decade. The same may not be true for coal due to the abundance of natural gas and renewables to replace coal in the power sector. Finally, to quote the Red Queen (oil) to Alice (renewables) from *Alice in Wonderland*, "Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

Endnote

Dr. Deshpande presented on related topics at the JPMCC's 3rd Annual International Commodities Symposium on August 12, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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Will the U.S. Become the Home of LNG Price Formation?

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The nature of price formation in the global liquefied natural gas (LNG) market is increasingly the subject of both industry and academic attention. As the market shows greater appetite to gradually transition from oil indexation towards gas-to-gas pricing, many alternative price references have emerged as regional price signals reflecting respective markets; the question remains as to which region or market among the three – Europe, Asia, or the U.S. – is best positioned to host the core price-discovery benchmark.

This article examines how a new U.S. business model is moving the LNG market toward greater competitiveness and efficiency by transforming the anatomy of LNG trading transactions, also referred to as the market microstructure. This has positioned the U.S. to be the most likely anchor for price formation for the global LNG market.

Price formation in the LNG market is a complex process as the landscape is still evolving. Building a benchmark for LNG depends on the well-functioning, competitiveness, and efficiency of three endogenous and exogenous factors: supply chain, sound delivery system/infrastructure relevance, and market participation.

U.S. LNG developers are innovating in their contractual arrangements and project structuring. This has given birth to a new U.S. institutional model founded around three pillars: volume flexibility, destination optionality, and market competitiveness.

U.S. LNG Supply Chain

The current natural gas supply level has positioned the U.S. among the world’s top gas producers. This has considerably reduced the marginal cost of producing LNG and has substantially lowered the price of an LNG cargo. Additionally, U.S. output is produced through new supply chain models. The commercial structure of the supply chain of an LNG project is very important in understanding the LNG market because it defines the return and risk allocation among the investors or stakeholders at each link of the chain.

LNG projects are capital intensive investments that require financing typically through forming joint ventures or partnerships. The decision to adopt any project structure depends on a confluence of various considerations including legal, fiscal, financing, commercial, and the risk appetite of participants. U.S. LNG developers have adopted innovative business models and novel contractual clauses to enhance flexibility and competitiveness.

1. Traditional Integrated Market Structure

LNG project structures have traditionally relied on a vertically-integrated model centered around ownership concentration. As such, project owners control assets throughout the supply chain: from upstream resources, the liquefaction plants, to sometimes even the shipping element. Project developers share costs and revenues across the supply chain and hold the title of the natural gas from the wellhead to the sale of the LNG.

This integrated market structure is based on long-term rigid agreements known as LNG sale and purchase agreements (SPAs), which typically contain destination restrictions that ensure that a specific gas volume is liquefied and shipped to a specific market via commercial transactions with long-term buyers such as utilities or gas companies. While this point-to-point chain offers the buyer reliability of delivered volumes and secures the seller a constant cash-flow stream, this design is solely for supply security and is consumption driven. This model does not enable suppliers or buyers to capture any arbitrage opportunity as the market price moves.

2. U.S. Merchant Market Structure

Under the merchant market structure, a project developer owns the liquefaction facility and procures feedstock gas from producers via natural gas sales agreements at market prices. The merchant then liquefies the gas into LNG and subsequently sells it to different off-takers including portfolio players (aggregators), utilities, and others under LNG SPAs. This business model is driven by a series of arm's length transactions that aim to capture any potential gain based on the competitiveness of the spread between the input (gas) and the output (LNG).

3. U.S. Tolling Model

Under the U.S. tolling model, the liquefaction plant does not take title of the LNG. Instead, it processes feedstock gas supplied by the LNG buyer/off-taker for a tolling fee based on a negotiated rate. This is analogous to the role of the natural gas pipeline which does not own gas but provides transportation services to shippers. Among the benefits of this project structure is the flexibility and diversity in ownership throughout the supply chain. The LNG plant operator is not tied to any particular upstream source and marketer.

Under both market frameworks, each component of the supply chain operates independently and efficiently through competitive market offerings. In addition, the ownership structure is also diverse.

4. Equity or Tellurian Market Model

This market model was recently introduced by two main project developers: Tellurian and LNG Canada in 2018. This structure offers the buyer an equity stake in the project (e.g., 65-70% in the case of Tellurian) with its integrated components: upstream equity gas, through liquefaction to shipping, marketing and trading. This project structure looks at return and risk across the supply chain instead of looking at each chain link separately. LNG buyers buy equity and receive LNG in proportion to their ownership stake. Designing such a novel model was an attempt to attract investors with equity ownership to secure financing in a low-priced environment that currently favors the buyer.

Volumetric Flexibility & Destination Optionality

The U.S. model fundamentally relies on volumetric and destination optionality, which is the cornerstone of spot trading. The U.S. SPA is based on an enhanced version of the take-or-pay (ToP) contract structure. This contract construct stipulates that the buyer is contracted to lift an annual quantity called the "annual contract quantity" or "ACQ" at a pre-determined price or else to pay any shortfalls. With enough advance notice – usually two months – the ACQ is subject to downward/upward adjustment rights or cancellation rights that can be exercised by the buyer based on global seasonal demand. The contract structure of SPAs offers flexibility to both the buyer and the seller. The buyer has the optionality to lift LNG or not, depending on current demand, without breaching any contractual obligations. The seller will collect cash flows either as LNG sale proceeds or as cancellation fees, irrespective of whether the buyer takes delivery of LNG or not. The embedded destination flexibility of U.S. SPAs allows cargoes to be redirected where it is economically favorable depending on spot price signals. This means they can be sold multiple times before they are lifted from the terminal. These factors have contributed to the rise of LNG spot trading and created new permutations between buyers and sellers.

New Developments of LNG Cargo Trading

1. Rise of Portfolio Optimization

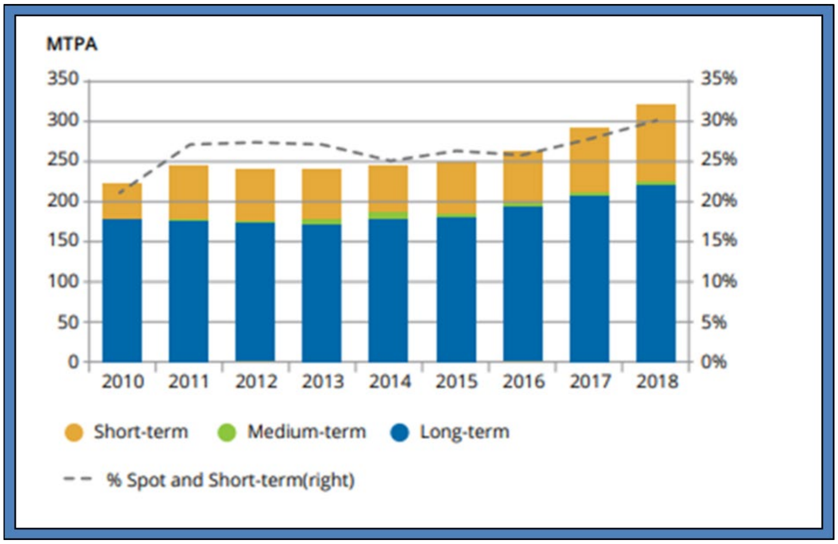
Significant volumes of contracted U.S. LNG are owned by portfolio optimizers. These aggregators are generally large energy companies such as Shell, BP, and Total, which own upstream assets or capacity and have long term off-take agreements. These aggregators are driven by margin optimization and act as market makers. They engage in short-term trading to capture price arbitrages using sophisticated strategies like buying cargoes on term contracts and selling on a spot basis or vice versa. LNG portfolio optimizers play a key role in reshaping the microstructure of LNG trade as they act as market makers. Their importance is analogous to the role played by traditional marketers in the natural gas market back in the 1990s. Portfolio optimizers' ability to raise capital at lower costs enhances their marketing capabilities and enables them to be the conduit between the primary market and the secondary/resale market. This has led to a progressive increase in LNG spot trading, which is also referred to as the swing market.

2. Short-Term Trade Duration

While the LNG market has traditionally relied on long-term contracts, spot trading has been growing for the second consecutive year and reached 99 MT in 2018. This represents an increase of 31% of global trade. However, the largest growth came from the U.S. where approximately 70% of Sabine Pass exports were traded spot in 2017 due largely to the flexibility of U.S. LNG volume that facilitated cargo diversions coupled with the increasing activity of portfolio optimizers who own significant capacity in

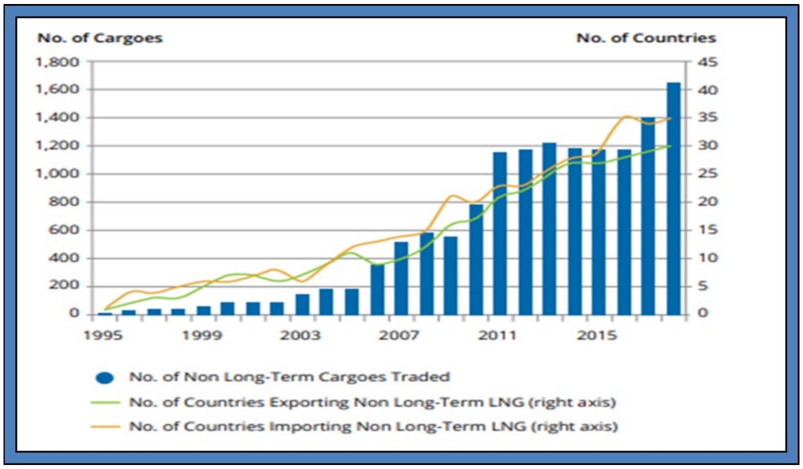
U.S. Gulf Coast ("USGC"). Figures 1 and 2 show that cargoes traded with short-term duration are getting momentum while the medium term is increasing at a slower pace.

Figure 1
Short, Medium and Long-Term Trade, 2010-2018



Source: International Gas Union (IGU).

Figure 2
Short-Term/Spot Trading by Number of Cargoes & Countries



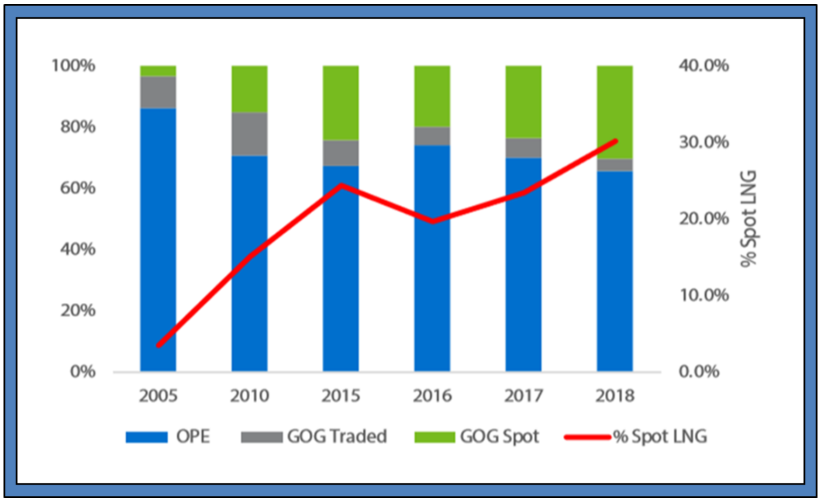
Source: IGU.

3. Price Discovery

The global LNG market is based mainly on two structurally different pricing regimes: oil-indexation and gas-to-gas pricing. This is in addition to regulated prices, which are more relevant in state-run economies. Historically, oil indexation was a cornerstone of long-term LNG contracts, especially in Asia and some parts of Europe. LNG was linked to oil prices with a three- or four-month lag. While linking oil to gas made sense in the 1960s as oil was used as a substitute in power generation, this rationale is increasingly obsolete. Additionally, this mechanism has failed to accurately reflect the fundamental values of the gas market and limits the possibility of arbitrage. Due to these shortcomings, European Union energy policies and major suppliers have started to substitute oil index contracts with hub-based ones. Also, since 2015, Asian buyers have sought to diversify the pricing structures of their LNG agreements, shifting away from long-term oil-linked contracts with traditional fixed-destination clauses.

In contrast, under a gas-on-gas pricing mechanism, the price is determined by the interplay of supply and demand either at a physical hub (e.g., Henry Hub) or at a virtual hub (e.g., NBP). Hub pricing as a price formation model is prominent in the U.S., U.K., and other parts of continental Europe. Netback pricing is an important concept, and it is derived by estimating the net revenue from the sale of LNG in destination markets less all costs including sourcing, regasification, and shipping. As shown in Figure 3, gas-on-gas ("GOG") competition for spot LNG imports increased 10% globally in 2018 compared to Oil Price Escalation ("OPE") or oil indexation.

Figure 3
World Price Formation 2005 to 2018 – Spot LNG Imports



Source: IGU.

U.S. SPAs introduced a new pricing approach based on a Henry Hub-linked LNG formula. Cheniere was the first U.S. supplier to introduce a Henry Hub-linked LNG formula. This formula is based on off-takers that are contracted to lift LNG and pay an approximate fixed fee between $2.25 to $3.5 per MMBtu plus a charge of 115% of the Henry Hub (HH) price. The fixed "take-or-pay" fee is paid irrespective of lifted volume and can be considered as a sunk cost as it is designed to cover the capital investment to build the liquefaction plant. The decision to export is determined by the arbitrage window or the netback margin between the variable costs for delivered LNG to a market and the prevailing regional spot price at the same destination. The variable costs include (1) a 115% Henry Hub charge, which represents the cost of procuring feedstock gas that is variable depending on the volume lifted, (2) shipping costs, which in turn include the charter rate and bunker fuel cost, and (3) regasification costs, which can be considered as either variable or sunk costs depending on the downstream participant and destination.

An important implication of such a structure is that the trading determination process is driven by the short-term marginal cost; an off-taker elects to export LNG when the spot price at the destination is greater than the delivered variable costs (including, as noted, 115% of the HH price as well as the shipping and regasification costs.) Consequently LNG will be delivered to whatever location has the highest netback spot price. However, when the spot price at the destination is high enough and exceeds both variable and sunk costs (i.e., the fixed fee), trading and cargo diversion is based on the full cost of the exported LNG.

This pricing structure can essentially be viewed as a complex spread option where the strike price is LNG delivered variable costs (again, including 115% of the HH price as well as the shipping and regasification costs.) Sometimes the shipping and regasification costs can be considered as sunk costs when the off-taker has in-house transportation and an existing contract with the regasification terminal. In this case, the payoff of the spread option depends on the spread between the regional spot price and Henry Hub.

Interconnectivity & Infrastructure Relevance

The development of price benchmarks in energy in general is intrinsically linked to the physical market and its commercial implications. Well-developed infrastructure and the proximity to supply ensure three elements: (1) alignment to the balance of supply and demand, (2) smoothness of price discovery formation, and (3) enhancement of the price response.

Most U.S. projects are situated in the Gulf of Mexico except Cove Point, which is in the northeast. The Gulf of Mexico has logistical and infrastructural advantages and encompasses one of the most developed energy infrastructures in the world. The region has a concentration of facilities throughout the gas supply chain, including production upstream, gathering and processing plants, extensive pipeline system, storage, and industrial access. In addition, the U.S. Gulf Coast possesses a highly-skilled workforce.

The competitiveness of U.S. LNG exports was also enhanced by the recent Panama Canal expansion, which has substantially reduced the voyage time, distance and costs of LNG vessels to travel from the USGC to the Pacific Basin. According to the U.S. Energy Information Administration (EIA), the newly expanded canal will be able to handle 90% of the world's current LNG tankers with a shipping capacity of

3.9 Billion cubic feet (Bcf). The expansion considerably reduces the voyage time to Japan from 34 days to 20 days and shortens the distance from 16,000 to 9,000 miles compared to traversing the Suez Canal or around the Cape of Good Hope, which adds 12-13 days to the shipping time and more cost. With respect to the voyage to South America, transit through the Panama Canal shortens the duration from 20 days to 8-9 days and from 25 days to 5 days going to Chile and Colombia/Ecuador respectively. Therefore, the USGC has both physical capabilities and robust supply, which allows it to attract the strong physical trade volume needed for benchmark creation.

Conclusion

Oil indexation is losing its luster and becoming an archaic mechanism that is less likely to survive against hub pricing in the long run. With the U.S. LNG institutional model profoundly changing LNG contractual, pricing, and trading apparatus, the USGC has the potential to become a major physical hub for global LNG price formation due its strategic location and easy access to flexible supply.

Endnote

For further coverage of the natural gas markets, the reader is invited to read past *GCARD* articles on these markets.

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Adila Mchich is a Director in Research and Product Development at the CME Group. She focuses on the fundamentals of energy markets. She has over 10 years of experience serving multiple roles in Market Research & Development, Risk Management, and Product Valuation at the CME Group. Ms. Mchich started her career as a Quantitative Analyst.

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Part 1: Trend, My Friend, Is This the End?

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In Part 1 of 2 we explore the reduced performance of trend followers over the past decade but fail to find evidence that this is due to the commonly proffered reason of overcrowding of the strategy. Instead we find that the cause can be laid at the feet of the markets themselves – those markets commonly traded by trend followers have simply not trended as strongly in the past decade. In Part 2 we will turn our attention to the "trendiness" of a novel dataset of alternative commodity markets, selected based on a set of simple criteria. This will feature in a forthcoming edition of the GCARD.

Trend Followers

As is well known, classical trend following in liquid markets has struggled over most of the past decade since the global financial crisis (GFC), and stands in sharp relief to the performance of similar systems prior and during the crisis. As an example, taking March 2009 as the start of the post-GFC period,[1] we find that the Sharpe Ratio (SR) of the BarclayHedge Barclay CTA Index has been essentially zero (0.1 +/- 0.3 standard error) compared to a SR of 0.8 (+/-0.2 s.e.) before then. Via Opdyke (2007) the probability that the pre-GFC SR is positive is 99%, but it is only 60% for the post-GFC SR whilst the probability that the post-GFC SR is *less* than the pre-GFC period is 95%. Clearly, something has changed!

Why Has the Performance Declined?

Is it Overcrowding?

A common hypothesis is that the amount of capital deployed in trend-following strategies has reached the scale where competitive saturation is now a significant concern. This refers to the degradation in performance caused by increased competition for the same source of alpha. Indeed, recent reduced Commodity Trading Advisor (CTA) performance has been coincident with assets under management (AUM) in Managed Futures strategies at historic highs ($350Bn), and this growth has outstripped the increase in the size and number of futures markets, with the ratio of managed futures AUM to total average daily futures trading volume (in dollars) doubling from pre- to post-GFC periods (0.16 to 0.27).

But, correlation does not necessarily mean causation. We here attempt to measure any impact on CTA performance arising from a general crowding of the strategy. Direct observation is of course impossible, because one cannot evaluate market behavior on a counterfactual basis. We can however simulate the counterfactual: *what would have happened if one had traded behind everybody else?* This implementation lag refers to the negative impact on performance of the inevitable delay between sample time (when the model "sees" the price) and execution time (when the model "fills" its desired holdings.)

Quantifying Saturation via Alpha Decay

The crux of this analysis is that if the recent growth in assets and players is cannibalizing alpha, then we should see an increasingly negative cost to "trading late," because all those assets and players will have created a "footprint" in the market, and the late entrant will buy after the competition has bought, or sold after they have sold.

We backtest a trend-following simulation on a set of over one hundred *liquid* futures markets from 2000-2019 (across bonds, rates, currencies, equities and commodities), comparing the resulting performance when we either assume the theoretical – but unachievable – case of simultaneous sampling and execution (Lag 0) to the case where we trade a *full* 24 hours later (Lag 1). The Lag 0 SR before fees is 0.75, dropping to 0.7 for Lag 1. At 10% annualized volatility, 0.05 Sharpe points equates to 50bps annualized loss in performance, or about a cost of 8% of net alpha (for a Lag 0 after fees SR of 0.66.)

To address the possibility of crowding leading to increased alpha degradation, we need to know if this cost has been accelerating. This would manifest itself as an increasing performance differential over time. However, the cumulative differential between the Lag 0 and Lag 1 account curves has been stable over time (Figure 1), and there is no obvious acceleration over the recent past. Thus, we see no footprint of increased trend-follower AUM leading to competitive saturation and overcrowding.

Figure 1
Cumulative Lag 1 Underperformance versus Lag 0 Backtest, Showing the Consistent and Persistent Gradient

Sources: Gresham Investment Management (GIM), Bloomberg.

Why Haven't Assets Swallowed Alpha?

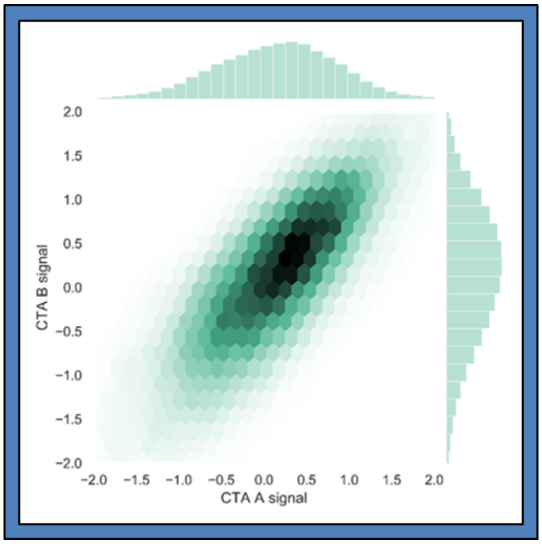
One explanation is "stock versus flow." The natural concern is that any individual CTA will overestimate available liquidity inasmuch as it fails to fully consider the combined assets of similar participants, who will also presumably be making their own assessment of available liquidity. However, this phrasing of the issue ignores a key differentiation between positions and trades – what we call the *stock* (the collective position across the space) and the *flow* (the incremental changes in that position by participant, for which the question of liquidity is highly relevant.) Indeed, even for two hypothetical CTA's with identical market allocations, they may have substantial differences in their respective parameterizations (e.g., speed) of their strategies.

Toy Model

Two similar trend-following strategies are run on each liquid futures market. Here trend following has been defined as being an exponentially weighted moving average crossover (EWMAC). The two strategies have similar effective speeds in terms of information window, defined as the number of days into the past that contain 50% of the EWMAC weight. For CTA A, a single medium speed EWMAC has been used. For CTA B, a mix of both a fast and slow EWMAC has been used. Both CTAs have an effective speed of around 45-50 days.

The mean signal correlation between CTA A and B across more than 100 such markets is 0.77 over the past decade, whilst for the changes in signal (Δsignal), the mean correlation is 0.58. Next, because signals are all normalized into the same units, we can aggregate all the data into a single relationship. This is displayed as a density plot in Figure 2 due to the large number of data points (260,000). For this super-sample, signal correlation is 0.79 and Δsignal correlation is 0.58 – very similar to the individual market analysis.

Figure 2
Signal Density for CTA A and B across Liquid Futures



Sources: GIM, Bloomberg.

Note that the Δsignal correlation is likely to represent an *upper* limit for the degree of overlapping trading behavior, because the only difference introduced was in terms of trend horizons and even then, they were "effective speed" matched – we will relax and test this hypothesis next.

A Step Closer to Realism

In the real world, different CTAs – even in the narrowly defined trend bucket – employ a wide range of different techniques to achieve their ends: there are different definitions of "trend" (EWMA oscillator and break-out, for example), different "splines" or response functions mapping raw signal to model conviction, different risk models for inverse-volatility scaling, different portfolio risk controls, different smoothing, buffering and trade/position limits … the list is as potentially as long as there are lines of code in the strategy codebase.

We attempt to construct a more realistic comparison between two (somewhat arbitrary) trend-following CTAs. For CTA A, we adopt a plain-vanilla 1-month realized volatility for inverse position sizing, for which we then simulate positions and trades. For CTA B, an approach more similar to our own strategies has been adopted, including our proprietary robust volatility model, signal and position buffering, and a signal spline incorporating endogenous awareness of forecast uncertainty and trend exhaustion.

We cannot meaningfully aggregate positions across all futures markets (as notional positions are not normalized) but we can find the correlation for each market in turn, and the average correlation of each pairwise position was 0.74, and the average trade correlation was 0.30 – again, not high, and substantially lower for the "flow" than for the "stock." So, despite having very similar positions, two CTAs' trades can in fact be quite uncorrelated.

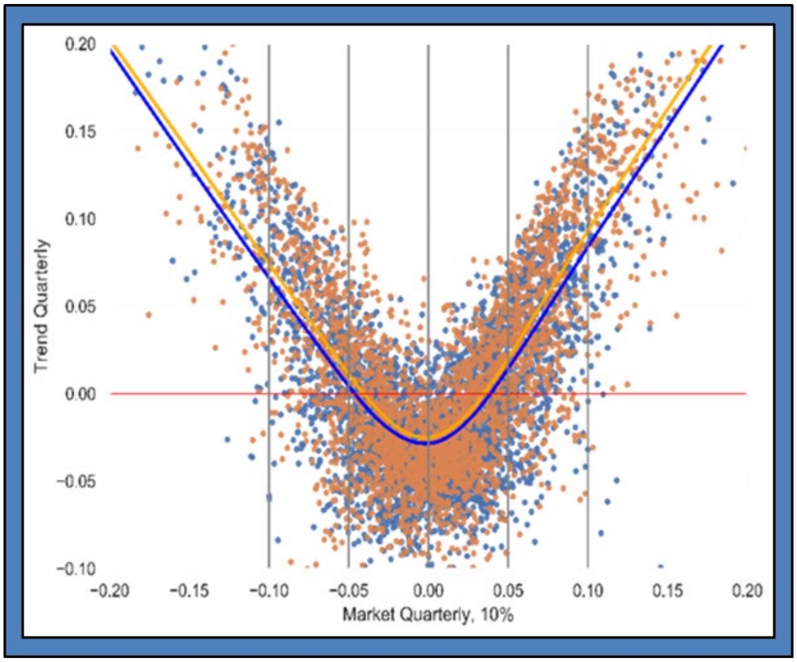
Maybe It's the Signal?

When we looked for evidence of overcrowding we failed to find its footprint in the lag-trading analysis. Furthermore, the notion that all trend followers' trading activity is similar was found to be less likely than is commonly believed. So, if we cannot convincingly blame overcrowding for poor trend performance post-GFC, perhaps we can instead blame the machinery of trend following itself. Maybe EWMACs and their ilk no longer efficiently capture trends in markets?

Using the same trend-following definition as used in Figure 1, we plot in Figure 3 the risk-adjusted quarterly returns[2] of futures markets[3] versus the resulting simulated quarterly return from trend following[4] on those individual markets, splitting the data into pre- and post-GFC. For both periods we overlay a Loess line of best fit. The resulting convex "CTA smile" is a well-known result and demonstrates how trend following is akin to a synthetic long straddle (e.g., Merton (1981), Fung and Hsieh (1997) and Dao *et al.* (2016).) It is perhaps remarkable that the pre- and post-GFC relationship is virtually identical. Crucially, therefore, the mechanism by which trend following translates market moves into trend returns has not altered.

Figure 3

Quarterly Return CTA Smile for Liquid Futures in Two Periods (orange = pre-GFC, blue = post-GFC). Loess Fits Indicated. Market Quarterly Returns are Risk-Adjusted to 10% Annualized Risk.



Sources: GIM, Bloomberg.

So What Changed?

If we look at the density of data in different regions of the observed CTA smile, we find that there is a difference between the two periods. Table 1 sets out the proportion of quarterly market returns that were “small” (absolute returns < 5%) and “large” (absolute returns > 10%). There has been a marked shift of occurrence away from *large* trends and into *small* trends.

Table 1

Occurrence Counts for Small and Large Risk-Adjusted Market Quarterly Returns

	Small Trend (|Mkt Retn| < 5%)	Large Trend (|Mkt Retn| > 10%)
pre-GFC	59% of quarters	10% of quarters
post-GFC	68% of quarters	5% of quarters

Given that trend following, viewed as a straddle, can be characterized as bearing an options cost when markets are not trending (the central region) and a pay-off when markets are trending (the tails), this observation explains the weak performance of trend following in the post-GFC period – markets spent more of their time in small weak trends and the occurrence of larger trends was almost halved. It is beyond the scope of this paper to proffer a reason as to why markets have trended less in the past decade but the fact that the cause lies with the markets rather than with trend following itself suggests that those same markets could exhibit larger trends again in the future, with a commensurate improvement in trend-following performance.

Concluding Remarks

We were unable to find evidence that the poor performance of mainstream trend followers over the past decade (post-GFC) was due to overcrowding and found that even similar trend-following approaches can result in lowly-correlated trading activity. Indeed, the "mechanical" transformation of market moves into resulting trend-following returns was shown to be the same pre-/post-GFC, implying that the act of trend following itself was not "broken." Rather, it appears that the cause lies with the behavior of the markets themselves, with a marked reduction in the occurrence of large (quarterly) moves in markets. Therein lies some hope for mainstream trend followers since the cause appears to be exogenous and one might expect that the behavior of markets could change again in the future. However, as we do not have a crystal ball we will instead look elsewhere for markets that have continued to exhibit larger trends – this will be covered in Part 2 in a forthcoming edition of the *GCARD*.

Endnotes

1 Exact date choice has minimal impact on conclusions.

2 Chosen to be similar in timeframe to the horizon of medium-speed trend followers.

3 Risk-adjusted to an annualized risk of 10%.

4 Again, targeting 10% annualized risk.

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Commodity Portfolio Management

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Investing in the commodities markets has become increasingly popular over the last two decades. Several research articles have concluded that adding commodities to the classical portfolio construction, which usually consists of 60% of equities and 40% of bonds, helps to diversify portfolio risk while protecting investors against inflation-driven asset value erosions. The goal of the present research is to dig deeper into the structure of commodity markets and understand its evolution over time. The present paper will analyze liquid and exchange-traded (ICE and CME) commodity futures prices from three different sectors ranging from January 2010 to August 2019: energy (which can be further sub-divided into crude grades and petroleum products), agricultural, and metals (which can be further sub-divided into precious and base metals.) The aforementioned sectors contain the following sets of futures contracts:

- Energy: Brent Crude, West Texas Intermediate (WTI) Crude, European Low Sulphur Gasoil (diesel), New York Reformulated Blendstock for Oxygenate Blending (RBOB) Gasoline, and Dutch Title Transfer Facility (TTF) Natural Gas;

- Agricultural: U.S. Sugar Number 11 and White Sugar Europe; and

- Metals: Gold, Silver, Copper.

Managing a commodity portfolio is not particularly easy because commodities markets respond to idiosyncratic features, which cannot be found in equities, nor in the fixed income markets. In fact, their response to changes in the macroeconomic, financial and geopolitical landscapes might considerably differ from one commodity to another. In order to better address the aforementioned problems, the present research will examine four important aspects of commodity portfolio management: (1) commodity market returns; (2) commodity volatilities; (3) commodity seasonal volatility; and (4) trend and mean reversion.

Commodity Market Returns

In this section, the collective performance of a hypothetical portfolio will be examined. Specifically, the true object of study here is not to examine the return provided by a specific strategy but rather the cumulative portfolio returns yielded by the market itself over the course of the last 9.5 years. The returns can also be thought of as the portfolio performance of an investor with a passive investing strategy in a commodity basket.

Figure 1
Commodity Portfolio Aggregated Logarithmic Returns

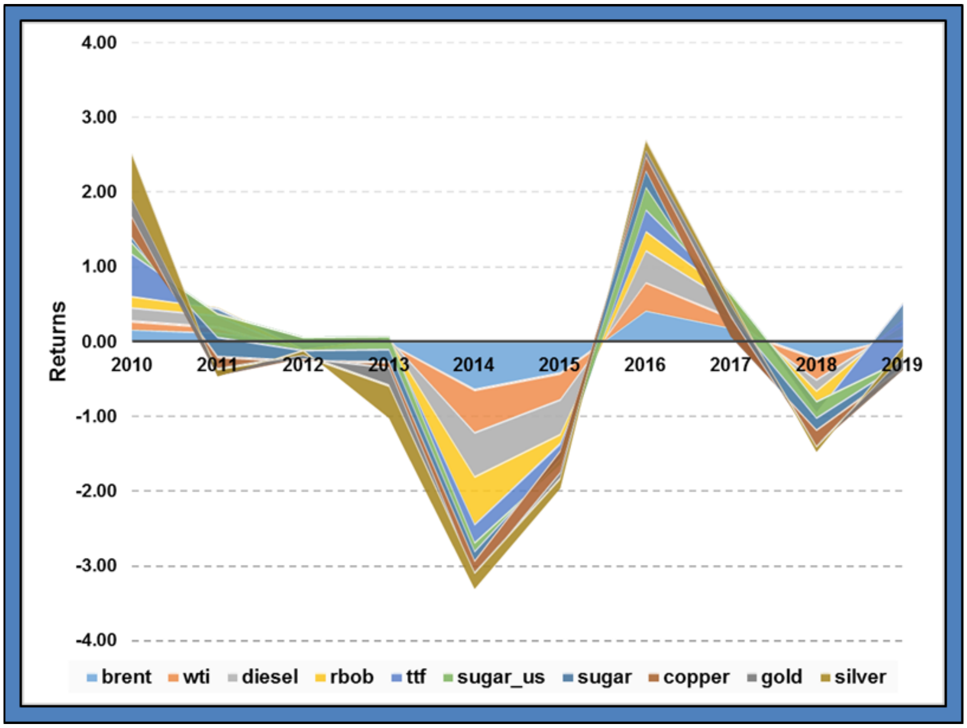
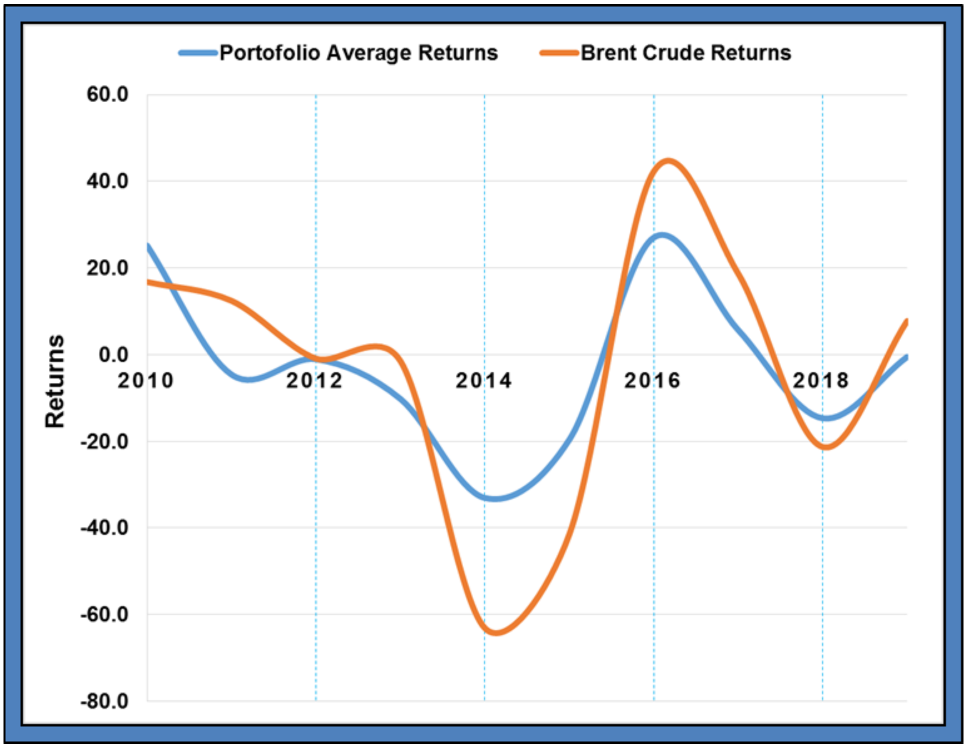


Figure 1 shows that the commodity market performance has been rather volatile over the last decade despite the steady performance of the S&P 500 index. The chart shows quite clearly that commodity market returns have been negatively affected by the Greek crisis of 2011-2012, moved sideways in 2013 but then dropped dramatically in 2014. Nevertheless, the aggressive plunge in commodity returns was arguably not due to global macroeconomic dynamics, but rather to the violent downtrend in crude oil prices caused by OPEC members who drastically increased their oil output to counterbalance the rise of American shale oil production and avoid losing market share. It is clear that the fluctuation of crude oil prices strongly impacts industrial production and the cost of transportation of all other commodities, so it is reasonable to expect that a large change in crude grade prices would trigger a domino effect on other commodities. Portfolio performance quickly improved in 2016 and slowed down in 2017 although it remained largely positive in 2017. Portfolio performance plunged again in 2018 and suffered an increase in volatility in the first half of 2019. Specifically, trade frictions between the U.S. and China and fears of a slowdown in global growth, fueled by the fact the economy is in its late business cycle, have contributed to an increase in selling pressure, which dragged commodity prices, but also equity indices, all the way down in Q4 2018. However, since January 2010, there have been commodity markets that have returned more positive yields than others. For example, the European low sulphur gasoil (diesel) market yielded positive returns for 6.5 years while both the European and American sugar markets returns were positive only for 3 years. Another market where returns remained positive for a long time is gold (more than 7 years) while silver managed to return above-zero yields only for 4.5 years. Overall, since January 2018 until now, we can say that gold futures, along with energy futures (Brent, WTI, Low

Sulphur Gasoil, New York RBOB and Dutch TTF Natural Gas), have largely outperformed all the other commodity markets under examination.

Figure 2
Average Commodity Portfolio Logarithmic Returns

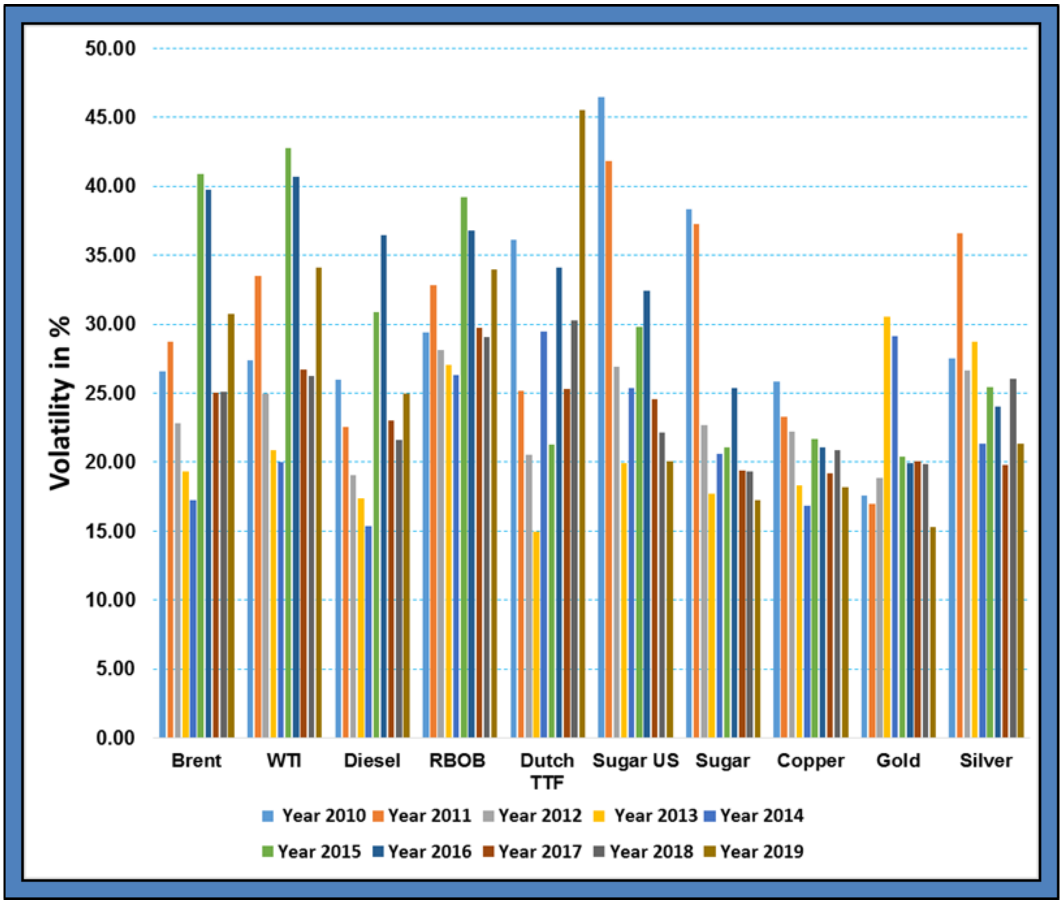


The average performance of the above-mentioned commodity portfolio and the impact that idiosyncratic and global fundamental shifts have had on it can be more visibly observed in Figure 2. Furthermore, in order to better highlight how important it still is to hold positions in crude grades, the returns of the Brent Crude market have been plotted: the Brent market is obviously more volatile, but its fluctuations are the most correlated to the chosen commodity portfolio. On the other hand, though, the sugar markets, and in particular the European one, have shown to be the least correlated to the portfolio under study, which automatically means they might be particularly good asset classes to further diversify commodity risk.

Commodity Volatilities

Commodity markets, in addition to being inflation-hedging "tools," are also known for being some of the most volatile asset classes. Volatility implies higher risk but also more opportunities.

Figure 3
Yearly Median Stochastic Volatility for Commodity

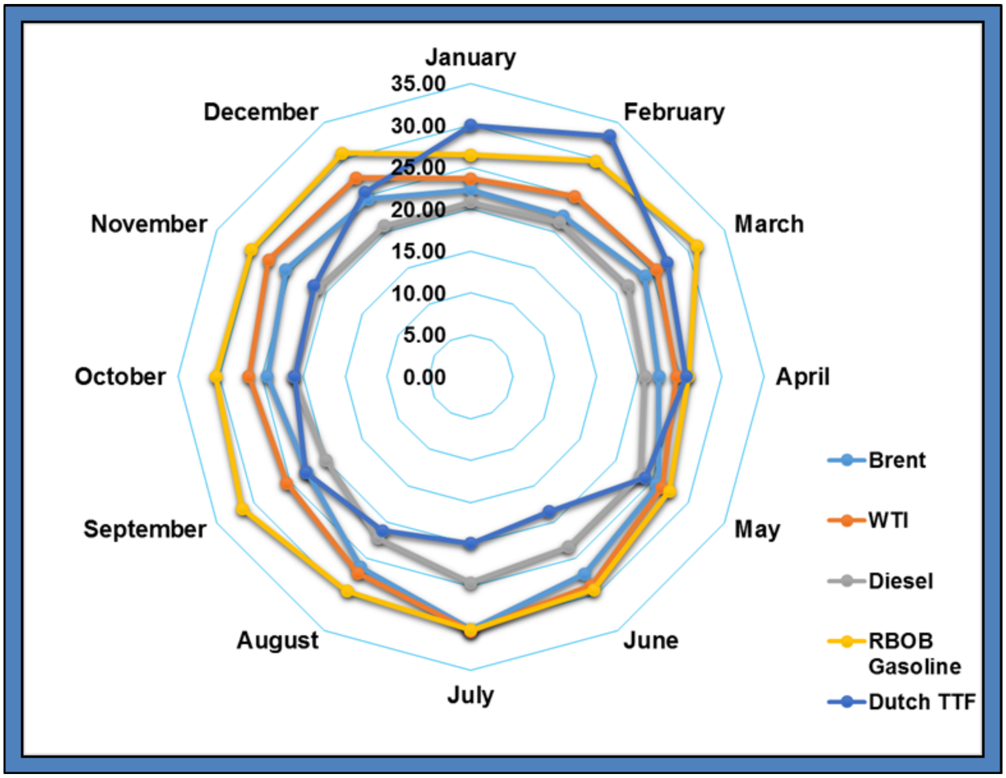


The first thing that it is worth noting is that the portfolio average stochastic volatility went down from 30.12% in 2010 to 21.48% in 2013. However, the trend reversed in 2014 and the rising volatility environment continued also in 2015 and 2016 when it reached its maximum of 31.06%. 2017 experienced a lower degree of market fluctuations (23.28%) while in 2018 and in the first half of 2019, stochastic volatility started to move back up, reaching 26.15%. Stochastic volatility peaked when commodity markets crashed while it softened when prices moved back up. On average, New York RBOB (31.25%) and WTI (29.72%) futures proved to be the most volatile markets while Copper (20.75%) and Gold (20.87%) futures were the least volatile among the selected portfolio components. However, it is U.S. Number 11 Sugar (46.49%) and Dutch TTF Natural Gas (45.54%) futures markets that experienced the highest peaks in volatility. Paradoxically, the Dutch TTF Natural Gas is also the market with the lowest stochastic volatility recorded (14.97%) along with Gold (15.32%) and European Low Sulphur Gasoil (15.35%) futures.

Commodity Seasonal Volatility

Volatility is one of the key indicators as far as portfolio management is concerned because it is one of the main metrics for asset class selection in factor investing. Nevertheless, commodity markets tend to be particularly sensitive to seasonality given their idiosyncratic demand/supply dynamics and therefore price volatility fluctuations vary greatly from month to month. The commodity volatility seasonal study was conducted using stochastic volatility estimates calculated over 9 years' worth of futures prices ranging from January 2010 to December 2018. The findings will be examined by sector and the first one to be analyzed will be in the energies.

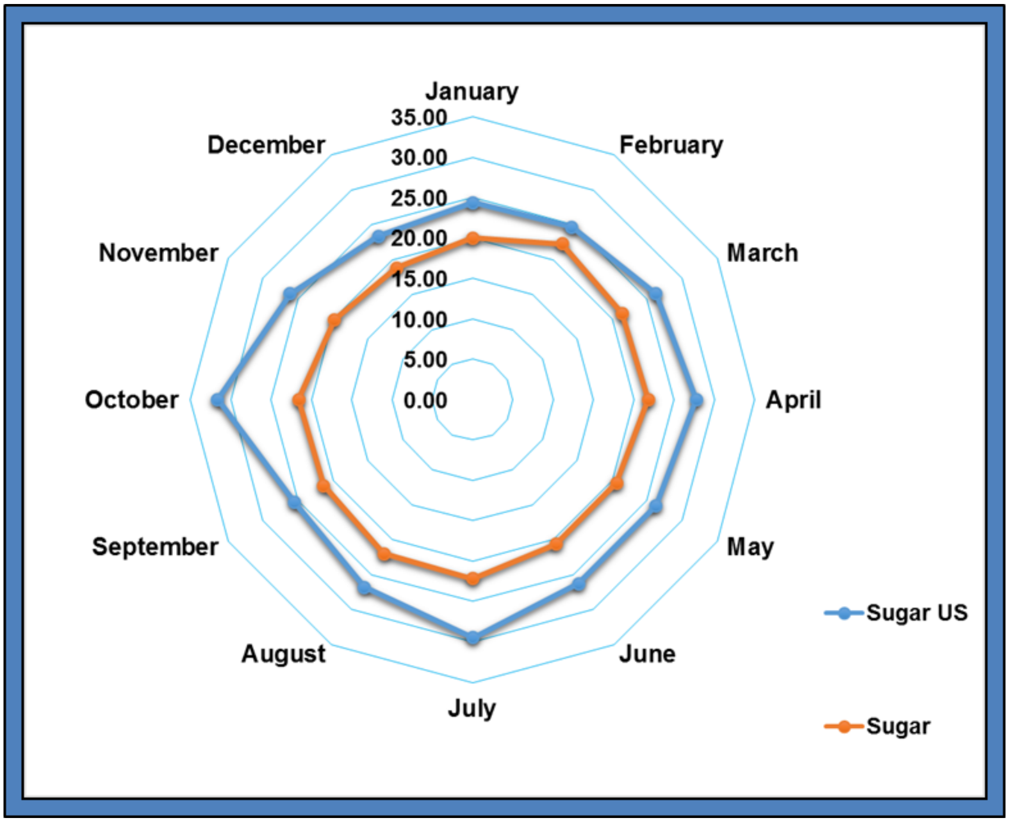
Figure 4
Seasonal Stochastic Volatility by Month - Energy



The seasonal volatility chart in Figure 4 shows that, over the course of the last 9 years, the most volatile month for Brent, WTI and Diesel was July while for RBOB it was September. On the other hand, the most volatile month for Dutch TTF Natural Gas is February due to its usage for heating. Conversely, the months with the lowest volatility for WTI and Brent are January and February respectively while for the Low Sulphur Gasoil market (diesel), the fluctuation rate touches the bottom in September. The month of September is crucial for petroleum products such as gasoline and diesel because it is when the switch between summer and winter grade fuel happens. Nevertheless, the grade switching causes volatility to peak in the RBOB Gasoline market and to bottom in the diesel one. This phenomenon is predominantly due to the fact that U.S. gasoline prices tend to drop as the driving season (summer) draws to a close, pushing up volatility, while European diesel prices tend to become more expensive during the winter time because of the particular additives, which get blended into the fuel to lower as much as possible its freezing point. Dutch TTF Natural Gas volatility, instead, tends to increase with a higher buying pressure, which is precisely why it peaks in February, while in June it tends to drop, as prices soften, and this explains the low volatility.

Let us now focus on the agricultural segment of the portfolio and in particular on the European and American sugar markets.

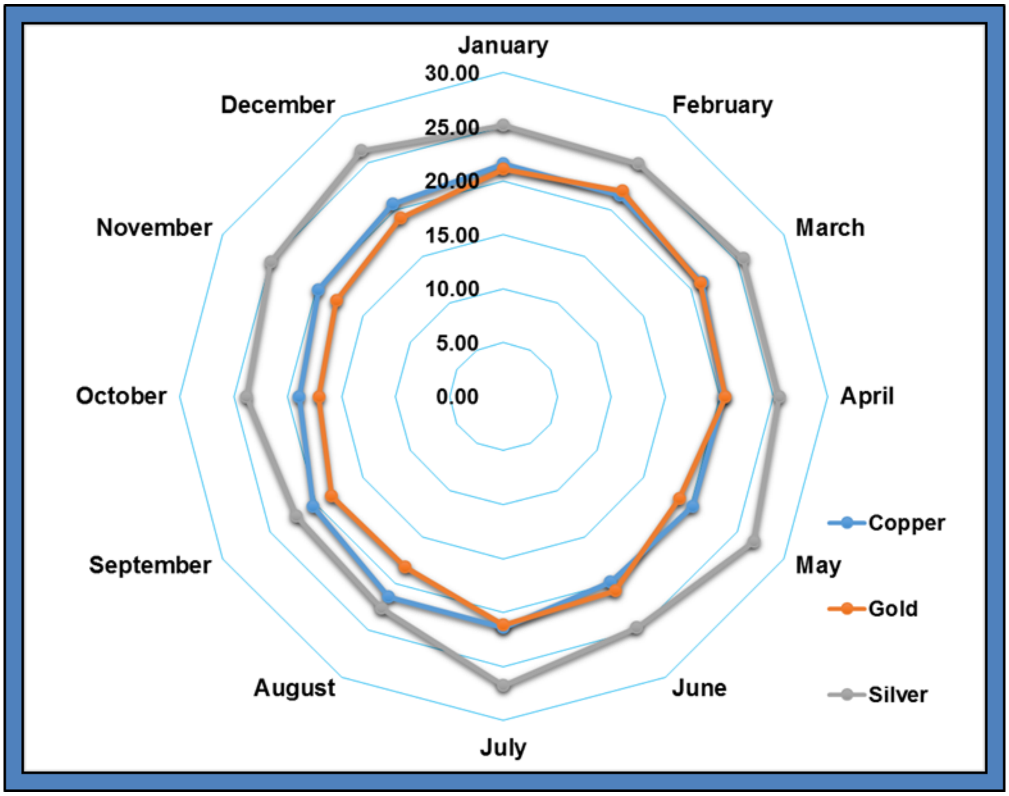
Figure 5
Seasonal Stochastic Volatility by Month – Agricultural



European and American sugar markets differ quite significantly as far as volatility is concerned. In fact, while volatility in the European White Sugar market peaks in the month of February, the fluctuation rate for American Sugar achieves its highest level in the month of October. Nevertheless, the lowest volatility point is reached in the month of December, as plants' sugar content tends to be at its highest within the last months of the year when it is harvested.

The last portfolio segment to analyze is the metals sector, which contains both precious metals like gold and silver, as well as copper, a base metal.

Figure 6
Seasonal Stochastic Volatility by Month – Metals (Precious and Base)



Stochastic volatility in the precious metal markets tends to reach its highest point in the month of February (Gold) and May (Silver) while the fluctuation rate in the copper market achieves its yearly high in the month of January. Nevertheless, volatility in all metal markets in the commodity portfolio tends to bottom in the second half of the year; in fact, September (Silver) and October (Gold and Copper) are their least volatile months.

Trend and Mean Reversion

The present research has so far examined commodity returns, commodity volatilities as well as their seasonality and these are all important variables that need to be taken into account when managing a commodity portfolio.

However, given the cyclical nature of the fundamentals which govern commodity markets, it is worthwhile to analyze the tendency of mean reversion which each commodity has experienced over the course of the last 9.5 years. In order to test this phenomenon, the present research uses the Hurst Exponent. The interpretation of the exponent is fairly straightforward:

- If the Hurst Exponent is lower than 0.5, the commodity is considered to be mean reverting;

- If the Hurst Exponent is equal to 0.5, the commodity is considered to be following a Geometric Brownian Motion, which means it follows a random walk; or

- If the Hurst Exponent is higher than 0.5, the commodity is considered to be trending.

The following table displays the aforementioned Hurst Exponents calculated for each commodity and for each year; the Hurst Exponents for 2019 have been calculated using a time series ranging from January to August 2019.

Table 1
Yearly Hurst Coefficient by Commodity

	Year 2010	Year 2011	Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019
Brent	0.34	0.31	0.49	0.39	0.65	0.46	0.34	0.53	0.42	0.41
WTI	0.29	0.37	0.39	0.46	0.61	0.46	0.37	0.46	0.44	0.35
Diesel	0.29	0.28	0.49	0.43	0.58	0.42	0.32	0.50	0.38	0.33
RBOB	0.33	0.41	0.30	0.20	0.61	0.62	0.38	0.16	0.54	0.46
Dutch TTF	0.39	0.29	0.34	0.28	0.62	0.22	0.33	0.55	0.27	0.25
Sugar US	0.63	0.46	0.22	0.42	0.28	0.41	0.35	0.57	0.40	0.03
Sugar	0.55	0.38	0.23	0.18	0.34	0.31	0.36	0.49	0.26	0.02
Copper	0.47	0.26	0.38	0.38	0.31	0.39	0.29	0.41	0.27	0.39
Gold	0.24	0.30	0.44	0.42	0.20	0.07	0.47	0.14	0.40	0.48
Silver	0.53	0.39	0.52	0.51	0.42	0.18	0.49	0.28	0.29	0.49

The first thing worth noting is that all analyzed markets tend to have low Hurst Exponents, implying that a certain degree of mean reversion has been idiosyncratic to all commodities across the last 9 and a half years. The most mean-reverting commodity markets in our portfolio are Copper, Gold, European Sugar and Dutch TTF Natural Gas futures. On the other hand, the commodity markets with the highest propensity to trend for a long time are Silver, Brent and WTI futures.

Conclusion

The present research is far from exhaustive; however, it aims to provide a good understanding of some of the things that should be taken into account when managing a commodity portfolio. Furthermore, it is crucial to point out that for commodities, metrics such as volatility and seasonality deserve to be addressed specifically and separately: an equity-style approach would ignore the strong idiosyncratic features characterizing each commodity, inevitably leading to inefficient portfolio construction and to a suboptimal allocation of resources.

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Mr. Vito Turitto joined the S&P Global Platts Commodity Risk Solutions team in 2015. Prior to joining Platts, he started his career in the City of London trading options on crude oil and other energy markets and went on to build HyperVolatility Ltd., a boutique quantitative investment consultancy. Mr. Turitto's field of expertise is in volatility trading, analysis and modeling. Mr. Turitto holds a B.A. in International Economics Relations from the University of Rome "La Sapienza" and received his Master of Science in International Finance and Investment from London South Bank University after completing a dissertation on forecasting volatility in the American crude oil market via stochastic volatility models.

Impact of Automated Orders in Futures Markets

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The staff of the Market Intelligence Branch in the Division of Market Oversight ("DMO") conducted research on the entering of orders manually and automatically in commodity futures markets in the United States to determine how technological change is affecting futures trading. DMO staff used internal CFTC transactional data for thirty futures contracts during the period January 2013 – December 2018, and examined what effects, if any, the manual and automated order placement mechanisms had on these markets.

The research produced the following findings:

1. The percentage of automatically placed orders has increased for all commodity futures markets;
2. Automated orders have a smaller number of contracts per transaction than manual orders and their resting times are shorter than the resting times of orders placed manually;
3. Automated orders are almost always limit orders; and
4. Although the level of automation increased steadily each year, historical volatility of end-of-day prices did not exhibit the same trend.[1]

Automated and Manual Order Entry

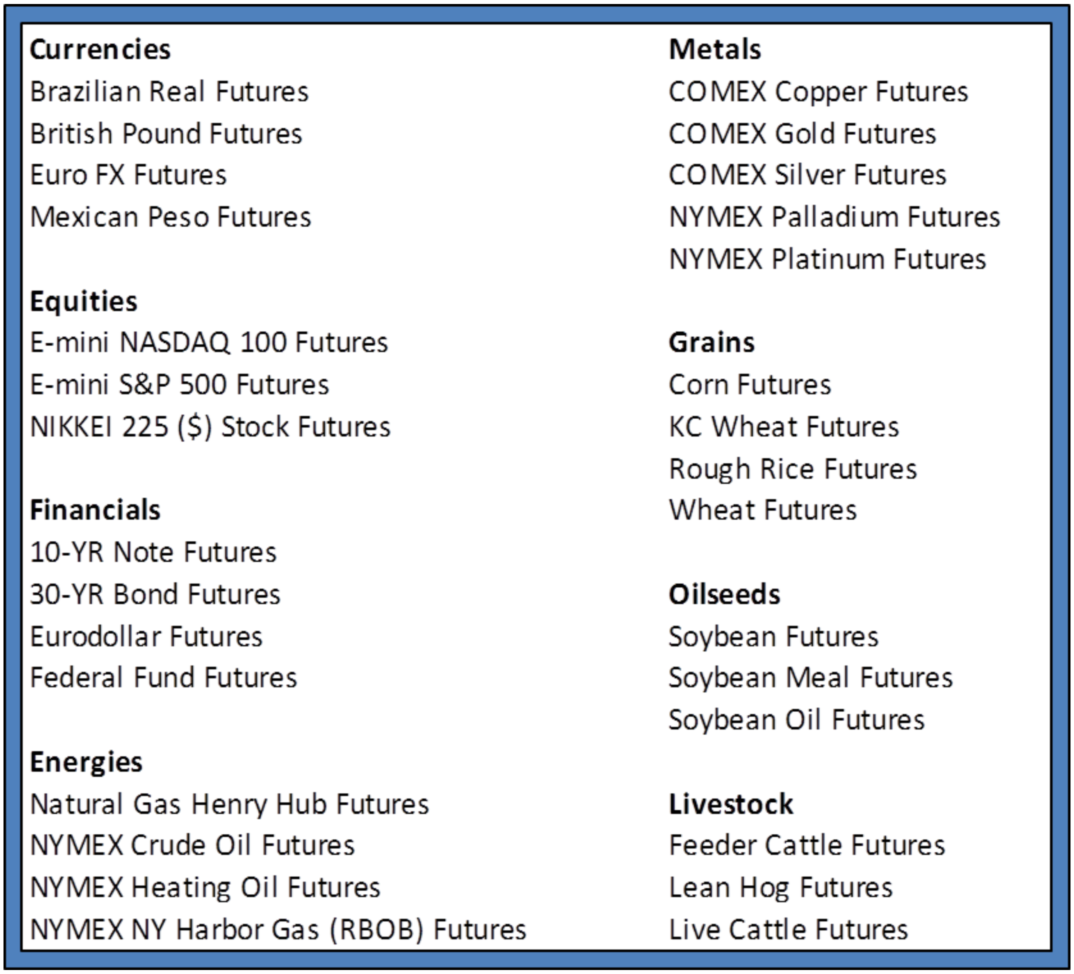
Automated and manual order entry refers to how an order is entered on the order entry message. Automated order entry refers to orders that are generated and/or routed without human intervention. This includes any order generated by a computer system as well as orders that are routed using functionality that manages order submission through automated means (i.e., an execution algorithm). Manual order entry refers to orders that are submitted to CME Globex by an individual directly entering the order into a front-end system, typically via keyboard, mouse, or touch screen, and which is routed in its entirety to the matching engine at the time of submission.

Type of order entry is a self-identified tag, which market participants submit themselves. This tag is required only by the Chicago Mercantile Exchange (CME), as documented in CME (2012). Therefore, DMO staff analysis is limited to CME contract markets.

Level of Automation in Futures and Options Markets

DMO staff began the analysis by reviewing daily transactions in 30 futures contract markets. Staff classified the markets into eight commodity groups including: Currencies, Equities, Financials, Energies, Metals, Grain, Oilseeds, and Livestock.

Figure 1
Commodity Groups and Corresponding Commodity Contracts



Currencies
Brazilian Real Futures
British Pound Futures
Euro FX Futures
Mexican Peso Futures

Equities
E-mini NASDAQ 100 Futures
E-mini S&P 500 Futures
NIKKEI 225 ($) Stock Futures

Financials
10-YR Note Futures
30-YR Bond Futures
Eurodollar Futures
Federal Fund Futures

Energies
Natural Gas Henry Hub Futures
NYMEX Crude Oil Futures
NYMEX Heating Oil Futures
NYMEX NY Harbor Gas (RBOB) Futures

Metals
COMEX Copper Futures
COMEX Gold Futures
COMEX Silver Futures
NYMEX Palladium Futures
NYMEX Platinum Futures

Grains
Corn Futures
KC Wheat Futures
Rough Rice Futures
Wheat Futures

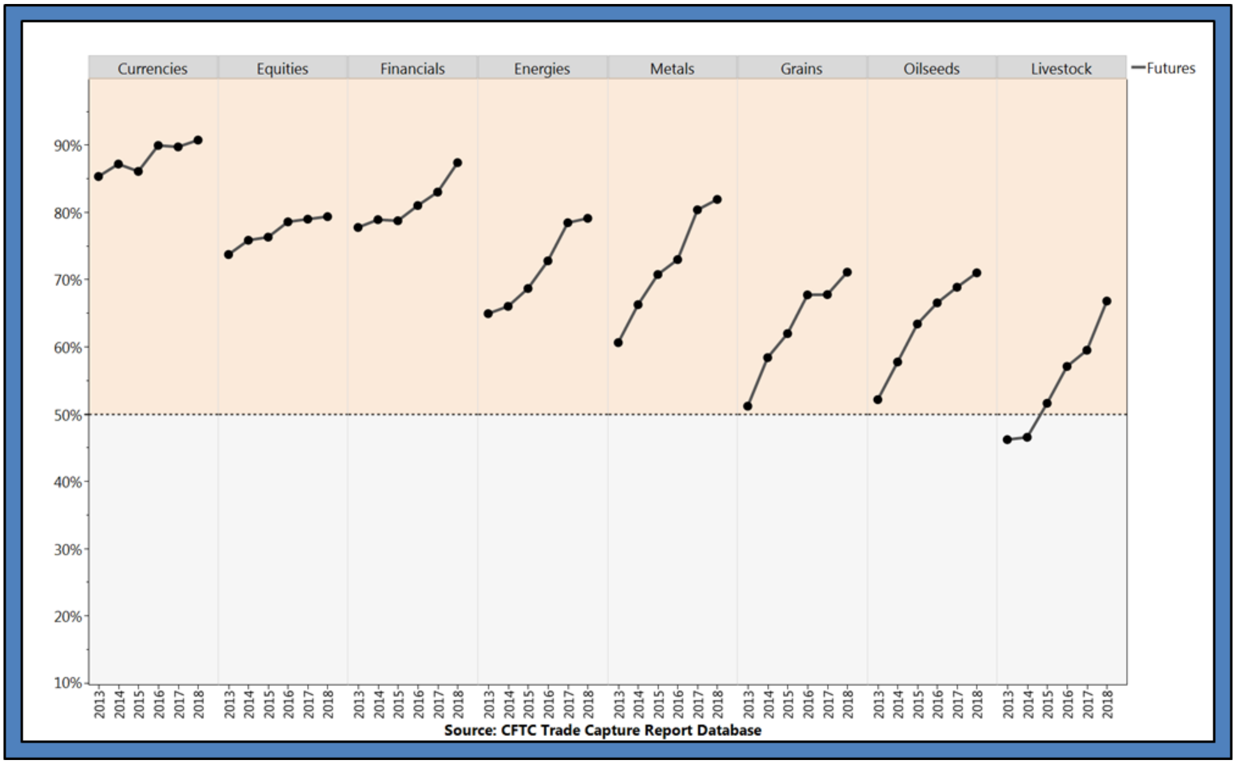
Oilseeds
Soybean Futures
Soybean Meal Futures
Soybean Oil Futures

Livestock
Feeder Cattle Futures
Lean Hog Futures
Live Cattle Futures

Figure 1 is a list of futures contracts that DMO staff assigned to the eight commodity groups. Staff included the most actively traded futures contracts within each commodity group.

Within each DMO-assigned commodity group, staff calculated the total number of outright and spread order transactions that were entered on CME Globex, which originated from either manual inputs or an automated trading system (ATS). Then, staff aggregated the individual markets' total number of consummated transactions for every year.

Figure 2
Share of Automated Futures and Options Transactions



Source: CFTC Trade Capture Report Database

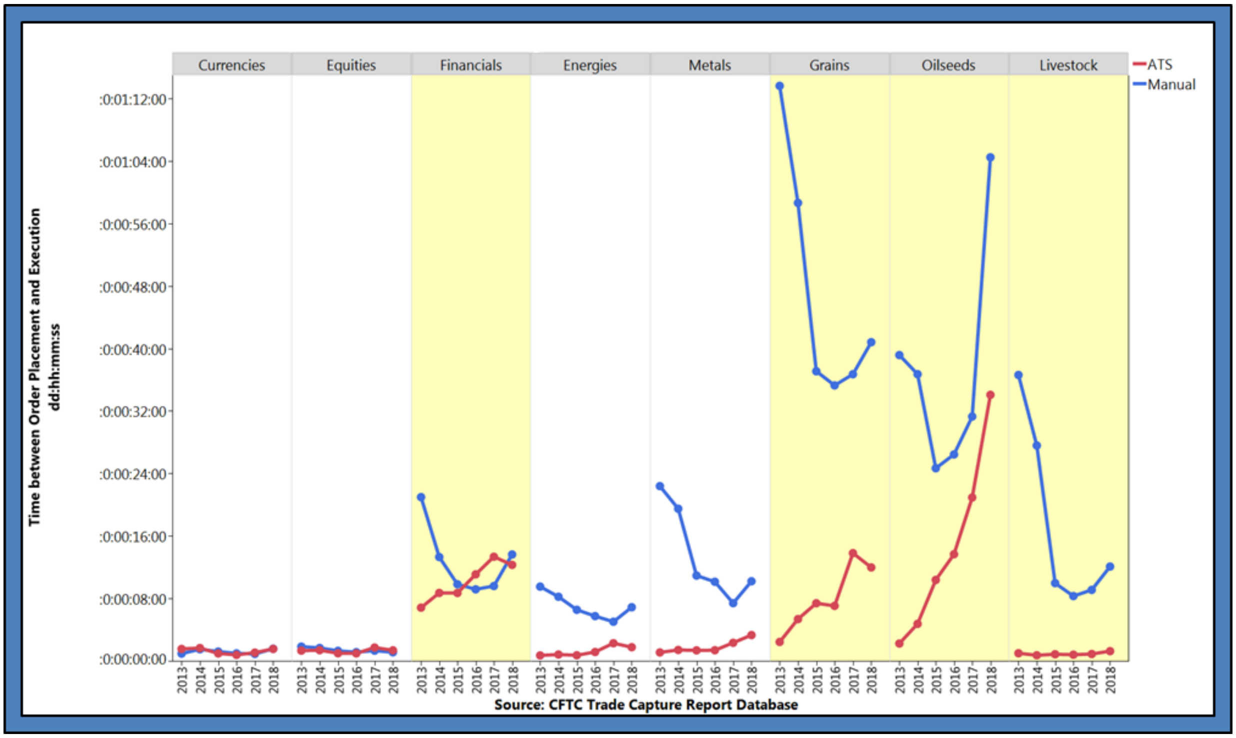
Figure 2 shows the share of ATS orders entered in futures markets. Overall, across all the commodity groups, the share of ATS orders[2] increased from 2013 to 2018. On average, the share of ATS orders in Currencies, Equities, and Financials increased 7%. The average percentage increase was 19% for Energy, Metals, Gains, Oilseeds, and Livestock.

Throughout the study period, the share of ATS orders was generally higher for financial products (i.e., Currencies, Equities, and Financials) than for physical commodities. After conducting interviews with market participants who trade futures and underlying cash products, DMO staff determined that a possible explanation for the higher level of automation in the financial products is the large transactional volume and low basis risk between the futures contracts and the underlying cash markets. Furthermore, the lower share of automation in the physical commodities may be attributed to the usually higher basis risk associated with delivery specifications in the cash markets and, in some cases, slight differences in the futures contracts to the actual cash market.

Resting Time

DMO staff reviewed the time period during which limit orders were exposed to the market before being filled. The time between when an order is entered and the time when it is consummated is known as order resting time. DMO staff considers resting time to be a measure of the speed of trading.

Figure 3
Median Resting Time of Limit Orders



Source: CFTC Trade Capture Report Database

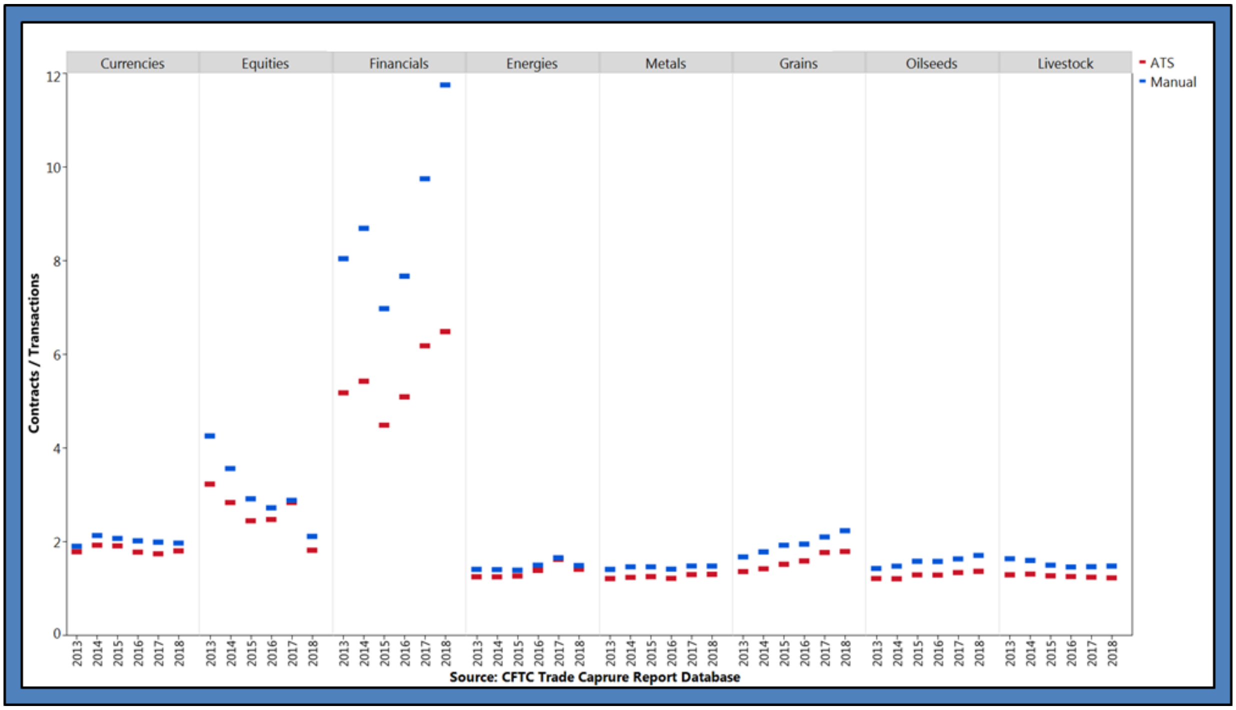
Figure 3 depicts median resting times for limit orders over the period from 2013 to 2018. The red lines show the ATS orders and the blue lines show the manual orders. DMO staff calculated the median resting time within each commodity group by using the individual contract markets' resting times, ordering them in value, and then finding the median for the entire group. In the groups with the white background, for all or most of the contract markets included in those groups, the exchange uses a first-in, first-out (FIFO) algorithm to match buy and sell orders; whereas for some of the contracts in the groups shaded in yellow, the matching algorithm prioritizes using order size.

The graph above shows that manual orders were exposed to the market for a slightly longer time than ATS orders. Based on interviews conducted with market participants, DMO staff determined that one contributing factor for these longer resting times may be that, in general, manual limit orders tend to be placed away from the market. The graph also shows that some commodity groups had shorter ATS order resting times than others. Based on the aforementioned interviews, DMO staff discovered that one explanation for the shorter resting times may be the significant high frequency trading activity in these commodity groups.

Transaction Size

DMO staff examined the average number of contracts per transaction during the period from 2013 to 2018. To calculate the average number of contracts within each commodity group, staff divided the total number of contracts by the total number of transactions and trading days for every year.

Figure 4
Average Number of Contracts Per Transaction



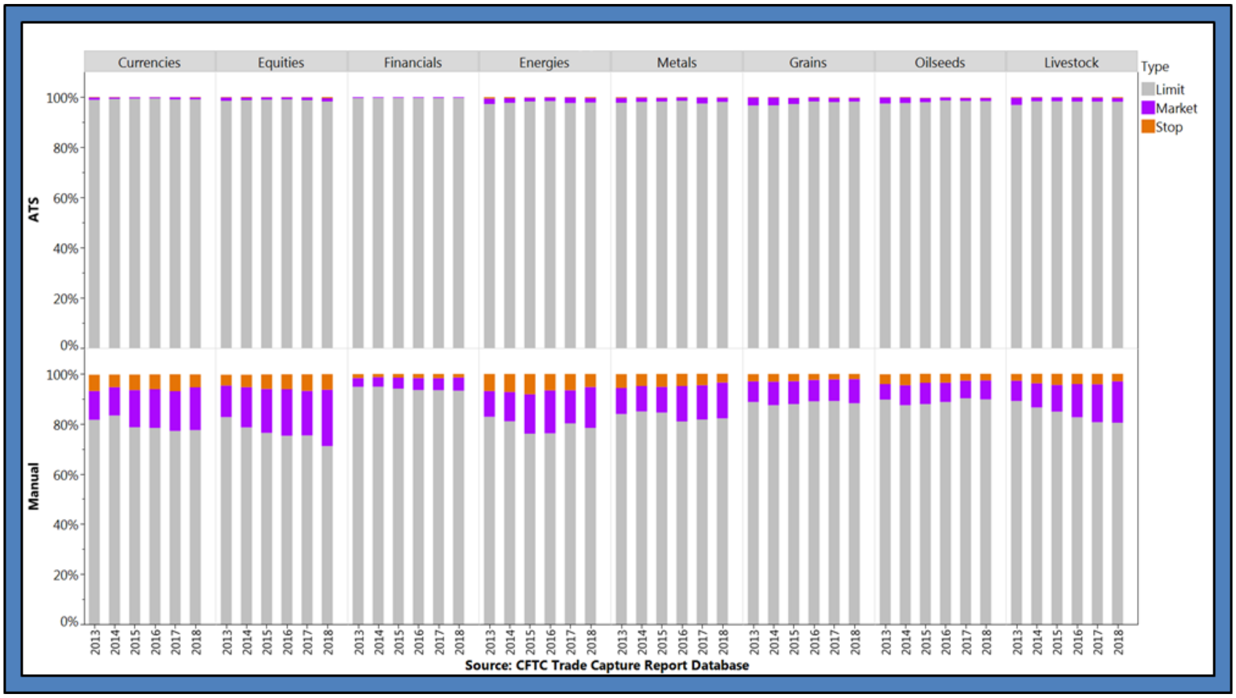
Source: CFTC Trade Caprure Report Database

Figure 4 depicts, on average, the number of contracts that were consummated in every ATS order (in red) and manual order (in blue). Across all commodity groups, contract sizes per transaction for ATS orders were slightly smaller than for manual orders. Both groups had an average transaction size between 1 and 2 contracts. However, contract sizes per transaction in the Equities and Financials groups tended to be larger. After examining the market participants listed in the CFTC trade capture report database, DMO staff determined that there were considerable numbers of big institutional traders in the Equities and Financials groups who generally consummated more contracts per transaction.

Types of Orders

DMO staff examined the order type composition of automatically and manually entered orders. Staff categorized the order types simply based on whether they were limit, market, or stop orders. Limit orders define the maximum purchase price for buying and the minimum sale price for selling an instrument. Market orders get executed immediately at the current market price. Stop-loss orders do not immediately go on the book – they must be “triggered” at the price level submitted with the order.

Figure 5
Futures Order Type Breakdown



Source: CFTC Trade Capture Report Database

Figure 5 breaks down the order composition for ATS orders (top panel) and manual orders (bottom panel). The different order types are marked as follows: limit in grey, market in purple, and stop in orange. Staff calculated the order type percentage breakdowns in each commodity group based on the total traded volumes of the individual contract markets within the group. As the graph shows, ATS orders were almost exclusively limit orders. Manual orders were stop-loss orders 4% and market orders 11% of the time.

Based on interviews that DMO staff conducted with market participants who enter orders both manually or automatically, staff identified that a main reason for this difference is the ability of automated traders to replicate the functionality of stop-loss and market orders by relying on their speed in reading prices and placing limit orders instead. The implication of this finding is that market events, in terms of excessive price movements, cannot be explained solely by investigating stop-loss orders that were entered during the event. To reflect this, the CME's velocity halt logic includes both stop-loss and limit orders (CME, 2019).

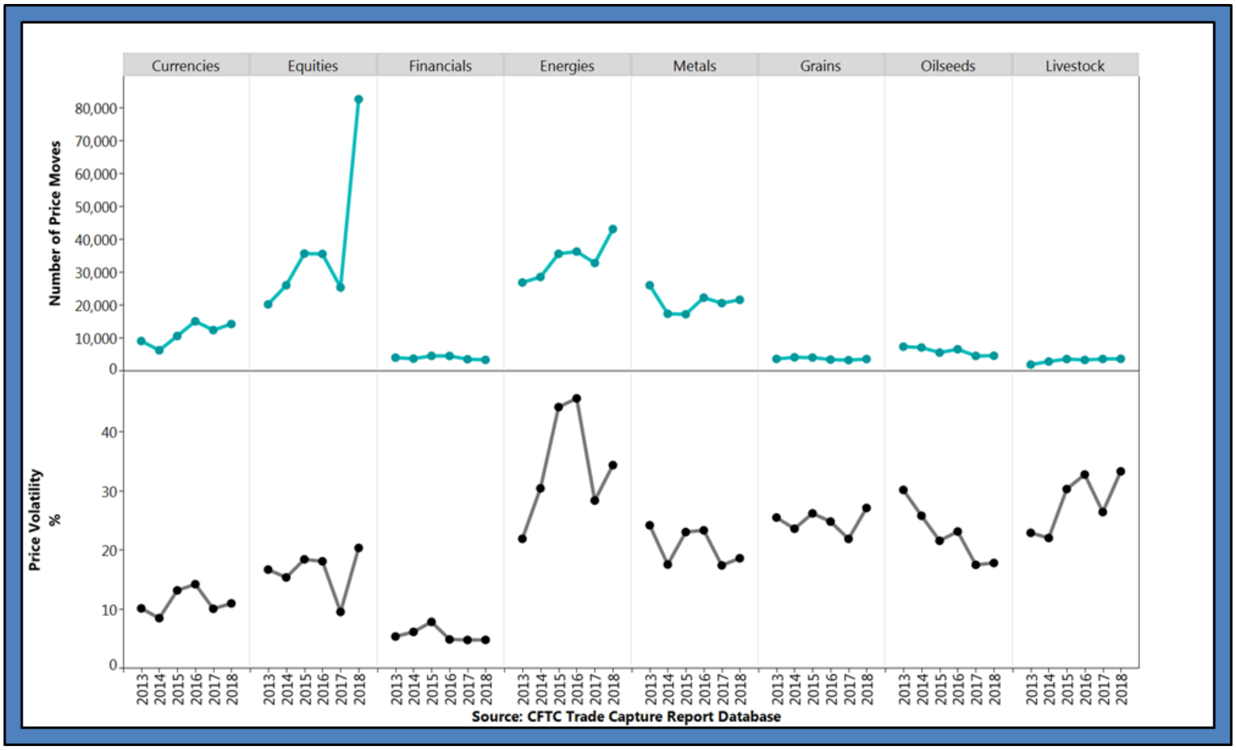
Price Moves and Historical Volatility

DMO staff quantified the overall movement of commodity prices in two ways. First, staff counted the average number of daily price moves (up or down movements) in all contract markets within each commodity group. Second, staff calculated the standard deviation of a 252-day window of one-day, natural logarithm price returns. The aforementioned price returns were derived from the end-of-day settlement prices and were normalized to an annual volatility measure. Staff first calculated this historical price volatility for the individual contract markets. Then, staff averaged these numbers within each commodity group to arrive at a common volatility representation for every year. This depiction of volatility is considered to be driven by market fundamentals because it involves the change in prices over long periods of time, in this case over years.

Intra-day volatility, using pricing data within each trading date, from open to close, was not analyzed in this study.

Figure 6

Average Number of Daily Price Moves and Price Volatility



Source: CFTC Trade Capture Report Database

Figure 6 depicts the average number of daily price moves in the top panel, and the historical price volatility in the bottom panel of the graph. Based on this yearly depiction of the two price measurements, DMO staff concluded that for most of the commodity groups, when historical end-of-day volatility increased or decreased so did the number of daily price moves.

To further investigate the relationship between the two price measurements, DMO staff performed a correlation analysis, depicted in Figure 7 on the next page. Staff showed the degree and pattern of the relationships between the paired variables as a scatterplot. The numbers within the individual blocks represent the correlation coefficients. Most of the coefficients are above 0.5, meaning that there is moderate to high positive correlation between the two price measurements. This observation suggests that, in general, the fundamentals-driven historical volatility is not disconnected from trading activity that drives the number of up or down price ticks each day.

Figure 7
Correlation between Historical Volatility and Price Moves

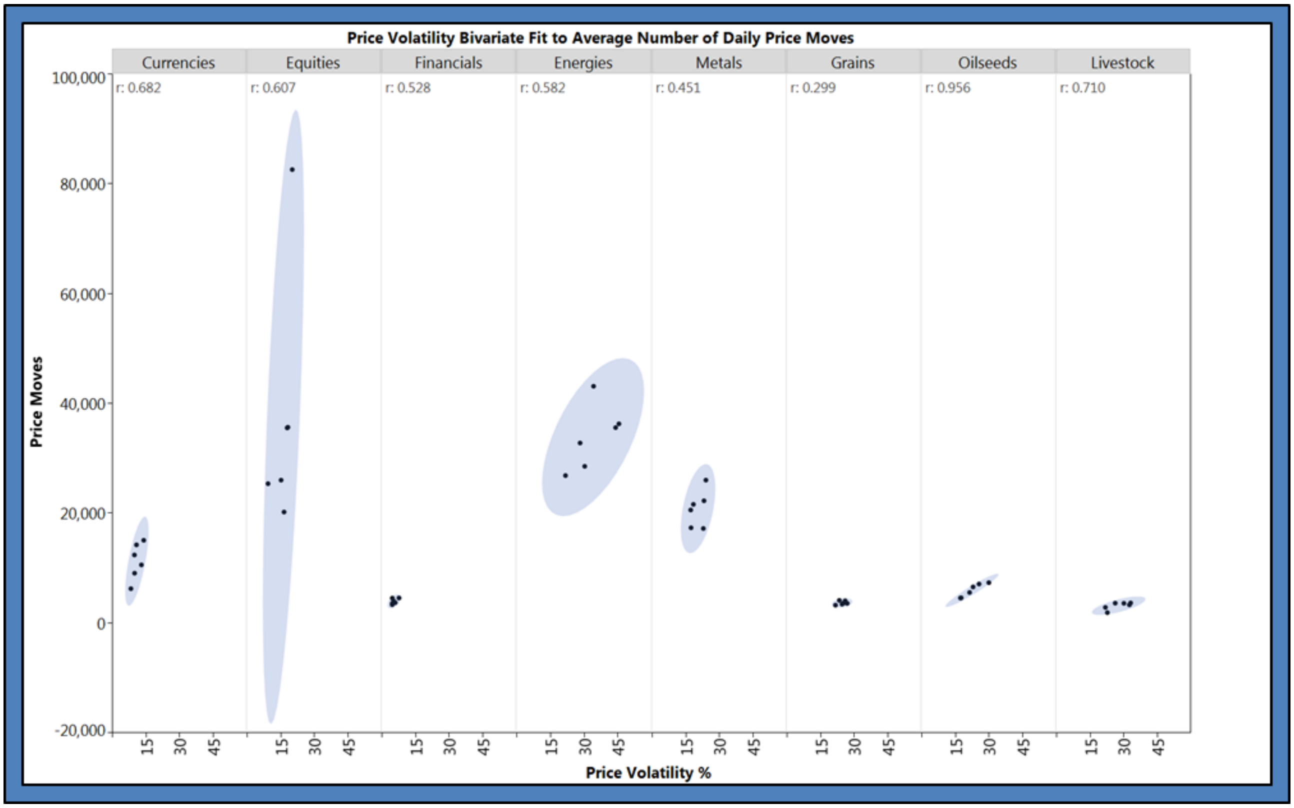


Figure 8
Correlation between Historical Volatility and Share of Automated Orders

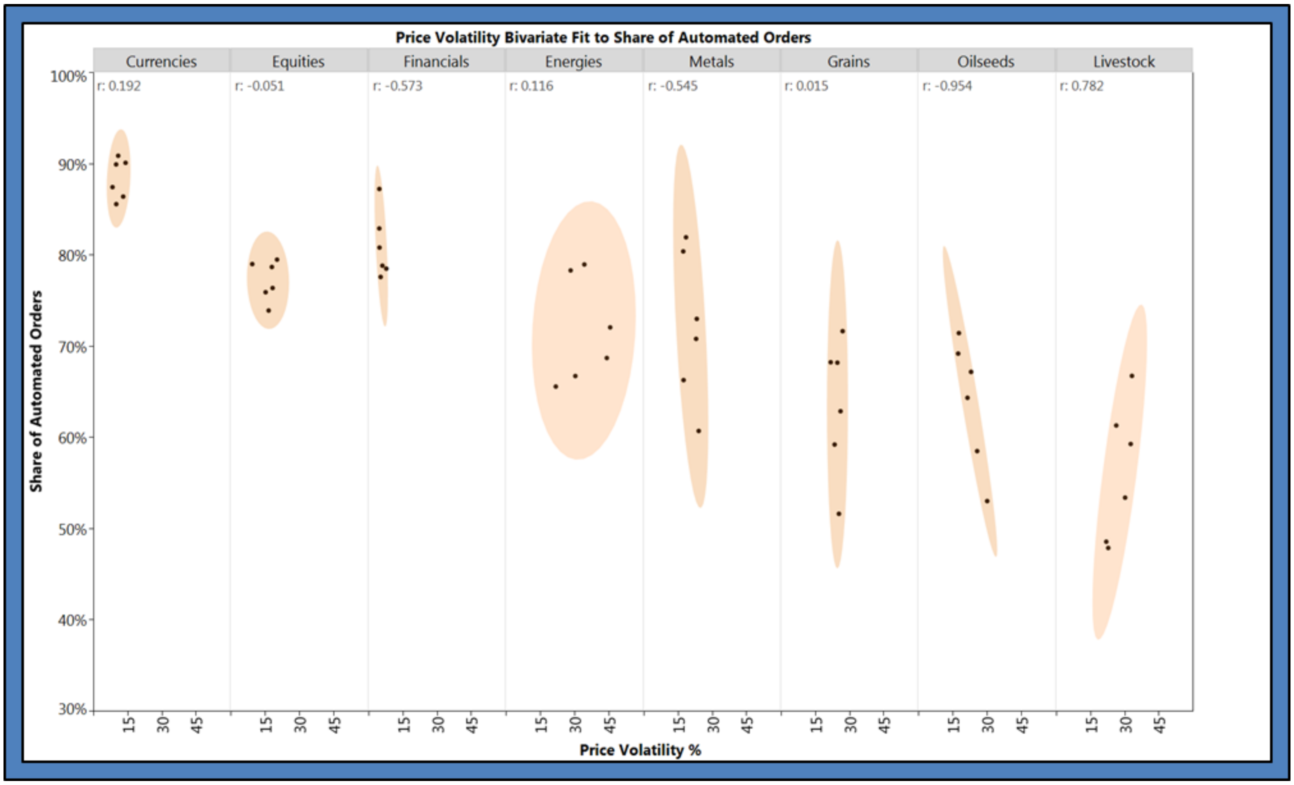


Figure 8 above shows a correlation analysis between historical end-of-day price volatility and share of automated orders. The numbers within the individual blocks represent the correlation coefficients. The majority of the correlation coefficients between these two variables are either around 0.1, which implies no relationship, or negative numbers, which implies a negative linear relationship.

As discussed at the beginning of this report, the level of automated trading in futures markets has been increasing steadily over the period from 2013 to 2018. The aforementioned price analysis shows that historical end-of-day price volatility has not been equally increasing year-over-year. However, this does not imply that automated trading has not affected short term market events or intra-day price volatility which was not part of this study.

Price Volatility and Transactional Volume

DMO staff also examined the volume traded, total number of transactions, and historical price volatility over the study period.

Figure 9
Total Futures Volume, Number of Transactions and Price Volatility

Source: CFTC Trade Capture Report Database

Figure 9 superimposes the total volume traded (in blue), the total number of transactions (in red), and the historical price volatility (in black) for every commodity group. Based on this analysis, the graph shows that generally as historical volatility goes up, so does the trading volume and number of transactions. For example, the notable decrease in historical volatility from 2015 to 2016 and its subsequent increase in 2017, in the Equities commodity group, are similarly reflected in the changes in volumes for the same years.

Conclusions and Takeaways

This research examined the effects that manually and automatically entered orders had on futures markets over a period of six years. DMO staff observed that automation has increased consistently over the study period. Furthermore, automatically submitted orders had a smaller number of contracts per transaction and were exposed to the market for shorter periods of time compared to manually entered orders. DMO staff also observed that historical end-of-day price volatility was positively correlated with the average number of daily price changes. Lastly, although DMO staff did not analyze intra-day price volatility movements, staff did not find a systematic rise in end-of-day historical price volatility as the share of automation increased across all futures markets.

Endnotes

1 End-of-day volatility is defined in this report as the statistical volatility calculated as a standard deviation of the natural logarithm of the end-of-day settlement price returns over a period of one year.

2 The analysis was based on the number of transactions regardless of the number of underlying contracts in each transaction.

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Mr. Rahul Varma is the Associate Director, Division of Market Oversight, at the Commodity Futures Trading Commission. He has been an Associate Director at the CFTC since May 2013. From 2013 through 2016, Mr. Varma was in Market Surveillance with responsibility for Energy, Metals, Agricultural, and Softs markets. Since 2017, Mr. Varma has been in the newly formed Market Intelligence Branch of DMO.

Interview with Blythe Masters

A Global Leader of Innovation across Markets and Asset Classes[1]

Former J.P. Morgan senior executive, **Blythe Masters**, during a visit to the JPMCC's commodity lab at the University of Colorado Denver Business School.

Each issue of the *GCARD* includes an interview with a thought leader or innovator in the commodity or digital asset arena. In this issue, we have the immense privilege of interviewing Ms. Blythe Masters, a former senior J.P. Morgan executive, who has distinguished herself as a thought leader and innovator across many disciplines, including in derivatives, commodities, and in digital asset technology. Importantly for this publication, these are all areas which are covered at the J.P. Morgan Center for Commodities (JPMCC) and in the *GCARD*.

Blythe Masters has a special connection to the JPMCC. She was a member of the J.P. Morgan senior leadership team that worked on the bank's $5.5 million gift to the University of Colorado Denver Business School in 2012. This donation, along with significant contributions from CoBank and George Solich of FourPoint Energy, among others, led to the establishment of the JPMCC.

It is entirely appropriate to review Master's accomplishments, but in order to inject a note of originality in this introduction, we will provide a personal anecdote first. In November 2015, Ms. Masters presented to the Federal Reserve Bank of Chicago's Working Group on Financial Markets[2] on "How Blockchain Technology Could Completely Change Clearing and Settlement in the Financial Services Industry," which the Contributing Editor of the *GCARD* attended as a member of this advisory group. In presenting and answering questions, Masters spoke without hesitation in complex paragraphs, only pausing for breaths. The next day she was to travel from Chicago to London to provide a similar presentation to the Bank of England. This brief anecdote illustrates the intelligence and energy level that Masters possesses, and furnishes some insight into the traits that are absolutely necessary for industry participants whom are at the very top of their respective professions.

As for Blythe Master's professional career thus far, she held a number of high-ranking (and high-profile) positions at J.P. Morgan in a career that spanned 27 years at the bank. These positions included becoming a managing director at the age of 28 for her work in commercializing innovative derivatives structures, followed by serving as the Chief Financial Officer of J.P. Morgan's Investment Bank, after which she became the head of J.P. Morgan's Global Commodities division. Masters left the bank in 2014 after successfully selling the bank's physical commodities business to the Swiss commodities trading group, Mercuria.

From 2015 to 2018, Masters served as the CEO of Digital Asset Holdings, which licenses digital ledger technology software to large financial institutions. (An interview with Digital Asset's co-founder, Don Wilson, is included in the Winter 2018 issue of the *GCARD*.) In review, a "distributed ledger is decentralized to eliminate the need for a central authority or intermediary to process, validate or authenticate transactions," explained Belin (2019). As argued by Masters in Lee (2016), the cost-savings potential of this type of shared infrastructure for financial institutions is immense: "We're not talking five, 10 or 15% cuts in costs; we're talking 30%, 40%, 50%. There's only one way to do that and that is to share a mutualized common infrastructure that previously was kept separately and run independently by every market participant."

Master's additional positions include serving as the Chairman Emeritus of the Governing Board of the Linux Foundation's open source Hyperledger Project as well as serving as a member of the International Advisory Board of the Santander Group and as an Advisory Board Member of the U.S. Chamber of Digital Commerce.

Returning to our interview, we ask Masters how she became involved in the commodity industry and also how the structure of the industry has changed over time. In addition, we inquire about her predictions on promising financial technologies, particularly those impacting the commodity markets. As the *GCARD* is an educational institution publication, we next ask Masters on her advice for students involved in her varied areas of expertise. Finally, given Masters' pioneering role with the JPMCC, we conclude the interview with her views on how the JPMCC can continue to provide value to the commodity industry.

Interview with Blythe Masters

How did you first get involved in the commodities markets?

In 1990, I began my third internship for J.P. Morgan, in New York, on August 2nd, the day that Iraq invaded Kuwait, triggering the first Gulf War. I was assigned to the then small commodities desk, which provided full service bullion trading and financial derivatives in oil and refined products. Needless to say, a period of significant market volatility ensued. The experience was fascinating, not just because of the price fluctuations, but because of the diversity of risk management challenges that arose. These included the physical logistics of engineering movements of gold bullion through a war zone. Also this was my first introduction to basis risk: jet fuel swaps provided to airline customers hedged with long crude oil futures positions proved to be exceptionally challenging when the price differential between crude and fuel (the basis) expanded to unprecedented levels.

Later after I graduated in 1991, I joined the commodities business full time, initially as a trader making prices for customers. Later I joined investor derivatives marketing where I advanced the introduction of commodities as an investable asset class and authored the J.P. Morgan Commodities Index.

Many years later in 2007, I returned to the, by then substantially more complex, commodities space to build a full-service physical and financial business across the full spectrum of commodities.

What are some of the major changes that have occurred in the commodity markets over time?

Commodities markets are as old as human civilization itself, with the earliest evidence of trading between settlements dating to 8500 BC, and even that most modern of futures markets, the venerable CBOT, dating to 1848. What is remarkable given that enduring history is the extent of change that has occurred in the past 30 years.

During that time we have seen the emergence of giant forward and futures markets for new commodities including natural gas and LNG, electricity, coal and emissions, which arise from the regulation of polluting activity, and which permit trading in certificates evidencing the absence of emissions of invisible gases!

As the scope of tradable futures and forwards markets has grown, this has enabled greater integration of physical and financial activities, allowing structures in which real-world commodity-intensive operations from mining to refining and beyond are capitalized, financed and hedged to produce far more predictable returns for investors.

As with every other market, the advent of the internet and online trading has also changed commodities markets, attracting a new class of participants enjoying fewer barriers to entry and improved access to information.

Also over this time we have seen the articulation of the case for commodities as an asset class and the corresponding development of index funds as a vehicle for investors. The so-called financialization of commodities markets has prompted furious debates over its impact on prices and volatility. While transitory price impacts can't be ruled out, persistent ones can be. A more lasting impact is that increased participation has improved liquidity and lowered bid-offer spreads.

What is your outlook for digital ledger technology, including blockchain, particularly its impact on the commodity industry?

Blockchain or distributed ledger technology allows independent entities, which have a common interest in something of value, to share and update a common record, without blindly trusting anyone, safe in the knowledge that the record cannot be changed without the knowledge of the impacted parties.

The technology has several applications in commodity markets which I will illustrate with two examples.

First, supply chains — everything involved from the extraction of raw materials to the distribution of goods—are notoriously complex. They can span hundreds of stages, multiple international locations, multitudes of invoices, payments and letters of credit, and involve many entities, extending over months of time. It's extremely difficult to investigate supply chains and prove provenance when there is suspicion of illegal or unethical practices. They can also be highly inefficient as vendors, suppliers and financiers try to connect the dots on who needs what, when and how.

Blockchain technology has the potential to impact the way extractive industry and related supply chains operate profoundly, delivering a much-needed productivity boost. Blockchain offers a shared, immutable record of all parties' participation, certification, attestation, and validation, facilitating the exchange of critical trade documents, such as bills of lading and letters of credit, between connected users securely and confidentially. This facilitates fewer paper exchanges, faster transactions, fraud prevention, and proof of provenance, sustainability and compliance. Clearly, this can benefit the commercial, financial and operational aspects of commodities markets.

Second, financial market efficiency: in just the same way that blockchain can eliminate the complexity of physical supply chains, it can do the same for financial markets. By creating immutable, secure, shared yet confidential data, the parties involved in financial data processing are able to eliminate the data silos that plague post-trade today. This means faster settlements, fewer errors, greater automation and straight through processing, dramatically reduced reconciliation requirements, real or near real time data for risk management and regulatory reporting, and any number of new services that will be driven by better access to higher quality data.

Given your experience across industry disciplines, what advice might you give to students specializing in financial technology, derivatives, and/or commodities?

My advice for students focused in these areas probably wouldn't be much different than for those working elsewhere:

Sweat the details: there's no substitute for preparedness and thoroughness.

Always make your assumptions explicit: often some of the most significant risks are those which have been assumed away (operational risk, counterparty failure, basis risk, liquidity risk).

Avoid crowded trades: the exit strategy is usually more important than the entry strategy.

Get deep and establish differentiated expertise before you aim to go broad. It is almost impossible to head in the opposite direction.

Study history: what you've experienced almost always falls short of what could happen.

Choose who you work with carefully. Seek out and emulate traits you admire.

How can the JPMCC continue to be of most benefit to the commodity industry?

The center should seek to continue to be a valuable source of education and training, debate, incubation and transparency in markets which generally lack these. Pick up on the hot topics and cast daylight on them, but ground the analysis in fundamentals.

Thank you, Blythe, for this opportunity to interview you!

Endnotes

1 As noted by Shah (2014).

2 The organizer of the Federal Reserve Bank of Chicago's Working Group on Financial Markets meeting in November 2015 was Mr. John McPartland, whom in turn co-authored the article, "Blockchain and Financial Market Innovation," for the Summer 2019 edition of the *GCARD*.

For further coverage of the digital asset markets, the reader is invited to read past *GCARD* articles on these markets.

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Biography

BLYTHE MASTERS

Ms. Blythe Masters is an internationally recognized innovator in derivatives, commodities, and in digital assets. Most recently, from 2015 to 2018 she was the CEO of Digital Asset Holdings, which is using digital technology to enhance settlement and recording of both digital and mainstream financial assets.

Ms. Masters was previously a senior executive at J.P. Morgan which she left in 2014, following the successful sale of the bank's physical commodities business which she built. Between 2007 and 2014 Ms. Masters built the bank's leading commodity business, including market-making, structuring, risk management, financing and logistical capabilities. From 2012, she was also responsible for Corporate & Investment Bank Regulatory Affairs. She was a member of the Corporate & Investment Bank Operating Committee and previously the firm's Executive Committee. From 2004 to 2007, she was CFO of the Investment Bank. Prior to that, she was head of Global Credit Portfolio and Credit Policy and Strategy, responsible for managing the credit and market risks of the bank's retained credit positions. Earlier positions include head of North American Structured Credit Products, co-head of Asset Backed Securitization and head of Global Credit Derivatives Marketing. Ms. Masters joined J.P. Morgan full-time in 1991, after completing a number of internships at the bank dating back to 1987.

Ms. Masters is the former Chair of both the Global Financial Markets Association (GFMA) and the Securities Industry and Financial Markets Association (SIFMA), which represent the common interests of leading financial and capital markets participants and whose missions include building trust and confidence in financial markets. She is a board member of the Breast Cancer Research Foundation and the Global Fund for Women and former Chair of the Greater New York City Affiliate of Susan G. Komen.

Ms. Masters has a B.A. in Economics from Trinity College, Cambridge.

EDITORIAL ADVISORY BOARD MEMBER NEWS

Investing in Infrastructure, Energy and Commodities

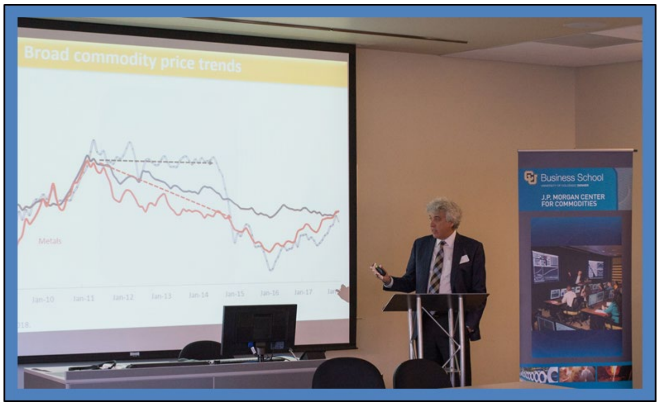
Robert Greer participated in the "Investing in Infrastructure, Energy and Commodities" session at the ALTSLA conference on March 14, 2019 in Los Angeles. Pictured from left to right are Esther Zurba, Castlehall; Toby Loftin, BP Capital Fund Advisors; *Robert Greer*, Scholar-in-Residence, JPMCC; and Josh Duitz, Aberdeen Standard, during the panel session. (Photo courtesy of ALTSLA.)

Robert Greer, Scholar-in-Residence, J.P. Morgan Center for Commodities (JPMCC) and Member of the *GCARD*'s Editorial Advisory Board, was a featured panelist at the "Investing in Infrastructure, Energy and Commodities" session during the 2019 ALTSLA conference. Mr. Greer is also a Senior Advisor at CoreCommodity, LLC.

Mr. Greer was interviewed in the Winter 2017 issue of the *GCARD*. In this article, Mr. Greer explains how he became involved in the commodity markets and what led him to writing the first published article on an investable commodity index. He also touches on some of the major changes facing the commodity industry.

Commodities, Volatility and Risk Management

John Baffes, Ph.D., Senior Economist at the World Bank and Member of the *GCARD*'s Editorial Advisory Board, provided his organization's outlook on the commodity markets in conferences in New York, Tokyo, and Paris during the Spring of 2019. During the Paris conference, Dr. Baffes participated in a panel on "Trade Restrictions, Trade Wars, and Commodity Price Risk" at a conference on "Commodities, Volatility and Risk Management," which took place on May 15, 2019. This conference was organized by the Inter-American Development Bank and Oilseed Markets Research Initiative.



In addition to his other conference addresses, **John Baffes**, Ph.D., has also presented to the JPMCC's Advisory Council at the University of Colorado Denver Business School.

Women Innovators in Finance

The International Association for Quantitative Finance (IAQF) held its first annual "Women Innovators in Finance" conference in New York City in May 2019. This event featured experts in factor-based strategies, data science, risk management, and dynamic derivatives strategies that include commodities. The event was co-organized by Monique Miller of Euclidean Capital and **Hilary Till**, both of whom are board members of the IAQF. Of note is that the IAQF is a professional society partner of the *GCARD*.

(Continued next page)

Women Innovators in Finance (Continued)

The event's panel of experts included Katelyn Gallagher, BlackRock; Melanie Petsch, New York Stock Exchange; and Melissa Sexton, Morgan Stanley Wealth Management with Yana Keresteliev, UBS, participating as the moderator.

Hilary Till, Contributing Editor of the *GCARD* and Board Member of the International Association for Quantitative Finance (IAQF), co-organized the IAQF's first annual "Women Innovators in Finance" conference on May 21, 2019 at BlackRock in New York City. Pictured from left to right are Melissa Sexton, Morgan Stanley Wealth Management; Melanie Petsch, New York Stock Exchange and past *GCARD* Editorial Advisory Board Member; and *Hilary Till*, Solich Scholar, JPMCC, during the kick-off of the conference. (Photo courtesy of David Jaffe, Executive Director, IAQF.)

Bretton Woods Committee

Dr. Kaifeng (Kevin) Chen, Ph.D., lectured on "Supply Side Economic Reform in China and Global Commodities Dynamics" during one of the JPMCC's international commodity symposiums at the University of Colorado Denver Business School.

Dr. Kaifeng (Kevin) Chen, Ph.D., Chief Economist for Horizon Financial and adjunct associate professor at New York University's School of Professional Studies Center for Global Affairs, has been selected to join the esteemed Bretton Woods Committee. The committee is a nonpartisan network of prominent citizens that works to demonstrate the value of international economic cooperation. Dr. Chen is also a member of the *GCARD*'s Editorial Advisory Board and is a past contributor to the *GCARD*.

GLOBAL ENERGY MANGEMENT

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GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

The *Global Commodities Applied Research Digest* (*GCARD*) is produced by the J.P. Morgan Center for Commodities (JPMCC) at the University of Colorado Denver Business School.

The JPMCC is the first center of its kind focused on a broad range of commodities, including agriculture, energy, and mining. Established in 2012, this innovative center provides educational programs and supports research in commodities markets, regulation, trading, investing, and risk management.

Subscriptions to the *Global Commodities Applied Research Digest* are complimentary because of a generous grant from the CME Group Foundation: http://www.jpmcc-gcard.com/subscribe/.

The *GCARD* is edited by Ms. Hilary Till, the JPMCC's Solich Scholar, http://www.jpmcc-gcard.com/hilary-till, whom can be contacted at hilary.till@ucdenver.edu.

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