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

GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

WINTER 2022

Supported by funding from

CoBANK

IPI INTEGRATED PORTFOLIO INTELLIGENCE LLC

FOURPOINT ENERGY

CME Group

Business School
UNIVERSITY OF COLORADO DENVER

GLOBAL COMMODITIES APPLIED RESEARCH DIGEST

Vol. 7, No. 2: Winter 2022

Index of Articles

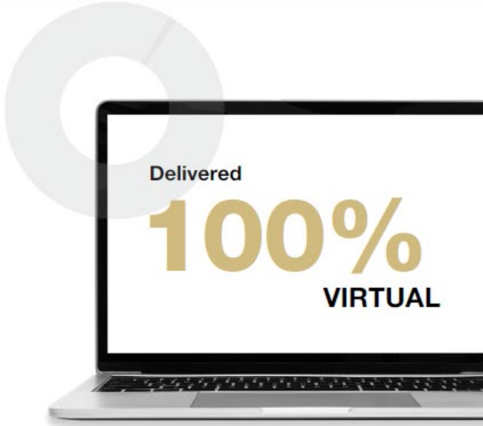
Business School
UNIVERSITY OF COLORADO DENVER

JP MORGAN CENTER FOR COMMODITIES

COMMODITIES GRADUATE CERTIFICATE

From the food we eat, to how we build our homes and cities and the energy that powers our lives, commodities underlie our global economy. Businesses around the world rely on professionals whom understand the critical relationships across, geopolitics and financial markets to drive success.

During the certificate program, you'll gain valuable insights from industry experts at the J.P. Morgan Center for Commodities and acquire essential knowledge about a broad range of commodities, including agriculture, energy, minerals and metals. Our program's strong industry support means that each of our career-focused courses will prepare you to solve real-world business problems in the commodities sector.



- Prepares you to build a successful career in the fast-paced world of commodities.
- Designed for students who want to explore the commodity sector, learn from professors with deep-industry experience, and develop an in-demand set of practical business skills.

This certificate is an excellent option for individuals who:

- Are seeking to enter into and advance into commodity producing companies, logistics and consulting firms and financial and trading organizations
- Are currently working and seeking a career pivot into the commodity sector
- Are seeking in-depth continuing education credits for their professional discipline
- Already hold an advanced degree and desire specialized knowledge around commodities

CERTIFICATE COURSES

CMDT 6802	FOUNDATIONS OF COMMODITIES	JAN 17 - MAR 11, 2023
	This course introduces students to the physical aspects of commodities and connects them to the financial markets in which commodities are traded. Fundamental concepts and terminology necessary for understanding commodity production, transportation, economics, financial analysis and marketing are introduced. Supply and value chains for a number of specific commodities are reviewed in detail as examples of the production and market structure knowledge needed to be successful professional participants in commodity research, analysis and trading capacities. The course also serves as a foundation for more focused education in other J.P. Morgan Center for Commodity courses.	

CMDT 6582	COMMODITY SUPPLY CHAIN MANAGEMENT	JAN 17 - MAR 11, 2023
	This course introduces students to the world of physical commodity supply chains. It explains the actors, factors, and mechanisms involved in the trade, marketing, and distribution of commodities and natural resources and the economic impacts on major capital projects. Students will leave the course with an understanding of worldwide supply and demand patterns, how commodity markets function, the risks involved in trading, and analytical skills to support strategic decision-making.	
CMDT 6490	**COMMODITY TRADING**	**MAR 13 - MAY 13, 2023**
	CMDT 6490 explores commodity trading as practiced at firms with physical & financial exposures to the agriculture, metals/minerals, and energy markets. Students will develop a methodology for translating fundamental information and prevailing market conditions into a perspective on the future of price. They will learn to develop & evaluate different strategies to implement their view of the market, then choose the best available option based on its performance characteristics. The course concludes by examining how traders execute in the market and manage the resulting positions, including an in-depth exploration of complex structured transactions.	
CMDT 6682	**COMMODITY HEDGING**	**MAR 13 - MAY 13, 2023**
	Hedging has been a staple in the commodities industry since the beginning of the Chicago Board of Trade in 1848. It has allowed producers as well as consumers to define their risk for tomorrow, today with the use of forwards, futures, swaps, and options. This class will examine the history of commodity hedging, how companies have blown up with improper hedges and how companies have used proper hedges effectively. Case studies will be examined. This class will also explore how to put on proper hedges, and learn the fundamentals of forwards, futures, swaps, and options. There will be practical application to build hedging solutions in various industry sectors.	

Our 100% online Commodities Certificate from the University of Colorado Denver Business School prepares you to build a successful career in the fast-paced world of commodities. Our program is designed for students who want to explore the commodity sector, learn from professors with deep-industry experience, and develop an in-demand set of practical business skills.

LEARN MORE ABOUT THE CERTIFICATE

Questions? Contact our team at commodities.center@ucdenver.edu.

CU DENVER BUSINESS SCHOOL

More Information: 303-315-8066

1475 Lawrence St. Denver, CO 80202

Denver

BUSINESS SCHOOL
J.P. MORGAN CENTER FOR COMMODITIES

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 in association with Premia Education, Inc.

The JPMCC's leadership team is as follows. Thomas Brady, Ph.D., is the CoBank Executive Director of the JPMCC. The JPMCC's Research Director is Jian Yang, Ph.D., CFA, who is also the J.P. Morgan Endowed Research Chair, JPMCC Research Director, and Discipline Director and Professor of Finance and Risk Management at the University of Colorado Denver Business School. The JPMCC's Assistant Director, in turn, is Erica Hyman. Periodic updates on the JPMCC's activities can be found at https://www.linkedin.com/school/cu-denver-center-for-commodities/.

The JPMCC's scholars are as follows. Hilary Till is the JPMCC's Solich Scholar, and Robert Greer is the Center's Scholar in Residence. In addition, the Chairman of the JPMCC's Industry Advisory Council is Chris Calger, Managing Director, Global Commodities, J.P. Morgan.

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* was seeded by a generous grant from the CME Group Foundation and is published twice per year. The *GCARD* is currently supported by funding from CoBank, Integrated Portfolio Intelligence LLC; FourPoint Energy; and the CME Group.

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/.

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.

The *GCARD* also benefits from its academic and professional society partnerships in furthering the international recognition of the digest. These partners include ECOMFIN (a co-sponsor of the publication), 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 include the International Association for Quantitative Finance (IAQF) and the Chartered Alternative Investment Analyst (CAIA) Association.

The Commodity Trading Association (CTA) is the latest professional society partner for the *GCARD*. This association comprises the professional graduates in commodity trading programs at the University of Geneva (Switzerland) and has distinguished itself over the past few years by organizing outstanding professional events that create unique networking opportunities for active professionals in the commodity trading, shipping, and financing industries.

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.

As noted, 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 *in association with Premia Education, Inc.*

PREMIA EDUCATION, INC.

The *GCARD*'s editorial staff is as follows. The *GCARD's* Contributing Editor is Hilary Till, M.Sc. (Statistics) and Member of both the JPMCC's Research Council and the Center's Industry Advisory Council. Till edits the *GCARD* under the aegis of Premia Education, Inc. The *GCARD*'s Associate Editors are Ana-Maria Fuertes, Ph.D., Professor in Financial Econometrics at Bayes Business School, City, University of London (U.K.) and Joseph Eagleeye, Principal, Premia Research LLC. The *GCARD*'s Editorial Assistant, in turn, is Katherine Farren, CAIA, who is also a Research Associate at Premia Education, Inc.

© The Regents of the University of Colorado, a body corporate. All rights reserved. Reproduction in whole or in part of any of this work without written permission is prohibited. The opinions expressed in the *GCARD* are those of the individual authors.

TABLE OF CONTENTS
Vol. 7, No. 2: Winter 2022

J.P. Morgan Center for Commodities (JPMCC)

The JPMCC is positioned as a collaboration between business and academia across the broad agriculture, metals, and energy commodity sectors. Our mission includes commodity business education, applied commodity research, and commodity-related public forums & discourse.

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 in association with Premia Education, Inc. The JPMCC's leadership team is as follows. Thomas Brady, Ph.D., is the JPMCC's CoBank Executive Director. The JPMCC's Research Director is Jian Yang, Ph.D., CFA, who is also the J.P. Morgan Endowed Research Chair, JPMCC Research Director, and Discipline Director and Professor of Finance and Risk Management at the University of Colorado Denver Business School. The JPMCC's Assistant Director, in turn, is Erica Hyman. In addition, the JPMCC's scholars are as follows. Hilary Till is the JPMCC's Solich Scholar, and Robert Greer is the Center's Scholar in Residence.

Update from the Executive Director

This article provides a brief update from Dr. Thomas Brady, including the recent news that CU Denver's J.P. Morgan Center for Commodities is merging with CU Denver's Global Energy Management (GEM) Program. In addition, he discusses the academic initiatives of the combined entity. On the applied research front, the merger will allow GEM industry partners and stakeholders to participate in the Center's annual applied commodity research symposium as well as contribute articles to the new version of the *GCARD*.

Research Director Report

Dr. Yang discusses (a) his co-authored paper on "Price Discovery in China's Crude Oil Futures Markets: An Emerging Asian Benchmark?", which is forthcoming in the *Journal of Futures Markets*; (b) the JPMCC's 5th International Commodities Symposium in August 2022; and (c) the media coverage of the JPMCC's 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*. The Chairman of the JPMCC's Industry Advisory Council is Chris Calger, Managing Director, Global Commodities, J.P. Morgan.

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* periodically draws from insightful work 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.

Research Council Corner

The authors' analysis of commodities sets the stage by first concisely identifying the three most significant macro-factors for the year. With the foundation set, we examine a selection of energy, metals, and agricultural products where we highlight both the similarities and key differences in terms of how each commodity responded to our three major macro-factors. The article closes with some observations concerning the drivers of commodity super-cycles and the difficulties of risk management when uncertainty is elevated and risk is hard to quantify.

JPMCC Symposium Presentations

The article discusses recent evidence that gasoline price shocks have not been the main determinant of U.S. inflation. This evidence runs counter to the narrative that inflation would subside if only gasoline (Continued on the next page.)

JPMCC Symposium Presentations
(Continued)

prices could be lowered. The article's analysis suggests that gasoline price shocks do not have large persistent effects on inflation or long-run inflation expectations, which argues against traditional models of wage-price spirals.

Hurricanes disrupt oil production in the Gulf of Mexico because producers shut in oil platforms to safeguard lives and to prevent damage. We examine the effects of these temporary oil supply shocks for real economic activity in the U.S. We find no evidence that temporary oil supply shocks affect state-level employment or indirectly affect industrial production in sectors not immediately related to oil production. Temporary oil supply shocks appear to have minor price effects, mainly for gasoline prices and CPI inflation. We also find no effect on imports, exchange rates or the import price of oil. Our results suggest that oil reserves held by U.S. refiners are largely sufficient to absorb any temporary production disruptions.

Research Digest Articles

The following research digest articles were contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics, Bayes Business School, City, University of London, U.K. and Associate Editor of the GCARD

This article re-examines the previously documented evidence of crude oil return predictability from several popular economic predictors and technical indicators and their combinations. It shows that monthly average oil returns are forecastable, in line with evidence documented in previous studies. On the contrary, no evidence of predictability is found for end-of-month oil returns. The authors conclude that the evidence of oil return predictability documented in previous studies may be misleading, as it stems from the use of within-month averages of daily oil prices in calculating monthly returns whereas end-of-month returns are more relevant for risk management and investment decision making as reflecting actual change in asset value.

Commodity style-integration is appealing because by forming a unique long-short portfolio with simultaneous exposure to mildly correlated factors, a larger risk premium can be captured over time than with any of the underlying standalone styles. (Continued on the next page.)

Research Digest Articles
(Continued)

A practical decision that a commodity style-integration investor faces at each rebalancing time is the relative weight of the predictive- or sorting-signal that underlies each standalone style. The authors of this paper develop a new Bayesian optimized integration (BOI) method that accounts for estimation risk in the style-weighting decision. Focusing on the problem of a commodity investor that seeks exposure to the carry, hedging pressure, momentum, skewness, and basis-momentum factors, they demonstrate that the BOI portfolio outperforms not only a battery of parametric style-integrations motivated by the portfolio optimization literature, but also the highly effective equal-weight integrated portfolio. The findings survive the consideration of transaction costs, alternative commodity scoring schemes, and long estimation windows.

Research by Yufeng Han, Ph.D., Belk College of Business, University of North Carolina at Charlotte; and Lingfei Kong, Ph.D., Olin School of Business, Washington University in St. Louis

This paper identifies a trend factor that exploits the short-, intermediate-, and long-run moving averages of settlement prices in commodity futures markets. The trend factor generates statistically and economically large returns during the post-financialization period 2004-2020. It outperforms the well-known momentum factor by more than nine times the Sharpe ratio and has less downside risk. The trend factor is not encompassed by extant factors and is priced cross-sectionally. An analysis of macroeconomic and other market-wide drivers suggests that this trend factor is stronger in periods of low funding liquidity as measured by the TED spread. Overall, the results indicate that there are significant economic gains from exploiting the information content of long histories of commodity futures prices.

Research by Ziran Li, Ph.D., School of Public Finance and Taxation, Southwestern University of Finance and Economics, Chengdu Sichuan, China; and Dermot Hayes, Ph.D., Department of Economics and Finance, Iowa State University

This article develops a theory of multiproduct hedging which serves to formalize Keynes's hedging pressure hypothesis that the need to attract speculative capital to match hedgers' trades creates a difference between the futures and expected maturity price. The authors test the theory empirically in the context of the soybean complex which has speculators and hedgers in soybeans, soybean meal and soybean oil. The focus is on the crush spread because it is unlikely that hedgers will want to make simultaneous trades on the opposite side of soybean crushers in all three markets. The findings reveal that there is a significantly positive return to speculators for providing this liquidity.

Contributing Editor's Section

With concerns on inflation flaring up, there has been renewed interest in potentially including commodities in diversified portfolios. This article builds off prior research in examining which commodities to include and in what size. After briefly reviewing the relevant literature, the article proposes a novel and uncomplicated portfolio solution, which takes into consideration both historical results and plausible new paradigms. In addition, an investor would be able to implement this portfolio solution through deeply liquid futures markets.

Editorial Advisory Board Analysis

In 2021, an average 35.5 billion cubic feet per day (Bcf/d) of natural gas was consumed in China, more natural gas than in any previous year. More than half of the natural gas consumed in China in 2021 came from domestic production, but China also imported record amounts of natural gas by pipeline and as liquefied natural gas (LNG), surpassing Japan as the largest LNG importer for the first time, based on data from Global Trade Tracker and China's General Administration of Customs. After becoming the world's largest LNG importer in 2021, China reduced its LNG imports by approximately one-third in the first seven months of this year. LNG imports in China have decreased this year for the first time since 2015. The decline in LNG imports was driven in part by the slower economic growth, high spot LNG prices, robust growth in hydro and non-hydro renewable power generation that displaced more expensive gas-fired power-generation, as well as government policies, which this year reprioritized supply security and economic stability over emissions targets.

The author uses a GVAR model to forecast the response of the global economy to Russian sanctions, and a continuation of the Russia- Ukraine War. She finds that the effects of sanctions on Russia and the unintended consequences for Saudi Arabia and European allies depend on the type of sanctions, i.e., whether they are trade sanctions targeting Russian oil production or financial sanctions targeting Russian GDP. The author also finds that sanctions targeting Russian oil flows are inflationary (Continued on the next page.)

Editorial Advisory Board Analysis
(Continued)

but have fewer unintended consequences for global equity markets. Financial sanctions are more effective, with fewer adverse implications for global inflation levels. The article's analyses also indicate that possible Russian measures to preempt further Western sanctions by implementing trade embargoes of products including natural gas and oil of their own will be counterproductive for the Russian economy.

Industry Analyses

By Deborah Cernauskas, Ph.D., Professor of Business Analytics and Finance, Benedictine University (Retired); Steve Josephs, PE, Consultant on Alternative Energy Projects; and Andrew Kumiega, Ph.D., Assistant Professor of Analytics, Illinois Institute of Technology, Stuart School of Business

The focus of this research is commoditizing environmental credits into standardized units by guaranteeing the provenance of the credit through the application of blockchain technology. The commoditization occurs by creating a decentralized clearing process using blockchain for the environmental credit market. The cleared standardized commodity units can then potentially be traded without the risk of rejection by the U.S. Environmental Protection Agency (EPA) because of production fraud or errors. The removal of the rejection risk would allow for small farmers, municipal wastewater plants and landfills to enhance their profitability by producing green electricity from biogas and receiving market tradable environmental credits. The complexity of the pathway requires blockchain, which creates an immutable ledger holding production and distribution data for the environmental credit. This immutable ledger supplies provenance that can eliminate counterparty risk when combined with the concept of decentralized clearing of the credits.

By Rajkumar Janardanan, SummerHaven Investment Management

The authors of the comprehensive paper document the properties of the first diversified commodity futures index introduced by the Dow Jones & Company in 1933 and use its live track record to study the properties of the asset class in an experimental setting that does not suffer from backfill, selection, or survivorship biases. Despite the setbacks posed by contract failure and trading suspensions of several index constituents, the index appreciated by 3.7% per year between 1933 and 1998, while an investment in collateralized front-month futures returned 4.5% in excess of the risk-free rate. The authors quantify the impact of trading suspensions and contract failure on estimates of the risk premium.

Economic History

By Scott Reynolds Nelson, Ph.D., Professor, Georgia Athletic Association Professor, University of Georgia

This article provides a summary of Professor Scott Reynolds Nelson's latest book, "Oceans of Grain." To understand the rise and fall of empires, … [one] must follow the (Continued on the next page.)

Economic History
(Continued)

Interview

CU Denver Business School Global Energy Management (GEM) Program

Editorial Advisory Board News

Update from the CoBank Executive Director of the J.P. Morgan Center for Commodities

Hello and welcome to our Winter 2022 edition of the *GCARD*! As we enter into the 8th year of publication, we continue to see wide and increasing interest as the *GCARD* fulfills a unique niche across the commodity sector, providing bridges in applied research between global academic and industry professionals.

The very big news at the JPMCC is that the Center and the Global Energy Management (GEM) program are in the process of merging. The GEM program is led by Sarah Derdowski. We are excited with this merger as both the JPMCC and GEM will be including many complementary programs and efforts under a combined entity that has an increased global reach, providing more opportunities for students, academicians and industry.

J.P. Morgan Center for Commodities Merging with the Global Energy Management (GEM) Program

Academics

In regards to academics, the JPMCC has traditionally offered courses at the University of Colorado Denver Business School to students seeking to obtain education in commodities to accompany their M.B.A. and other Master's Degrees. Entering its 15th year, GEM offers a full Master's level degree in energy business and leadership. Initially, JPMCC and GEM students will have the ability to enroll in the full suite of class offerings, with potential curriculum refinements occurring later next year. As of 2023, all courses will be in online formats, allowing students from around the world to gain instruction preparing them for challenging and exciting commodity careers.

For non-degree seeking working professionals, the Center continues to expand available courses with Commodity Sustainability launching in January. In addition, in partnership with Erasmus University and the Singapore Management University, the Center will again offer the Leadership in Commodity Trade & Supply Networks global program also in January. Over the period of six months, students will travel to Rotterdam, Denver and Singapore to further understand global commodity market fundamentals.

Applied Research

On the applied research front, the merger will allow GEM industry partners and stakeholders to participate in the Center's annual applied commodity research symposium as well as contribute articles to the new version of the *GCARD*.

Public Education

Finally, we look forward to advancing the 3rd piece of the Center mission around public education in energy and commodities. We will be continuing to offer webinars and speaking events concerning important topics in 2023!

For all of us at the Center, our hope for all of our students, partners and stakeholders is for a Happy Holiday season and exciting 2023.

From left-to-right: **Lance Titus**, Managing Director, Uniper Global Commodities and **Dr. Thomas Brady**, the CoBank Executive Director of the J.P. Morgan Center for Commodities (JPMCC), at the joint JPMCC/Global Energy Management (GEM) program Industry Advisory Council meeting in October 2022. Titus is also a member of the JPMCC Research Council as well as serving as an Editorial Advisory Board member of the *GCARD*.

Best Regards,

Tom Brady

Tom Brady, Ph.D.
CoBank Executive Director, J.P. Morgan Center for Commodities

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 Discipline Director and Professor of Finance and Risk Management, University of Colorado Denver Business School

Dr. Jian Yang, Ph.D., CFA, J.P. Morgan Endowed Chair and JPMCC Research Director, speaking at a JPMCC international commodities symposium.

In this report, the JPMCC's Research Director will provide updates about recent research activities from April 2022 through September 2022.

Recent Research Updates

The research paper coauthored by the research director, which is entitled, "Price Discovery in China's Crude Oil Futures Markets: An Emerging Asian Benchmark?", has been accepted for the publication by the *Journal of Futures Markets*. Later versions of the paper were also presented by the coauthors at the 8th International Symposium on Energy and Finance Issues (ISEFI-2022) in Paris and at the 2022 Annual Conference of the Asia-Pacific Association of Derivatives (APAD) in Busan, Korea.

The updated analysis in the final version, with the data extended to March 2022, shows an intriguing time-varying price discovery pattern of China's INE crude oil futures, particularly around the COVID-19 pandemic shock. While the INE crude oil futures started to perform certain price discovery functions even at the early stage for almost all the deliverable spot crudes and some non-deliverable crudes, its price discovery performance was severely damaged around the period of COVID-19 pandemic shock intensification in China (January to April 2020) with the temporary cancellation of nighttime trading (February to May 2020). Then it improved to some extent after China started the recovery from the shock, and yet such improvement deteriorated drastically and even disappeared since early 2021 (until March 2022, the end of the sample). Another interesting aspect of the research is that it addresses the cross-border price discovery of commodity futures for spot prices in other countries, which, to our knowledge, has not yet been much examined.

The 5th International Commodities Symposium in 2022

The JPMCC organized the 5th annual international symposium from August 15 to August 16, 2022 in a hybrid format, with over a hundred attendees joining us in Denver, Colorado and over Zoom from around the world.

Keeping its core strength on the interactions among academics, policy researchers and practitioners, the symposium included (a) five academic sessions (including a virtual poster session) representing presenters and discussants from twelve countries, and (b) two industry panels. The symposium included academic research from top universities (*e.g.*, Cambridge, Columbia, Yale, UC Berkeley, Toronto) and top policy institutions (*e.g.*, the Federal Reserve, IMF), and applied research insights from C-suite executives at commodity companies, hedge funds and experts at some of the largest law firms in the world. The keynote speakers were Dr. Nikolai Roussanov, a chair professor at the Wharton School of the University of Pennsylvania, and Robert Bryce, an author and journalist.

The symposium was well received. Dr. Andrei Kirilenko, a professor of finance and director of the doctoral program at the University of Cambridge's Judge Business School praised the symposium as "a top conference on commodities" based on "the quality of papers presented." There will be a special issue devoted to selected symposium papers in the core finance academic journal, the *Journal of Futures Markets*.

Congratulations to our best paper award and best discussant award winners! The best paper award was selected by a three-person committee co-chaired by Dr. Lutz Kilian of the Dallas Fed and Dr. K. Geert Rouwenhorst of Yale School of Management (with the JPMCC's Research Director, Dr. Jian Yang, CFA, as the third judge.) The best paper award this year was given to the authors of "What Drives Variation in Corporate Hedging: Price Expectations or Risk?" This paper was coauthored by Dr. Haibo Jiang (Université du Québec à Montréal), Dr. Nishad Kapadia (Tulane University), Dr. Yuhang Xing (Rice University), and Yifan Zhang (Rice University). The paper was formerly titled, "The Great Gold De-Hedging of the 2000s and Corporate Risk Management," when it was submitted to the symposium. The Best Discussant Award winners were Dr. Xuhui "Nick" Pan (University of Oklahoma), Dr. Veronika Selezneva (CERGE-EI, Czech) and Dr. Brian Wright (University of California, Berkeley) (in the alphabetical order of last names). Of note, Drs. Kilian, Rouwenhorst, and Wright are members of the JPMCC's Research Council.

The symposium was co-organized by Dr. Jian Yang, J.P. Morgan Endowed Chair and Research Director, and Dr. Tom Brady, the CoBank Executive Director, of the J.P. Morgan Center for Commodities. Erica Hyman, the Assistant Director, ran all logistics and registration for the symposium. The symposium this year was co-sponsored by the Center for International Business Education and Research (CIBER) at CU Denver, one of only fifteen such centers in the United States.

Media Exposure around the 2022 Symposium

An international media publication in English, *Yicai Global* (based in Shanghai), featured the 2022 symposium before its launch with the article, "World's Top Policy Researchers, Academics Gather at JPMCC to Discuss Commodities Research Trends." After the symposium, *Yicai Global* published two more news items, featuring research findings of many of the presenters at the symposium. One of the articles was entitled, "Economic Impact of Commodities Is Not Yet Well Understood, Experts Tell JPMCC Symposium," and this article was also reposted on the website of the World Economic Forum.

These new pieces also noted that this is the tenth anniversary of JPMCC. For example, in both news stories above, they shared such background on the JPMCC as: "Now in its 10th year, [the] JPMCC is known for innovative research on commodities. Recent studies by [the] JPMCC have explored topics such as the rapidly growing commodity futures market in China, including the Shanghai International Energy Exchange's crude oil futures. The center's applied research has been featured by *Reuters*, the *Financial Times*, *Bloomberg News* and dozens of other international media outlets."

Conclusion

With COVID-19 (hopefully) almost behind us, we were grateful that we were able to resume the in-person component of the symposium successfully this year, after about two and half years of solely virtual experiences. This will likely pave the way for more in-person participation at next year's symposium. We look forward meeting more friends, old and new, at the 2023 JPMCC symposium!

Best Regards,

Jian Yang, Ph.D., CFA
Research Director, J.P. Morgan Center for Commodities

References

Bryce, R., 2022, Ovintiv Industry Keynote Presentation, JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 16. Accessed via website: https://business.ucdenver.edu/commodities/content/bryce-keynote on December 7, 2022.

CU Denver Business School Newsroom, 2022, "JPMCC Hosts 5th Annual Commodities Symposium: CU Denver Business School Welcomed Distinguished Speakers from Universities and Private Industry," August 23. Accessed via website: https://business-news.ucdenver.edu/2022/08/23/20356/ on December 7, 2022.

Dou, S., 2022, "World's Top Policy Researchers, Academics Gather at JPMCC to Discuss Commodities Research Trends," Yicai Global, August 11. Accessed via website: https://www.yicaiglobal.com/news/world-top-policy-researchers-academics-gather-at-jpmcc-to-discuss-commodities-research-trends on December 7, 2022.

Dou, S., 2022, "Economic Impact of Commodities Is Not Yet Well Understood, Experts Tell JPMCC Symposium," *Yicai Global*, August 23. Accessed via website: https://www.yicaiglobal.com/news/economic-impact-of-commodities-is-not-yet-well-understood-experts-tell-jpmcc-symposium on December 7, 2022.

Dou, S., 2022, "Energy Prices May Not Cause Long-Run US Inflation, Economists Say," *Yicai Global*, August 23. Accessed via website: https://www.yicaiglobal.com/news/energy-prices-may-not-cause-long-run-us-inflation-economists-say on December 7, 2022.

Jiang, H., Kapadia, N., Xing, Y. and Y. Zhang, 2022, "What Drives Variation in Corporate Hedging: Price Expectations or Risk?", Presentation, JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/sites/default/files/attached-files/5._haibo_jiang_-_presenter.pdf on December 7, 2022.

New Directions in Commodities Research brochure, 2022, CU Denver Business School, Jake Jabs Event Center, Hosted by the J.P Morgan Center for Commodities and Co-Sponsored by the Center for International Business Education and Research, August 15-16. Accessed via website: https://www.jpmcc-gcard.com/digest-uploads/docs/JPMCC%20Symposium%20Brochure_rev.pdf on December 7, 2022.

New Directions in Commodities Research presentations, 2022, CU Denver Business School, Jake Jabs Event Center, Hosted by the J.P Morgan Center for Commodities and Co-Sponsored by the Center for International Business Education and Research, August 15-16. Accessed via website: https://business.ucdenver.edu/commodities/symposium-2022-presentations on December 7, 2022.

Pan, X., 2022, Discussant Presentation on "Hedging Pressure and Commodity Option Prices," JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/sites/default/files/attached-files/8._nick_pan.pdf on December 7, 2022.

Roussanov, N., 2022, Academic Keynote Presentation, JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/content/nik-keynote on December 7, 2022.

Selezneva, V., 2022, Discussant Presentation on "The Price Responsiveness of Shale Producers: Evidence from Micro Data," JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/sites/default/files/attached-files/selezneva.pdf on December 7, 2022.

Wright, B., 2022, Discussant Presentation on "The Dynamics of Storage Costs," JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 16. Accessed via website: https://business.ucdenver.edu/commodities/content/wright-discussant-2022 on December 7, 2022.

Yu, Z., Yang, J. and R. Webb, 2022, "Price Discovery in China's Crude Oil Futures Markets: An Emerging Asian Benchmark?", *Journal of Futures Markets*, Online Version of Record, October 6. Accessed via website: https://onlinelibrary.wiley.com/doi/abs/10.1002/fut.22384 on December 7, 2022.

J.P. Morgan Center for Commodities Advisory Council Members

Chris CALGER
Chairman of JPMCC Advisory Council
J.P. Morgan

David ALFANO Commodity Expert	**Chris LEWAND** *FTI Consulting*
Antony BAHR *CoBank*	**Thomas LORD** *Norton Rose Fulbright*
Fiona BOAL *S&P Dow Jones Indices*	**Mike MILLER** *Ardent Mills*
Jeff BORNMANN *Trinidad Benham Corporation*	**Peter O'NEILL, CFA** *Archer Daniels Midland Company*
Thomas BRADY, Ph.D. **Executive Director** *J.P. Morgan Center for Commodities*	**Bluford PUTNAM, Ph.D.** *CME Group*
Froydis CAMERON-JOHANSSON *Anglo American (U.K.)*	**Deanna REITMAN** *DLA Piper*
Kartik GHIA, Ph.D. *Bloomberg LP*	**Ron SCHNUR** *Integrated Supply Chain Consultants*
Robert GREER **Scholar in Residence** *J.P. Morgan Center for Commodities*	**Fred SEAMON, Ph.D.** *CME Group*
Jodie GUNZBERG, CFA *TradeBlock*	**Karl SKOLD, Ph.D.** *JBS*
Tad HERZ *FourPoint Energy and LongPoint Minerals*	**George SOLICH** *FourPoint Energy and LongPoint Minerals*
Wouter JACOBS, Ph.D. *Erasmus University (NL)*	**Sven STREITMAYER** *Robert Bosch GmbH (Germany)*
Daniel JERRETT, Ph.D. *Stategy Capital LP*	**Hilary TILL** **Solich Scholar** *J.P. Morgan Center for Commodities*
Bernadette JOHNSON *Enverus*	**Lance TITUS** *Uniper Global Commodities*
Nic JOHNSON Commodity Expert	**Bruce TURNER** *Fonterra (New Zealand)*
Matt KELSALL *FTI Consulting*	**Sharon WEINTRAUB** *bp (U.K.)*
Julie LERNER *PanXchange, Inc.*	**Jim ZADVORNY** *Ovintiv*

J.P. Morgan Center for Commodities Research Council Members

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

John BAFFES, Ph.D. *World Bank*	**Craig PIRRONG, Ph.D.** *University of Houston*
Thomas BRADY, Ph.D. **Executive Director** *J.P. Morgan Center for Commodities*	**Bluford PUTNAM, Ph.D.** *CME Group*
Colin CARTER, Ph.D. *University of California, Davis*	**Forest REINHARDT, Ph.D.** *Harvard University*
Graham DAVIS, Ph.D. *Colorado School of Mines*	**Michel ROBE, Ph.D.** *University of Illinois at Urbana-Champaign*
Jeffrey FRANKEL, Ph.D. *Harvard University*	**Ehud RONN, Ph.D.** *University of Texas at Austin*
Robert GREER **Scholar in Residence** *J.P. Morgan Center for Commodities*	**K. Geert ROUWENHORST, Ph.D.** **Co-Chair, JPMCC Research Council** *Yale University*
James HAMILTON, Ph.D. *University of California, San Diego*	**Bryce SCHNEIDER** *Xcel Energy*
Scott IRWIN, Ph.D. *University of Illinois at Urbana-Champaign*	**Margaret SLADE, Ph.D.** *University of British Columbia (Canada)*
Vince KAMINSKI, Ph.D. *Rice University*	**Sven STREITMAYER** *Robert Bosch GmbH (Germany)*
Lutz KILIAN, Ph.D. **Co-Chair, JPMCC Research Council** *Federal Reserve Bank of Dallas*	**Hilary TILL** **Solich Scholar** *J.P. Morgan Center for Commodities*
Dan KOWALSKI *CoBank*	**Lance TITUS** *Uniper Global Commodities*
Matthew MOST *Ovintiv*	**Robert VIGFUSSON, Ph.D.** *Amazon*
Nikos NOMIKOS, Ph.D. *Bayes Business School, City, University of London (U.K.)*	**Robert WEBB, Ph.D.** *University of Virginia*
Don PEARSON *Ardent Mills*	**Brian WRIGHT, Ph.D.** *University of California, Berkeley*
Robert PINDYCK, Ph.D. *Massachusetts Institute of Technology*	**Wei XIONG, Ph.D.** *Princeton University*

EDITORIAL ADVISORY BOARD
OF THE
GLOBAL COMMODITIES APPLIED RESEARCH DIGEST

Hilary TILL
Contributing Editor, *Global Commodities Applied Research Digest*
Solich Scholar, J.P. Morgan Center for Commodities

Kenneth ARMSTEAD *αPlus Management*	**John FAN, Ph.D.** *Griffith University (Australia)*	**John KOWALIK, CFA** *UBS Securities LLC*
John BAFFES, Ph.D. *World Bank*	**Adrian FERNANDEZ-PEREZ, Ph.D.** *Auckland University of Technology (NZ)*	**Thomas K. LEE, Ph.D.** *U.S. Energy Information Administration*
B. Salman BANAEI *Uniswap Labs*	**Isabel FIGUEROLA-FERRETTI, Ph.D.** *Universidad Pontificia de Comillas (Spain)*	**Michael McGLONE, CFA, FRM** *Bloomberg Intelligence*
Keith BLACK, Ph.D., CFA, CAIA, FDP Cryptocurrency Consultant	**Ana-Maria FUERTES, Ph.D.** *Bayes Business School, City, University of London (U.K.)* and Associate Editor, *GCARD*	**Adila MCHICH** *CME Group*
Michael BOOTH, Ph.D. *Hull Street Energy*	**David FYFE** *Argus Media (U.K.)*	**Daniel MURRAY, Ph.D., CFA** *EFG Asset Management Switzerland*
Ilia BOUCHOUEV, Ph.D. *Pentathlon Investments, LLC*	**Kartik GHIA, Ph.D.** *Bloomberg LP*	**Fergal O'CONNOR, Ph.D.** *Cork University Business School (Ireland)*
Thomas BRADY, Ph.D. **CoBank Executive Director** *J.P. Morgan Center for Commodities*	**Robert GREER** **Scholar in Residence** *J.P. Morgan Center for Commodities*	**Peter O'NEILL, CFA** *Archer Daniels Midland Company*
Bahattin BÜYÜKŞAHIN, Ph.D. *CoMeX Consulting and Advising*	**Jodie GUNZBERG, CFA** *TradeBlock*	**Xiao QIAO, Ph.D.** *Paraconic Technologies*
Kaifeng (Kevin) CHEN, Ph.D. *Edoc Acquisition Corp.*	**Richard HECKINGER** *Journal of Financial Market Infrastructures*	**Andrea RONCORONI, Ph.D.** *ESSEC Business School (France, Singapore)*
Jennifer CONSIDINE, Ph.D. *KAPSARC (KSA)* *and University of Dundee (U.K.)*	**David JACKS, Ph.D.** *Yale-NUS College (Singapore)* and *Simon Frasier University (Canada)*	**Mark SHORE** *DePaul University*
Anne-Sophie CORBEAU *Columbia University*	**Hyun Jin JANG, Ph.D.** *Ulsan National Institute of Science and Technology (South Korea)*	**Sven STREITMAYER** *Robert Bosch GmbH (Germany)*
Gillis BJÖRK DANIELSEN *APG Asset Management (NL)*	**Jan-Hein JESSE** *JOSCO Energy Finance & Strategy Consultancy (NL)*	**Lance TITUS** *Uniper Global Commodities*
Nancy DeVORE *DHF Team, LLC*	**Mark KEENAN** *Engelhart Commodity Trading Partners*	**Colin WAUGH** Commodities Researcher and Investor
Joseph EAGLEEYE *Premia Research LLC* and Associate Editor, *GCARD*	**Ebele KEMERY** *J.P. Morgan Wealth Management*	**Faouzi ALOULOU** *Energy Information Administration*

Commodities in 2022:
Risk Management Lessons from Russia-Ukraine, China, and the Dollar

Bluford Putnam, Ph.D.
Chief Economist, CME Group; and Member of the J.P. Morgan Center for Commodities' (JPMCC's) Research Council at the University of Colorado Denver Business School

Arthur Yu
Manager, Data Science, CME Group

Dr. Bluford Putnam, Ph.D., Chief Economist at the CME Group, presenting the J.P. Morgan Center for Commodities' international commodities symposium held at a University of Colorado Denver Business School.

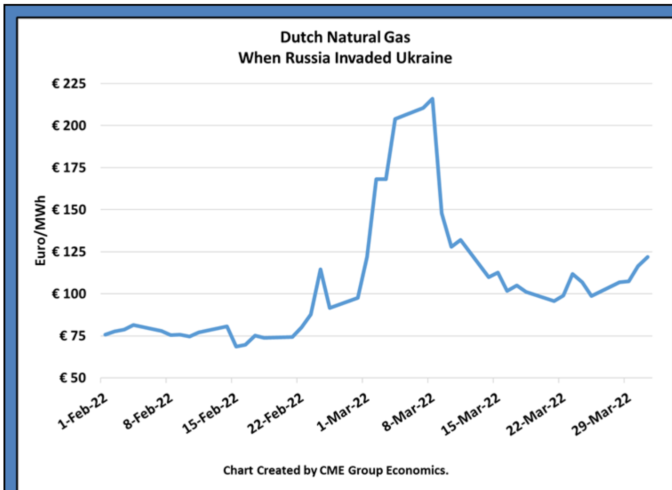
There were three major macro-forces influencing commodities during 2022, overwhelming myriad small factors, and providing a very interesting laboratory from which to draw some important macro-economic lessons about commodity risk management and price determination. The first half of 2022 saw many commodities hit their peak prices for the year due to the supply disruptions caused by the start of Russia-Ukraine War. The latter part of 2022 was a different story as weak economic activity in China and U.S. dollar appreciation created a downdraft for many commodities. Our analysis of commodities in 2022, sets the stage by first concisely identifying the three most significant macro-factors for the year. With the foundation set, we examine a selection of energy, metals, and agricultural products where we highlight both the similarities and the key differences in terms of how each commodity responded to our three major macro-factors. We close with some observations concerning the drivers of commodity super-cycles and the difficulties of risk management when uncertainty is elevated and risk is hard to quantify.

Macro-Factors

Russia-Ukraine War Supply Disruptions

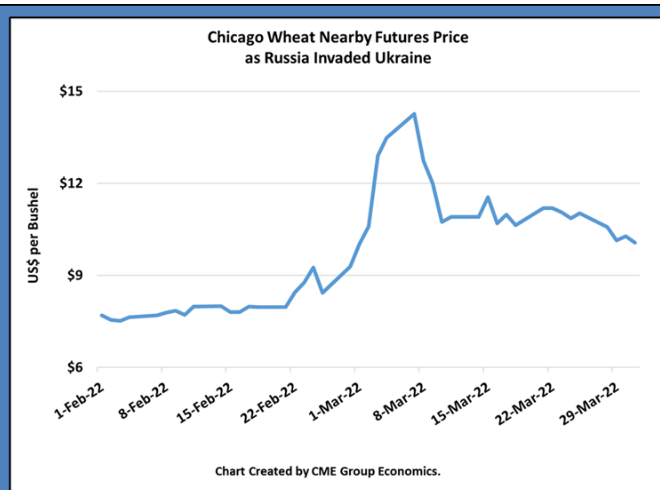
On February 24, 2022, Russia invaded Ukraine. Energy, metals, and agricultural markets were all affected to varying degrees; however, the biggest instantaneous impacts came in European natural gas and global wheat prices. While the Russian Government and many analysts initially expected a quick military victory, Ukrainian opposition was resilient, and Europe and the U.S. came together to provide considerable military assistance and strong economic sanctions on Russia.

Figure 1
Dutch Natural Gas



Source: Bloomberg Professional (TTFG1MON).

Figure 2
Wheat



Source: Bloomberg Professional (W).

As the war progressed, the market impacts of the European and U.S. constraints on Russian oil pushed up the price of oil in the first half of 2022. For its part, Russia curtailed and eventually shutdown the flow of natural gas to Europe. Turkey brokered an arrangement which allowed some Ukraine wheat and agricultural products to be shipped through the Black Sea to clients in the Mediterranean Sea regions, easing pressures on global wheat prices. When we examine the different commodity markets in the second section of this analysis, we will consider the Russia-Ukraine War as igniting severe supply-side disruptions.

China Demand Slowdown

The fast growth of China in the past 50 years has become a miracle in the global economy. Just like the former president Deng Xiaoping said: "White cat, black cat, who catches mouse is a good cat," China benefited a lot from its reform and opening policy. For the 1980s, 1990s, and first decade of the 2000s, the GDP growth rate of China averaged just fractionally above 10%, slowing only to just under 7% in the 2010s. But the most recent GDP data raises the concern of a slowing of the Chinese economy.

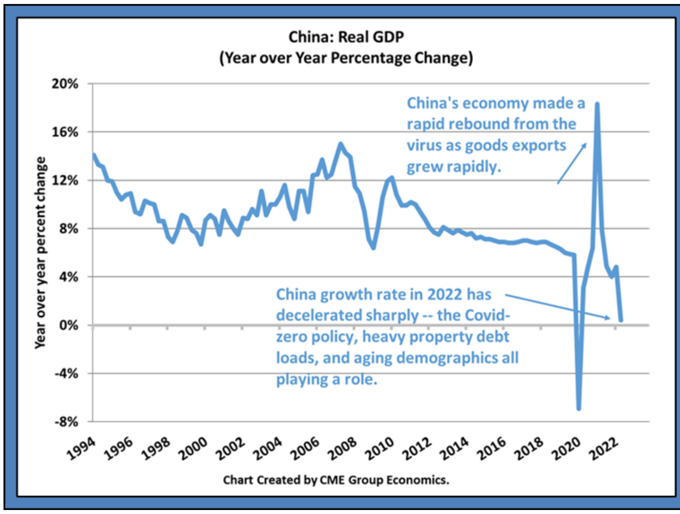
For the second quarter of 2022, China's real GDP was only 0.4% above the same period a year ago, making it the second lowest in 30 years. While the obvious reason was the reduced economic activities owing to the Covid-Zero policy, there were other critical short and long-run challenges as well.

For 2022, as many countries transitioned into a post-Covid reality, China remained in a Covid-Zero mode. The nationwide lockdowns and mandatory Covid tests slowed down factories' production and paused people's entertainment. In particular, the month-long lockdown of Shanghai early in 2022 stressed the global supply chain and reduced China's exports. U.S. and European countries, on the contrary, gradually moved into post-Covid activity patterns, which meant that the elevated demand of goods over the past two years because of COVID restrictions on dining, traveling and other entertainment decreased.

Besides the export challenge, the property debt burden remains a large drag on the Chinese economy. In 2022, many property owners began boycotting against real estate developers because of the long-lasting problem of unfinished buildings. While the owners have been paying loans, developers have been slowing and stopping their construction as a result of lacking necessary funds.

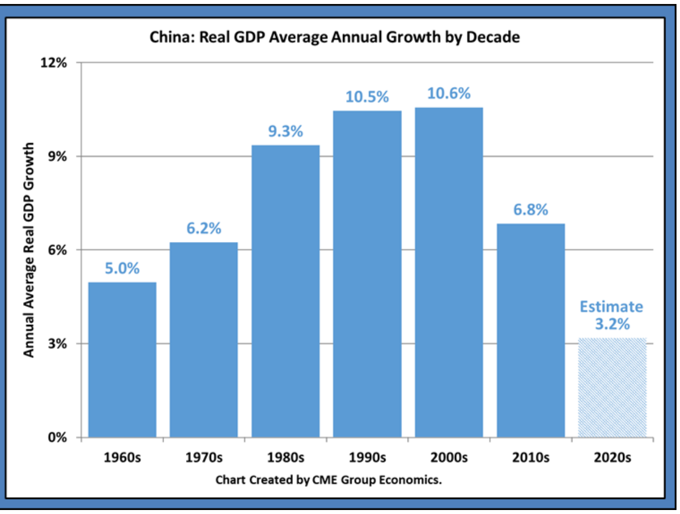
For the long-term, one challenge for the Chinese economy is the diminishing return problem. The primary monetary policy tool to stimulate the growth in China is to push new loans to the economy. Companies can benefit a lot from these loans, especially at early stages and during fast expansion. This tool worked extremely well in the infrastructure building period in the 1990s and into the early 2000s. But as the economy gets more industrialized, it does not produce as much growth as it once did. This is a common problem that happened to many economies in the past when transitioning from a manufacturing or export model to a more mature service economy model.

Figure 3
China Real GDP Quarterly



Source: Bloomberg Professional (CNGDPYOY).

Figure 4
China Real GDP by the Decades



Source: World Bank Real GDP Index from the Bloomberg Professional (WRGDCHIN). Estimates by CME Economics.

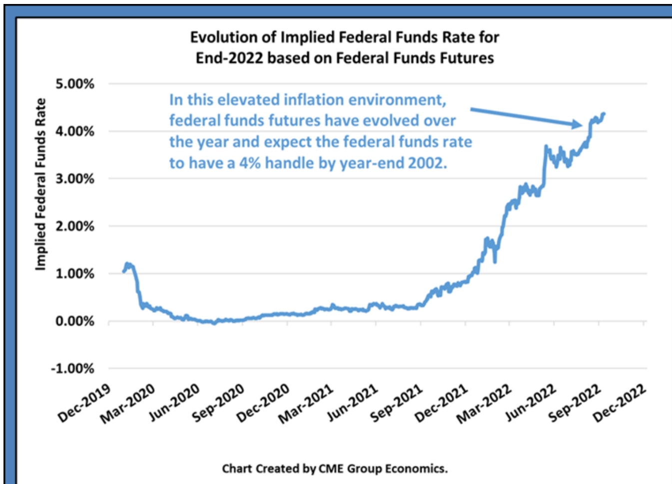
Another realistic challenge for the long term is demographics. The birth rate in China has gone down, although the stimulus from the two-child and the most recent three-child policy may incrementally raise the fertility in the future. Even so, the U.N. has predicted India will surpass China to become the most populated country in 2023 or 2024. In terms of growth implications, we observe that real GDP growth can be arithmetically decomposed into two parts: the growth of labor force and the growth of labor productivity. We note that the effort of transforming labor-intensity industry to knowledge/technology-intensity industry can incrementally help with the labor productivity.

In general, there are two ways to boost the labor force: increase total population or relocate unemployed people from rural to urban areas. The second approach reveals why China grew fast in the past decades albeit the one-child policy. In the 2020s, China's overall population is no longer growing, while the over-60 cohort is rapidly increasing its share of the total. (The official retirement age in China is 60/55 for male and 55/50 for female). What is more, the powerful rural-urban migration has also slowed down. With these factors, later in the 2020s, we might see much lower average real GDP growth comparing to the "golden age." That is, the lack of labor force growth and the headwinds of an aging population are likely to reduce China's economic growth in the 2020s to be more similar, if slightly higher, than mature western economies.

U.S. Dollar Strength

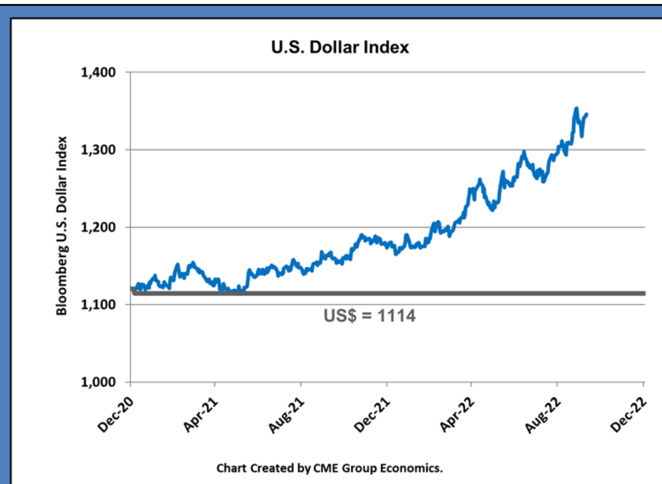
As U.S. inflation began moving higher in 2021, the policymakers' mantra was that the inflation was transitory and primarily related to supply-chain disruptions that would eventually be resolved. With inflation continuing to surge in 2022, the transitory debate was shelved in favor of a realization that the massive fiscal stimulus to support personal consumption during the worst of the pandemic job losses coupled with the financing of the fiscal stimulus through the Fed's asset purchases, created a demand-driven inflationary impulse on top of serious supply-chain challenges.

Figure 5
Federal Reserve Raises Rates



Source: Bloomberg Professional (FFF3).

Figure 6
U.S. Dollar



Source: Bloomberg Professional (BBDXY).

In early 2022, the Federal Reserve began to aggressively withdraw the considerable accommodation provided during the height of the pandemic. Not only did the Fed commence raising rates, but the Fed by June 2022 began reversing quantitative easing and shrinking its balance sheet as well. This withdrawal of accommodation put the Fed well ahead of fighting inflation compared to the European Central Bank (ECB) and the Bank of Japan (BoJ). The ECB did not even exit its negative rate policy until the summer of 2022. And the BoJ continued its zero-rate as well as its yield curve control policy through 2022. The yield curve control policy put a very low ceiling on the Japanese 10-Year Government Bond yields, in contrast to significant yield increases in U.S. Treasuries. The overall result was a persistently rising trend for the U.S. dollar again the euro, Japanese yen, and many other currencies, as reflected in the Bloomberg U.S. dollar index. Commodities are priced in U.S. dollars, so for 2022 the strong rising trend for the U.S. dollar was a serious demand-constraining headwind for commodities.

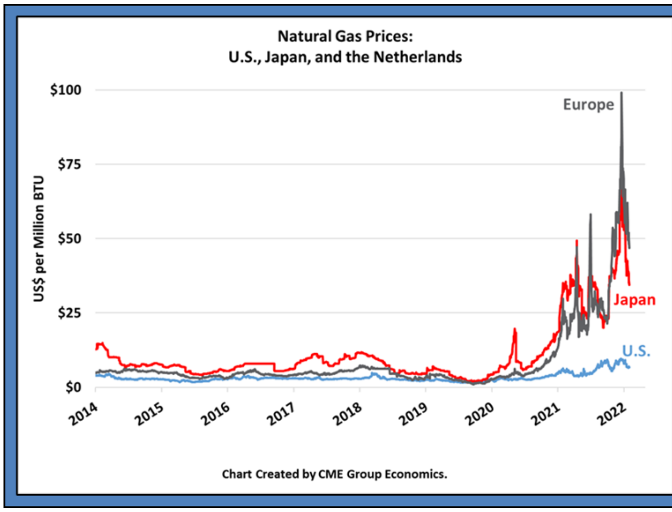
Commodity Analysis

<u>Energy</u>

For energy, the year 2022 was the story of two products – natural gas and crude oil.

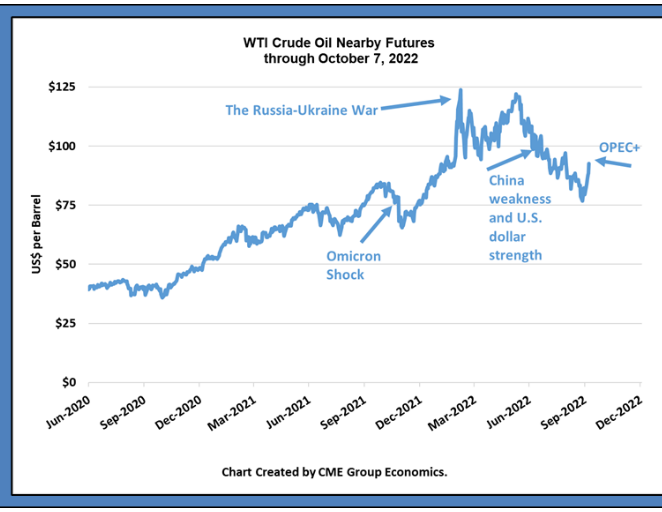
Natural gas prices had been increasing in Europe in 2021, reflecting reduced supply and increasing demand for natural gas to fuel electricity generation, as the continent reduced coal and uranium-powered electrical generation facilities. When Russia invaded Ukraine, it was clear that natural gas from Russia would be constrained, and eventually in 2022, shipments from Russia were cut to zero. To manage the loss of Russian natural gas, Europe imported more from the U.S. and from the Middle East. The ability of the U.S. to expand liquefied natural gas (LNG) to Europe, however, was severely constrained by infrastructure limitations. Qatar in the Middle East has been expanding its natural gas production capabilities, but much of the expansion is in the future and much of the current production was locked up in long-term contracts. Of course, in some case, the owners of the long-term contracts were able to re-sell and re-direct shipments to Europe. By September of 2022, it had become obvious that while Europe had done a much better job of building natural gas inventories in preparation for the winter heating season than many had anticipated, supply challenges would remain for a considerable time to come.

Figure 7
Natural Gas



Source: Bloomberg Professional (NG1, TTFG1MON, JKL1).

Figure 8
WTI Crude Oil



Source: Bloomberg Professional (CL1).

Crude oil had a strikingly different and more complex dynamic. The European Union, the U.K., and the U.S. moved immediately during the early stages of the war to aggressively impose economic sanctions on Russia, many of which were aimed at reducing Russia's oil revenues by constraining oil delivery to Europe. WTI crude's price peaked at $122/barrel on June 8, 2022, rising from the high $80s/barrel territory in January 2022. The peak price in June 2022 was approximately associated with market participants realizing that the point of current and future maximum oil sanctions had been reached.

The next developments in the oil price were driven by how the sanctions impacted the global flow of oil at the same time as demand challenges from China's economic deceleration and the broad-based appreciation of the U.S. dollar were having their effect. China and India began to import much larger quantities of crude oil from Russia at steep price discounts from 20% to 30%. The price competition from Russia as it sold more crude oil into the Chinese and Indian markets put downward pressure on global oil from the U.S. and Middle East. In Europe, the natural gas supply disruption worked to increase the demand for heating oil, which could be used to generate electricity. And in the U.S., export shipments of refined product increased.

As the sanctions were altering the market, so were the deteriorating economics in China and the impact from the strong dollar. China's Covid-Zero policy approach dramatically curtailed travel around the country, lowering demand for crude oil and refined products. On a global scale, with commodities priced in U.S. dollars, the strength of the currency worked to curtail demand, putting further downward pressure on oil prices. Early October 2022 saw OPEC+ vow to cut production to stem the slide in oil prices.

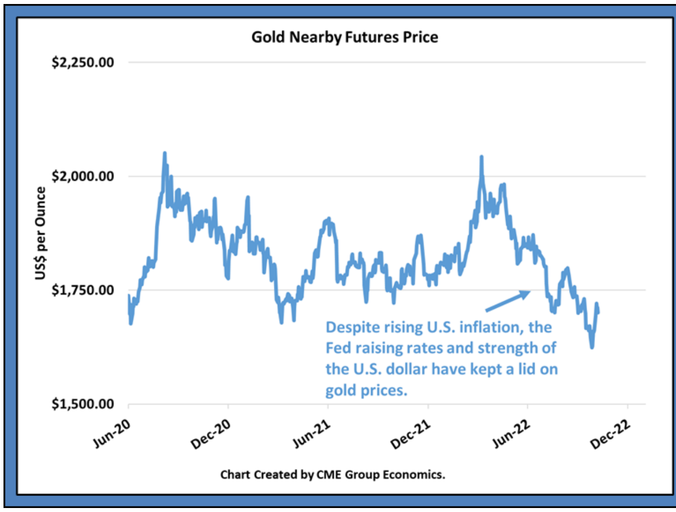
Metals

The narrative for gold in 2022 was not so much influenced by the Russia-Ukraine War, and only a little by the slowing economic conditions in China which dampened jewelry demand. For 2022, gold priced danced to the tune set by the appreciating U.S. dollar, driven by the Fed's withdrawal of accommodation, involving raising rates and shrinking its balance sheet.

Two features were in play. First, gold bears no interest, so gold as a store of value is disadvantaged to U.S. dollar cash when rates are rising.

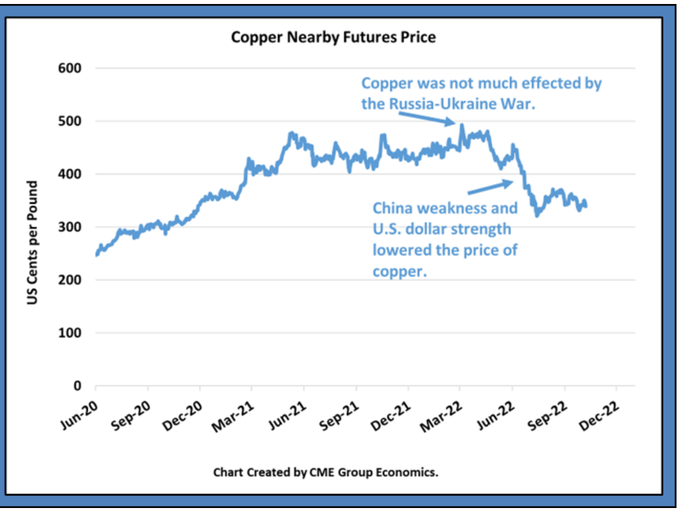
Second, and less well understood, is that gold is not so much a hedge against inflation as is commonly thought, as gold is a hedge against a depreciating U.S. dollar. The confusion stems from the 1970s, when the U.S. dollar was extremely weak coming off the breakdown of the Bretton Woods dollar standard of fixed exchange rates to the U.S. dollar, coupled with a decade of high and rising inflation. The inflation occurred in many countries around the world, not just the U.S., and from our perspective gold was not rising in price in the 1970s due to global inflation as it was serving as a hedge against a decade long slide in the value of U.S. dollar in which gold is priced.

Figure 9
Gold



Source: Bloomberg Professional (GC).

Figure 10
Copper



Source: Bloomberg Professional (HG).

Industrial metals, such as copper and aluminum were impacted jointly by the U.S. dollar strength and China economic weakness. For many commodities involved in country-wide infrastructure projects, China is the largest importer in the world. Weak economic demand from China in the second half of 2022, coupled with the strong U.S. dollar, hit many industrial metals very hard.

Agriculture

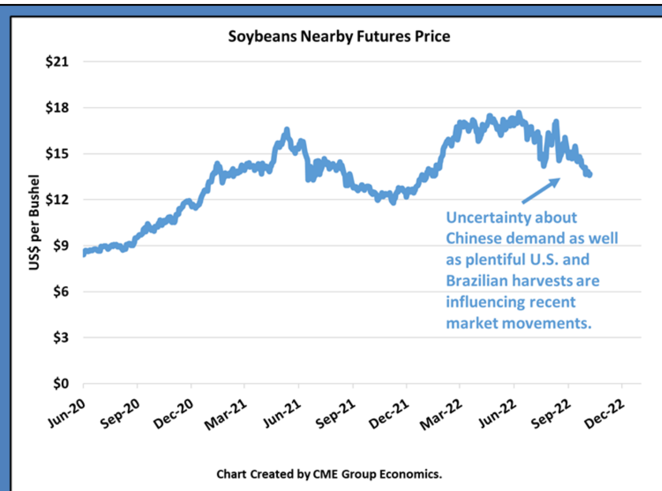
Wheat is grown in many countries all over the world, but Russia and Ukraine are major exporters. No surprise then that the Russia-Ukraine War hit wheat with a seismic surge. Wheat prices saw a decline once Turkey brokered a deal whereby Ukrainian wheat could be shipped through the Black Sea to European and African clients along the Mediterranean Sea.

Other agricultural products saw a steady lift for prices as the war started and these products substituted for wheat as a source of protein. The U.S. dollar's appreciation also took its toll on some agricultural products, but weather and the prospects for better-than-expected harvests in Brazil for corn and soybeans had an impact as well.

Figure 11
Wheat

Source: Bloomberg Professional (W).

Figure 12
Soybeans



Source: Bloomberg Professional (S).

Risk Management Lessons

Thoughts on the Next Commodity Super-Cycle

The last two major commodity super-cycles were the 1970s and the early 2000s. The 1970s was a decade both of inflation and a weak U.S. dollar. Elevated inflation occurred in many countries. Our interpretation is that the decade-long depreciation of the U.S. dollar was the primary driver. Given that commodities are priced in U.S. dollars, they can serve as an effective hedge. The early 2000s super-cycle was led by China's extraordinary double-digit growth as it invested heavily in infrastructure. What is of note, at least for 2022, was that both of these factors, the U.S. dollar and China, were headwinds for commodities, and not tailwinds. Any future commodity super-cycle will need a powerful driver, perhaps climate-change, perhaps India or other emerging market countries: only time will tell.

Risk vs. Uncertainty

The heighted volatility that the three major features of 2022 set in motion – the Russia-Ukraine War, China weakness, U.S. dollar strength – was reflected in a change in the nature of the way volatility was experienced. Volatility is typically measured as the day-to-day standard deviation of the percentage change in prices; that is, daily returns. As the three major factors collided in the markets, there were more days than previously with exceptionally wide intra-day price swings; that is, wider swings than would have typically been associated even with the elevated daily standard deviations. Also, there were an elevated number of large price gap days where the price made an abrupt, sharp move up or down, again in greater numbers than would have been suggested by the elevated daily standard deviations.

We interpret the changed nature of volatility using the classic distinction Professor Frank Knight (1885-1972) made back in the 1920s in his book, "Risk, Uncertainty, and Profit" (1921). In economics, "Knightian uncertainty" is risk that is extremely difficult to quantify while typical volatility is a risk around which we can utilize metrics, such as the standard deviation, among others. With a heightened sense of uncertainty during the year 2022, the changing nature of risk and volatility made sense, even if it also made risk management more difficult. Just because measuring something is difficult does not mean that one can avoid attempting to manage the risk.

Endnotes

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 authors 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 Biographies

BLUFORD PUTNAM, Ph.D.
Chief Economist, CME Group

Dr. Bluford Putnam is Managing Director and Chief Economist of CME Group. As Chief Economist, Dr. Putnam is responsible for leading the economic analysis on global financial markets by identifying emerging trends, evaluating economic factors and forecasting their impact on CME Group and the company's business strategy. He also serves as CME Group's spokesperson on global economic conditions and manages external research initiatives.

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 & Company, Chase Manhattan Bank and the Federal Reserve Bank of New York. Dr. Putnam holds a Bachelor's degree from Florida Presbyterian College (later renamed Eckerd College) and a Ph.D. in Economics from Tulane University.

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 latest book, Economics Gone Astray, is available from World Scientific (WS) Professional.

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

ARTHUR YU
Manager, Data Science, CME Group

Arthur Yu is a manager of Data Science in the Economics Department of the CME Group. He has a Master's in Analytics from the University of Chicago and is currently enrolled in the Master's in Computer and Information Technology program at the University of Pennsylvania.

He is also the president of the board of directors of Nankai University's American Alumni Association of Finance, a group of over 200 financial professionals and executives in the U.S. that provides collaborative opportunities in academics and business to students and faculties at the university. In his role as president, Mr. Yu is heavily involved in providing essential career guidance and informational services on important events to alumni to help establish themselves in the U.S.

He is the champion of China's most famous Trivia Show, "Who is Still Standing?" in 2018 representing the University of Chicago.

Are Rising Gasoline Prices the Main Determinant of the Surge in U.S. Consumer Price Inflation?[1]

Lutz Kilian, Ph.D.
Senior Economic Policy Adviser, Federal Reserve Bank of Dallas; and Co-Chair of the J.P. Morgan Center for Commodities' (JPMCC's) Research Council at the University of Colorado Denver Business School

Xiaoqing Zhou, Ph.D.
Senior Research Economist and Advisor, Federal Reserve Bank of Dallas

Introduction

It is widely believed that rising gasoline prices have been one of the primary determinants of the surge in U.S. consumer price inflation since 2021. In fact, one of the key policy responses of the Biden administration has been to curtail inflation by proposing gasoline tax holidays, releasing oil from the Strategic Petroleum Reserve, and exhorting U.S. oil producers to raise oil production and refiners to replenish gasoline stocks.

It is also commonly believed that fluctuations in U.S. household inflation expectations are driven almost entirely by shocks to the price of gasoline at the pump. For example, an extensively cited study by Coibion and Gorodnichenko (2015) concluded that nearly all the variability in one-year household inflation expectations is explained by variation in the level of oil and gasoline prices.

Recent research suggests that this conventional wisdom is not supported by empirical evidence. For example, the argument that gasoline price shocks explain headline consumer price inflation ultimately rests on the mistaken belief that the high inflation of the early 1970s was caused by the 1973/74 oil price shock. Yet, closer examination of the data shows that U.S. inflation was high and rising in the early 1970s, long before the oil and gasoline price shock occurred, and by no means can be attributed primarily to unexpectedly rising gasoline prices (see Barsky and Kilian, 2002).

Likewise, the view that inflation expectations are driven mainly by gasoline prices, perhaps because such prices are particularly salient to consumers, has been overturned in recent research (see Kilian and Zhou, 2022a). Once we recognize that the relationship between inflation expectations and the price of gasoline is by construction unstable over time and that modeling this relationship involves nonstandard statistical tests, earlier empirical evidence in favor of such a relationship tends to disappear.

An Alternative Modeling Framework

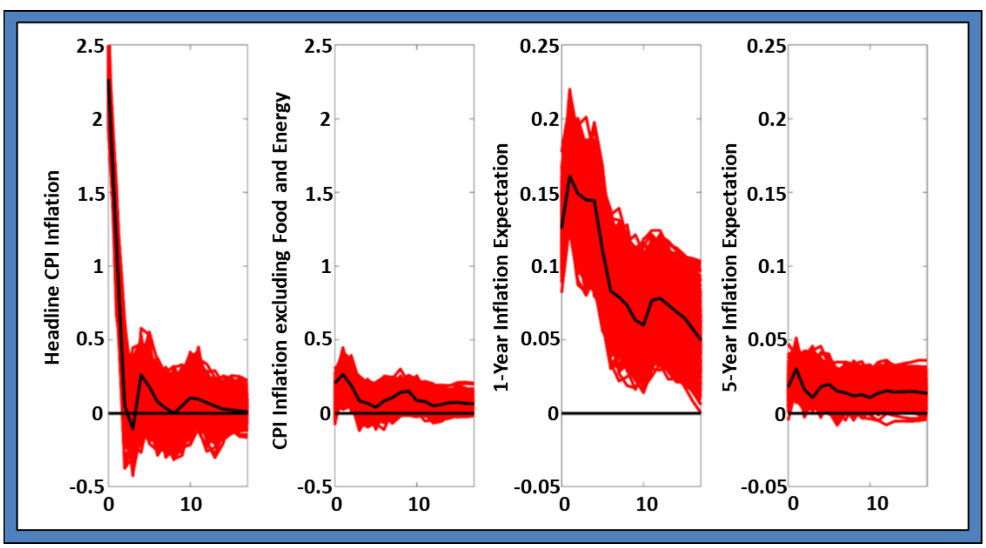
A more suitable class of models of the relationship between the real price of gasoline, headline inflation and household inflation expectations is a vector autoregression in which each model variable is allowed to depend on a fixed number of lags of every model variable. Vector autoregressive models have several advantages compared with traditional correlation analysis. They account for the endogeneity of the real price of gasoline with respect to domestic inflation variables, relax the dynamic restrictions implicit in traditional correlation analysis, and allow for delayed feedback from gas price shocks to inflation expectations. Under suitable additional assumptions about the structure of the model, we can recover the responses of the model variables to a nominal gasoline price shock. Kilian and Zhou (2022a) explore several such models and show that the model estimates are remarkably robust to changes in the estimation period and in the model specification.

Here we focus on an extension of this modeling framework proposed in Kilian and Zhou (2022b) whose objective was to shed light on the determinants of inflation and inflation expectations since 2020. The model includes the percent change in gasoline prices, headline and core inflation as well as 1-year and 5-year household survey inflation expectations from the Michigan Survey of Consumers. We stipulate that nominal gasoline price shocks are contemporaneously unaffected by shocks to inflation and inflation expectations, consistent with evidence in Kilian and Vega (2011). The estimation period starts in early 1990, when 5-year inflation expectations first became available and ends in May 2022, several months after the invasion of Ukraine.

Impulse Response Analysis

Figure 1 shows the responses of inflation and inflation expectations to a one-time nominal gasoline price shock in the estimated model. The magnitude of the shock is immaterial here, since we are concerned with the pattern and precision of the response estimates. A priori one may have expected that a gasoline price shock would raise headline CPI inflation, since gasoline accounts for about 4% of consumer spending on average, possibly followed by further increases in other consumer prices, as the initial inflationary stimulus spreads across the economy.

Figure 1
Responses to a One-Time Gasoline Price Shock, 1990.4-2022.5



Notes: The core and headline CPI inflation rates have been annualized. The set of impulse responses shown in black is the Bayes estimator under additively separable loss. The responses in red indicate the uncertainty about this estimate.

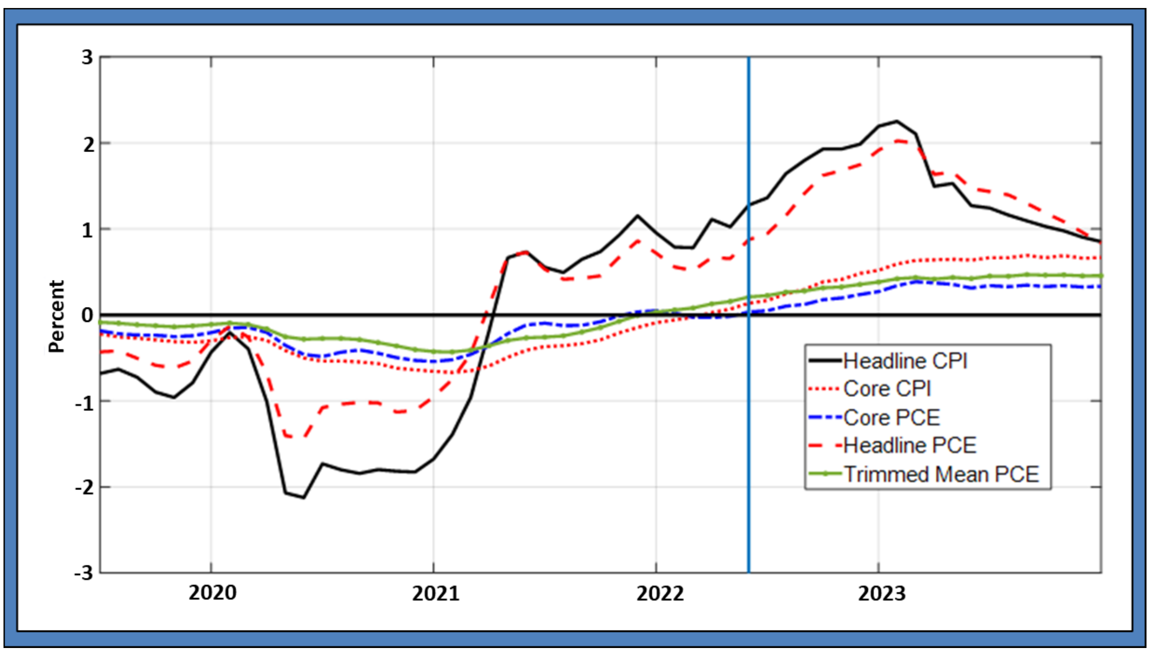
Figure 1 indeed shows an immediate sharp increase in headline CPI inflation, but that increase is short-lived and the response becomes indistinguishable from zero after two months. There is no evidence of large increases in headline CPI inflation in subsequent months. This finding is consistent with the response of core CPI inflation (defined as CPI inflation excluding food and energy). Following a modest increase on impact, the response of core inflation remains indistinguishable from zero. There is no evidence that a one-time gasoline price shock triggers subsequent waves of increases in core inflation or a large persistent increase in core inflation.

Figure 1 also suggests a precisely estimated positive response of household inflation expectations, especially at the one-year horizon. At the five-year horizon, the response is muted and hardly distinguishable from zero. Moreover, the magnitudes in question are quite small relative to the historical level of average household inflation expectations in the Michigan Survey of Consumers.

The Cumulative Impact of Gasoline Price Shocks on 12-Month Inflation

While these results are instructive, policymakers are less interested in the effect of a one-time nominal gasoline price shock than in the cumulative impact of all gasoline price shocks to date. This question is addressed in Figure 2, which recovers this cumulative impact from the estimated vector autoregressive model for each month since June 2019.

Figure 2
12-Month Inflation Caused by Gasoline Price Shocks, 2019.6-2023.12
$110 Oil Price Scenario Starting in June 2022



Notes: The vertical line marks May 2022, the end of the historical data and the beginning of the $110/barrel oil price scenario.

We consider a range of alternative inflation measures all expressed as year-over year (or 12-month) inflation rates. Consider, for example, the black line quantifying the cumulative impact at each point in time of nominal gasoline price shocks on 12-month headline CPI inflation. Figure 2 shows a pronounced decline in headline CPI inflation associated with falling gasoline prices at the onset of the COVID-19 pandemic in 2020. The recovery started in May 2020. By May 2022, marked as a vertical blue line in the chart, the cumulative impact of gasoline price shocks on headline CPI inflation amounted to 1.2 percentage points, which is quite modest compared with the observed 12-month inflation rate of 8.6% for that month. This point is important because it shows that gasoline price shocks have been far from the primary determinant of U.S. headline CPI inflation.

May 2022 was the most recent month in this study for which actual data were available. Figure 2 also considers a hypothetical scenario under which the price of oil remains at $110 from June 2022 until December 2023. Based on the cost share of crude oil in retail gasoline prices, we map the hypothesized percent change in the oil price to the percent change in the gasoline price, which allows us to recover the sequence of nominal gasoline price shocks required to implement this scenario in the VAR model. Figure 2 shows that, under this scenario, the cumulative impact of gas price shocks on 12-month headline CPI inflation would continue to increase until early 2023, peaking near 2.2 percentage points, before declining. Similar results apply to headline PCE inflation, the preferred inflation measure of the Federal Reserve. The cumulative impact of gas price shocks on core inflation measures gradually rises in 2022, reaching about half a percentage point by the end of 2023, with some variation depending on the measure of core inflation.

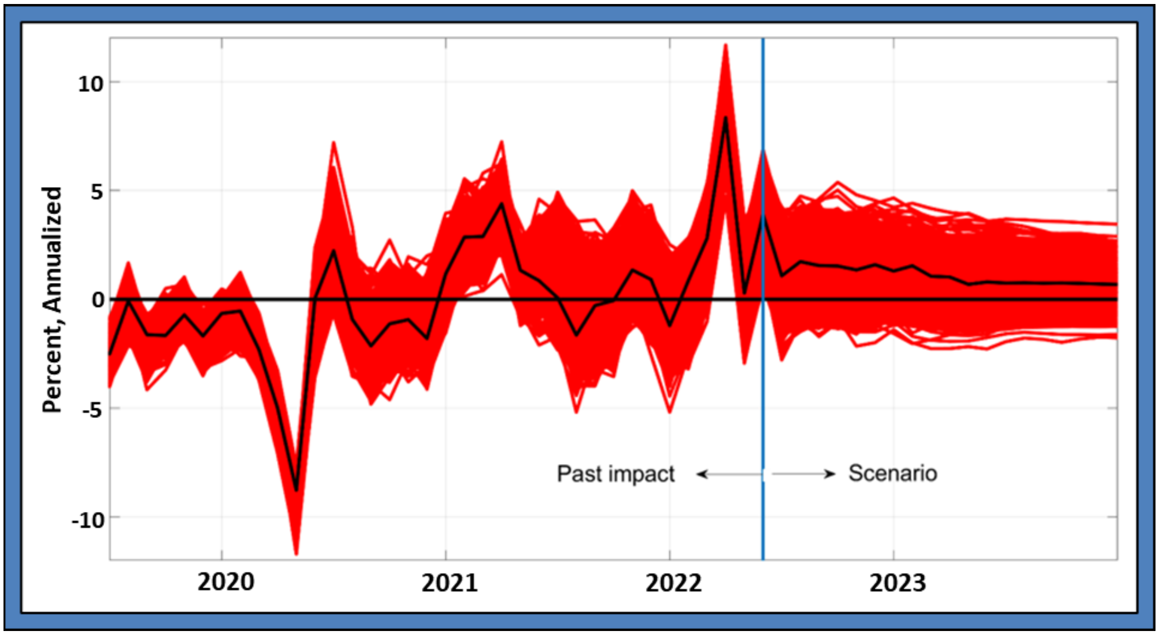
The Cumulative Impact of Gasoline Price Shocks on 1-Month Inflation

Figure 2 may seem to suggest that inflationary pressures will be increasing in the remainder of 2022 under the scenario, but the observed increase in the gas-price driven headline inflation rate is an artifact of the construction of the 12-month rate as a trailing 12-month average of the annualized monthly inflation rate. As Figure 3 illustrates, when focusing on the cumulative impact of gas price shocks on the monthly headline CPI inflation rate, under the maintained scenario, the largest increases are behind us. The impact of gas price shocks on the inflation rate declines starting in June 2022, reaching half a percentage point by the end of 2023. Of course, an actual decline in oil and gas prices, as occurred after our paper was written, would accelerate this process.

The Cumulative Impact of Gasoline Price Shocks on Household Inflation Expectations

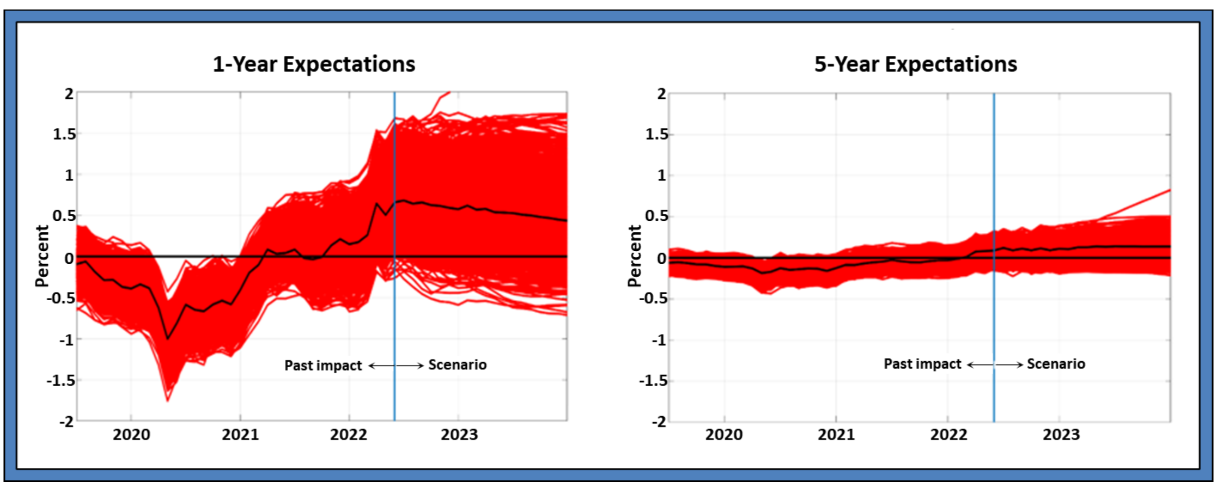
Figure 4 shows the corresponding results for household inflation expectations. Under the $110 oil price scenario, the impact of gas price shocks on 1-year inflation expectations would peak near 0.7 percent and gradually decline going forward. The maximum impact of 0.15 percent on 5-year expectations would be negligible.

Figure 3
Monthly Headline CPI Inflation Caused by Gasoline Price Shocks, 2019.6-2023.12



Notes: The expected path is shown as the black line. The red lines capture the uncertainty about this path.

Figure 4
The Rise in Inflation Expectations Caused by Gasoline Price Shocks



Concluding Remarks

We discussed recent evidence that gasoline price shocks have not been the main determinant of U.S. inflation. This evidence runs counter to the narrative that inflation would subside if only gasoline prices could be lowered. Our analysis suggests that much of the inflationary pressure reflected in headline and core inflation rates reflects strong demand, rising wages reflecting the growing bargaining power of workers, rising house prices, and supply chain bottlenecks.

There is no evidence that gasoline price shocks have been causing a wage-price spiral. Specifically, one might have expected that a one-time gasoline price shock would cause inflation to increase not only on impact, but again and again, as the initial gas price shock is propagated across sectors to other consumer prices. There is no indication in our estimates, however, of large secondary effects on headline or core inflation rates. Nor is there evidence that gasoline price shocks are causing long-run inflation expectations to become unanchored.

This does not mean that the dangers of a wage-price spiral should be ignored. Clearly, rising wages reflecting the growing bargaining power of workers in conjunction with persistent supply chain bottlenecks have the potential of creating a wage-price spiral with persistent inflation pressures over time becoming embedded in longer-term inflation expectations. Our point is merely that rising oil and gasoline prices are not likely to cause such a spiral.

In fact, our analysis shows that inflationary pressures in monthly data wane as soon as positive gasoline price shocks cease. This is the case even under our scenario of unchanged oil and gasoline prices in the remainder of 2022 and in 2023. To the extent that oil and gas prices have actually come down recently, contrary to the premise of our scenario, one would expect inflationary pressures from past gas price shocks to ease even more quickly. It has to be kept in mind, however, that the inflationary impact on year-over-year inflation rates looks more persistent due to temporal aggregation.

Endnotes

1 The views in this paper 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.

Dr. Kilian presented on this topic at the JPMCC's 5th Annual International Commodities Symposium during the "Economics of Energy Markets" session on August 15, 2022. The symposium, in turn, was co-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 and Dr. Thomas Brady, the Co-Bank Executive Director of the JPMCC.

References

Barsky, R.B. and L. Kilian 2002, "Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative," in B. Bernanke and K. Rogoff (eds.), *NBER Macroeconomics Annual 2001*, pp. 137-183.

Coibion, O. and Y. Gorodnichenko 2015, "Is the Phillips Curve Alive and Well After All? Inflation Expectations and the Missing Disinflation," *American Economic Journal: Macroeconomics*, Vol. 7, No. 1, January, pp. 197-232.

Kilian, L., and X. Zhou, 2022a, "Oil Prices, Gasoline Prices and Inflation Expectations," *Journal of Applied Econometrics*, Vol. 37, No. 5, August, pp. 867-881.

Kilian, L., and X. Zhou (2022b), "The Impact of Rising Oil Prices on US. Inflation and Inflation Expectations in 2020-23," Forthcoming: *Energy Economics*.

Kilian, L. and C. Vega, 2011, "Do Energy Prices Respond to U.S. Macroeconomic News? A Test of the Hypothesis of Predetermined Energy Prices," *Review of Economics and Statistics*, Vol. 93, No. 2, May, pp. 660-671.

Author Biographies

LUTZ KILIAN
Senior Economic Policy Adviser, Research Department, Federal Reserve Bank of Dallas

Dr. Lutz Kilian has been a Senior Economic Policy Adviser at the Federal Reserve Bank of Dallas since 2019. He received his Ph.D. in Economics from the University of Pennsylvania in 1996 and his M.A. in Development Banking from The American University in 1988. He joined the faculty at Michigan in 1996, where he was tenured in 2002 and promoted to Professor of Economics in 2008. Dr. Kilian's research interests include energy economics, time series econometrics, and empirical macroeconomics. He has published more than one hundred academic articles, many of which have appeared in leading general interest and field journals in economics and statistics. According to REPEC, he is the most cited energy economist in the world. He is also the author of a textbook with Helmut Lütkepohl on *Structural Vector Autoregressive Analysis*, Cambridge University Press, 2017.

Dr. Kilian is also the Co-Chair of the J.P. Morgan Center for Commodities' Research Council, and his previous articles for the *GCARD* are available here.

XIAOQING ZHOU
Senior Research Economist and Advisor, Research Department, Federal Reserve Bank of Dallas

Dr. Zhou is a Senior Research Economist and Advisor in the Research Department of the Federal Reserve Bank of Dallas. She received her Ph.D. in Economics from the University of Michigan. Her research interests include macroeconomics, household finance and energy economics with a special emphasis on modeling the aggregate implications of heterogeneity across households or regions. Previously, she worked as a Senior Economist in the Financial Stability Department of the Bank of Canada.

Are Temporary Oil Supply Shocks Real?[1]

Johan Brannlund, Ph.D.
Assistant Director of Scientific Computing, Bank of Canada

Geoffrey Dunbar, Ph.D.
Senior Research Advisor, Bank of Canada

Reinhard Ellwanger, Ph.D.
Senior Economist, Bank of Canada

Hurricanes disrupt oil production in the Gulf of Mexico because producers shut in oil platforms to safeguard lives and to prevent damage. We examine the effects of these temporary oil supply shocks for real economic activity in the U.S. We find no evidence that temporary oil supply shocks affect state-level employment or indirectly affect industrial production in sectors not immediately related to oil production. Temporary oil supply shocks appear to have minor price effects, mainly for gasoline prices and CPI inflation. We also find no effect on imports, exchange rates or the import price of oil. Our results suggest that oil reserves held by U.S. refiners are largely sufficient to absorb any temporary production disruptions.

Assessing the Economic Effects of Temporary Oil Supply Shocks

A classic question in energy economics is how oil supply shocks affect the broader economy. Measuring this effect is nontrivial because oil prices, oil production and economic conditions are interrelated and may be affected by common factors. In this paper, we investigate the effect of temporary oil supply shocks for U.S. economic activity using exogenous variation in U.S. oil supply that results from hurricane activity in the Gulf of Mexico.

We construct a series of exogenous and temporary oil supply shocks by combining data on the trajectory of hurricanes and the location of rigs in the Gulf of Mexico. Because oil rigs shut in production in anticipation of potential hurricane strikes, we use the month-on-month change in oil production in the Gulf for the month of the hurricane as our measure of the oil shock. We then investigate the effect of these shocks on various economic outcomes. Our key result is that temporary supply disruptions have short-lived effects on inflation, mainly for gasoline prices and the Energy CPI but no discernable effects on employment or industrial production beyond the directly affected areas and sectors. Overall, the shocks appear to be largely smoothed by oil inventories held by U.S. refiners.

Our findings contribute to an ongoing debate around the significance of oil supply shocks for various economic outcomes. One popular approach to identify oil supply shifts is via implementations of the structural vector autoregressive (SVAR) models of the global oil market (see, *e.g.*, Kilian, 2009; Kilian and Murphy, 2014; Baumeister and Hamilton, 2019). However, the outcomes of the models crucially depend on the assumption made about structural parameters. For example, SVARs which impose inelastic supply and elastic demand find small effects of oil supply shocks on U.S. GDP, whereas SVARs which impose more elastic supply or more inelastic demand find larger effects (Herrera and Rangaraju, 2020). Using quasi-experimental evidence, our results show temporary oil supply shocks have at most modest effects on the broader economy.

Dr. Reinhard Ellwanger, Ph.D., Senior Economist, Bank of Canada, presenting at a J.P. Morgan Center for Commodities (JPMCC) international commodities symposium at the University of Colorado Denver Business School.

Methodology

This paper exploits the fact that a significant fraction of U.S. oil production is located in the Gulf of Mexico, an area that is prone to hurricanes. As storms advance, oil platforms shut in production to safeguard lives and equipment. We construct oil supply shocks using monthly data from 1980M1 to 2019M12 on oil rig location and production in the Gulf of Mexico from the U.S. Bureau of Ocean and Energy Management. Following Brannlund *et al*. (2022), we combine this information with the National Oceanic and Atmospheric Administration's hurricane data to construct a hurricane indicator equal to 1 if a hurricane of category greater than or equal to 1 on the Saffir-Simpson scale passes within 500km of any oil producing lease in the outer continental shelf (OCS). We interact the hurricane indicator with the total change in OCS oil production for the corresponding month to obtain a series of temporary oil supply shocks.

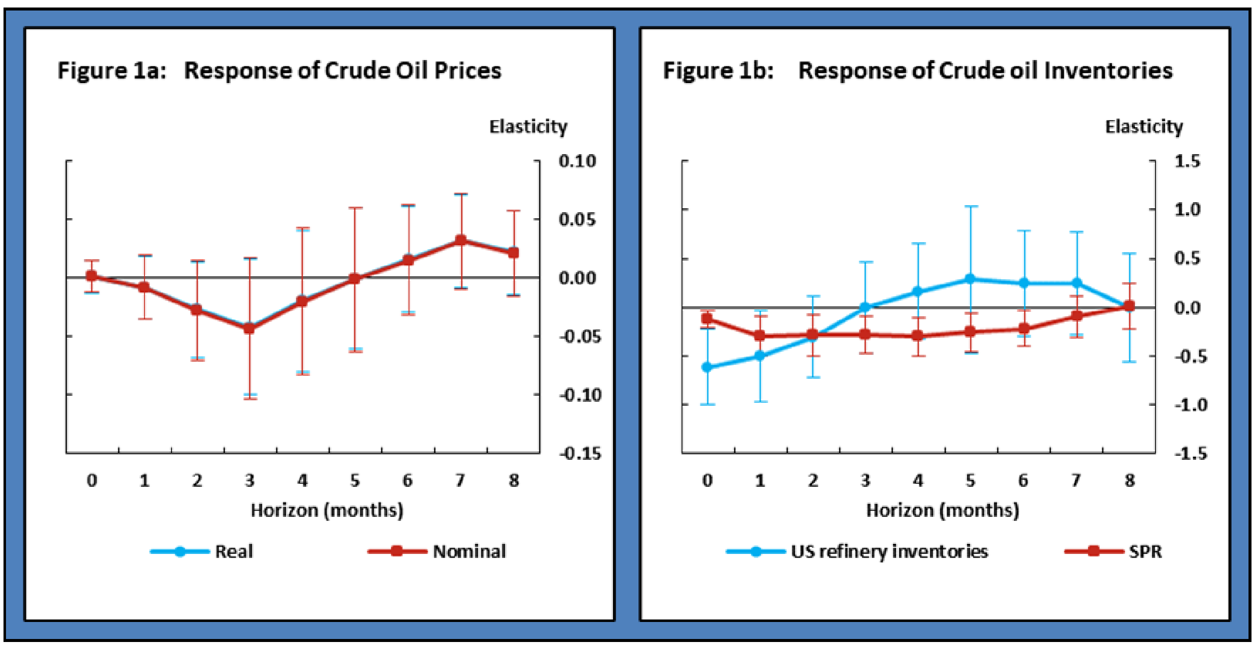
The shock measure attributes the entire change in OCS oil production for a month in which the area was affected to the hurricanes. Compared to alternative measures of shut ins, it allows us to obtain the total effect of hurricanes on the OCS production and to construct a long time series for our empirical analysis. Our first finding is that hurricanes often cause significant disruptions to U.S. oil supply. Some of the major storms in our sample, Hurricanes Katrina and Rita in 2005 and Gustave and Ike in 2008, lead to production shortfalls of roughly 20% of total U.S. oil production.

In a second step, we use a local projections econometric framework (Jordà, 2005) to estimate the effect of the shocks on various economic variables. Wherever possible, we focus on economic outcomes in areas outside of the Gulf of Mexico to avoid comingling our estimates with the direct impact of the hurricanes.

Effect of Temporary Oil Supply Shocks on the Oil Market and Macroeconomic Outcomes

Effect on oil market: We first consider whether the oil supply disruptions are reflected in the price of imported crude oil. Figure 1a presents the effects of the shocks on both the real and nominal price series, along with the whisker bars representing the 95 percent confidence intervals for the point estimates. None of the point estimates are significantly different from zero at any of the horizons up to 8 months from the oil supply shock, suggesting that there is no contemporaneous response of the price of imported oil to a transitory oil supply shock. Generally, the modest response of crude oil prices to supply shocks are more compatible with evidence obtained from SVAR models that impose a lower short-run supply elasticity (Herrera and Rangaraju 2020). It implies that identifying temporary oil supply shocks from oil prices is, at best, extremely difficult, at least for shocks localized to the U.S. For such shocks, even imposing a sign restriction on the short-run elasticity would seem to have little identifying power to differentiate the impulse responses at any horizon we consider. Another implication of the estimates is that there is little short-run change in U.S. demand for imported oil in response to a temporary oil supply disruption.

Figures 1a and 1b



One reason that there might be no demand response for imported crude from transitory oil supply shocks is that refineries smooth such shocks using crude oil inventories. We assess the impact of the oil supply shock for the oil inventories held by refineries and inventories held in the Strategic Petroleum Reserve (SPR). The estimated coefficients, presented in Figure 1b, can be interpreted as the portion of the oil supply shock smoothed by releases from these inventories. There is a statistically significant draw down of oil inventories in response to an oil supply shock both contemporaneously and one month after the shock. The point estimates are approximately 0.6 and 0.2 for commercial and SPR inventories, respectively, which suggests that the cumulative response is almost identical to the level of the shock. Overall, these results are consistent with the role of inventories for smoothing production disruptions highlighted in theory of storage (see, *e.g.*, Working, 1949; Pindyck *et al*., 1994), as well as the empirical evidence in Kilian and Murphy (2014). They suggest that oil reserves held by U.S. refiners are largely sufficient to absorb temporary production disruptions.

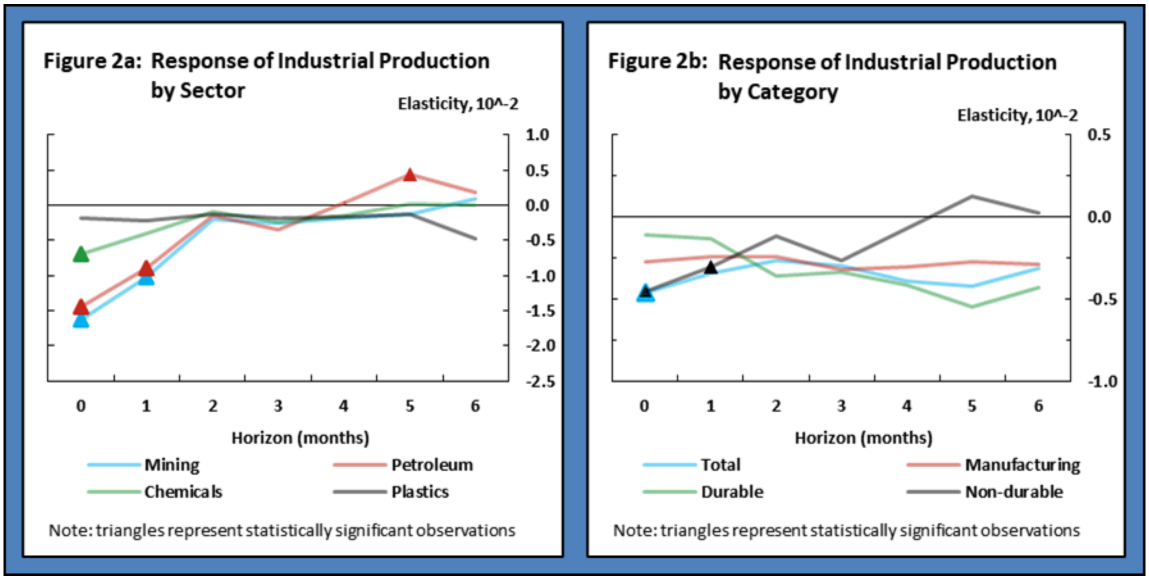
Roughly 40 percent of U.S. oil production is refined into gasoline, suggesting that a quantity shock in U.S. crude oil could still impact gasoline production. We find that gasoline prices in cities connected to Gulf refiners, such as Chicago, Boston and New York, tend to rise on impact and 1 month after the shock with a 10 percent increase in the supply shock leading to roughly a 0.3 percent rise in gasoline prices in both months. Cities which are not closely linked to oil production in the Gulf, such as West Coast cities, rise only in the following month by about 0.3 percent. Cost pressure from increased inventory drawdowns may explain the changes in gasoline prices. Substitution to Canadian energy products seems to play no role, as we do not find any significant effects on real Canadian energy exports or the Canadian dollar.

A potential concern with these results is that oil prices are largely determined by refinery demand and that our impulse responses might confound damage to refineries or pipelines with the impact of the hurricane shut-in production shock.[2] In our sample, there are two periods where hurricanes caused substantial disruption to refineries and pipelines: Hurricanes Katrina and Rita in September 2005; and Hurricanes Gustav and Ike in September 2008. We show that the results are robust to excluding these hurricanes, suggesting that our results are not driven by simultaneous disruptions of the refining sector but rather reflect the response to temporary crude oil production shocks.

Effect on macroeconomic outcomes: We next turn to the question of whether oil supply shocks affect the broader U.S. economy. Our interest is not whether hurricanes affect economic activity, but whether disruptions to oil supply caused by hurricanes affect economic activity.

We first examine the effect of oil supply shocks on production in the U.S. using disaggregated industrial production data. The response of industrial production differs by sector. Figure 2a on the next page shows that industries that directly measure oil extraction or usage, such as Mining, Petroleum and Chemicals decline on impact and remain depressed in the month following the shock. A 10 percent increase in the supply shock causes a decline of about 0.15 percent in Mining and Petroleum and less in Chemicals in that month.

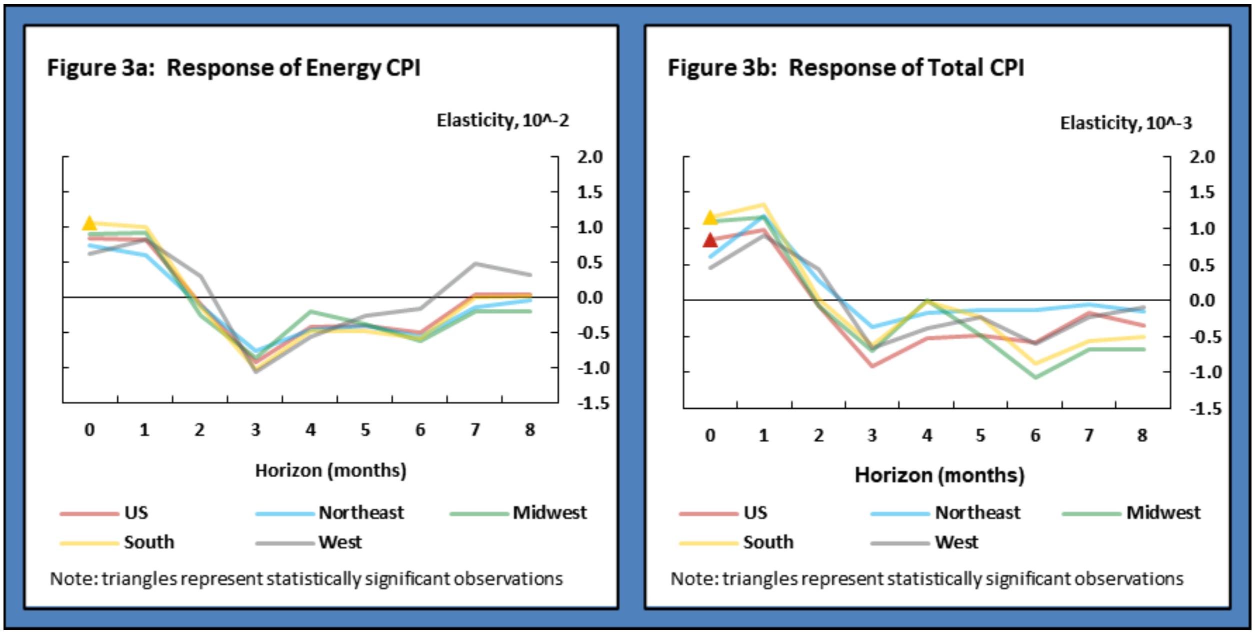
Figures 2a and 2b



Total and Non-Durable Industrial Production decline on impact and one month after the shock due to the direct impact of the shock (Figure 2b). Other sectors do not show a response to the temporary oil supply shocks. Overall, this suggests that oil supply shocks are localized to their industry and do not broadly affect U.S. aggregate production. The conclusion is consistent with evidence from a separate exercise, in which we find no effect on state-level unemployment up to 6 months outside the directly affected states in the Gulf regions.

Although there is little evidence that temporary oil supply shocks propagate to sectors of the economy not directly affected, one might expect that a reduction in industrial production in selected sectors would increase prices. We investigate this hypothesis by examining the impact of the shocks on inflation. Indeed, Figures 3a and 3b on the next page show significant impacts of these shocks on Energy CPI and Total CPI at the 1-month horizon for all U.S. regions. The point estimates are small – a 10 percent increase in the shock causes a 0.1 percent increase in the Energy CPI on impact and less on Total CPI. Non-energy CPI is unaffected for all regions.

Figures 3a and 3b



The evidence supports the conclusion that oil supply shocks are transitory and localized to a narrow subset of industries directly involved in oil production. Broader effects for the U.S. economy are effectively nominal shocks to prices and, even here, appear to be both muted and transitory.

Conclusion

We have used a quasi-random weather event, hurricanes, which lead to production shut-ins at offshore oil platforms in the Gulf to investigate the effect of oil supply shocks. We show that these hurricane events are associated with lower oil production in the Gulf and that the magnitude of these production changes can account for up to 20 percent of U.S. production. We analyze the effects of these oil supply shocks for oil prices, gasoline prices, employment, industrial production and international trade and finance. Overall, we find no evidence that temporary oil supply shocks have real effects for broader U.S. economic activity, while the nominal effects are modest and short-lived.

Endnotes

Dr. Ellwanger presented on this topic at the JPMCC's 5th Annual International Commodities Symposium during the "Economics of Energy Markets" session on August 15, 2022. The symposium, in turn, was co-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 and Dr. Thomas Brady, the CoBank Executive Director of the JPMCC.

1 The views expressed in this article are solely those of the authors and no responsibility for them should be attributed to the Bank of Canada.

2 Kilian (2010) and Kilian and Zhou (2020) argue for the importance of U.S. refinery demand for crude oil prices, particularly the impact of hurricanes on Gulf Coast refineries.

References

Baumeister, C. and J. Hamilton, 2019, "Structural Interpretation of Vector Autoregressions with Incomplete Identification: Revisiting the Role of Oil Supply and Demand Shocks," *American Economic Review,* Vol. 109, No. 5, May, pp. 1873-1910.

Brannlund, J., Dunbar, G., Ellwanger, R. and M. Krutkiewicz, 2022, "Weather the Storms? Hurricanes, Technology and Oil Production," Bank of Canada Staff Working Paper No. 2022-36, August.

Herrera A. and S. Rangaraju, 2020, "The Effect of Oil Supply Shocks on U.S. Economic Activity: What Have We Learned?", *Journal of Applied Econometrics*, Vol. 35, No. 2, March, pp. 141-159.

Jordà, Ò., 2005, "Estimation and Inference of Impulse Responses by Local Projections," *American Economic Review*, Vol. 95, No. 1, March, pp. 161-182.

Kilian, L., 2009, "Not All Oil price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review*, Vol. 99, No. 3, June, pp. 1053-69.

Kilian, L., 2010, "Explaining Fluctuations in Gasoline Prices: A Joint Model of the Global Crude Oil Market and the U.S. Retail Gasoline Market," *The Energy Journal,* Vol. 31, No. 2, April, pp. 87-112.

Kilian, L. and D. Murphy, 2014, "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil," *Journal of Applied Econometrics*, Vol. 29, No. 3, April-May, pp. 454-478.

Kilian, L. and X. Zhou, 2020, "Does Drawing Down the U.S. Strategic Petroleum Reserve Help Stabilize Oil Prices?", *Journal of Applied Econometrics,* Vol. 35, No. 6, September-October, pp. 673-691.

Pindyck, R., 1994, "Inventories and the Short-Run Dynamics of Commodity Prices," *RAND Journal of Economics,* Vol. 25, No. 1, Spring, pp. 141-159.

Working, H., 1949, "The Theory of Price of Storage," *The American Economic Review*, Vol. 39, No. 6, December, pp. 1254-1262.

Author Biographies

JOHAN BRANNLUND, Ph.D.
Assistant Director of Scientific Computing, Bank of Canada

Dr. Johan Brannlund is the Assistant Director of Scientific Computing at the Bank of Canada. He received a Ph.D. in Theoretical Physics from Stockholm University and worked at several universities across Canada before joining the Bank of Canada.

GEOFFREY DUNBAR, Ph.D.
Senior Research Advisor, Bank of Canada

Dr. Geoffrey Dunbar is a Senior Research Advisor in the International Economic Analysis Department at the Bank of Canada. His research focuses on both applied microeconomics and macroeconomics with a current interest on the effects of extreme weather events for commodities and trade. Previous research interests have included exchange rates and the role of family demographics on inequality and productivity. He received his Ph.D. in Economics from Queen's University (Canada).

REINHARD ELLWANGER, Ph.D.
Senior Economist, Bank of Canada

Dr. Reinhard Ellwanger is a Senior Economist in the Commodities Division of the International Economic Analysis department at the Bank of Canada. His research focuses on energy markets and empirical finance. He received a Ph.D. in Economics from the European University Institute in Florence (Italy).

Dr. Reinhard Ellwanger's previous co-authored articles for the *GCARD* covered (1) "The New Benchmark for Forecasts of the Real Price of Crude Oil" and (2) "The Effect of Oil-Price Shocks on Asset Markets: Evidence from Oil Inventory News."

The Illusion of Oil Return Predictability: The Choice of Data Matters!

Thomas Conlon, Ph.D.
Michael Smurfit Graduate Business School, University College Dublin, Ireland

John Cotter, Ph.D.
Michael Smurfit Graduate School of Business, University College Dublin, Ireland

Emmanuel Eyiah-Donkor, Ph.D.
Michael Smurfit Graduate School of Business, University College Dublin, Ireland

Published in: *Journal of Banking and Finance,* 2022, Vol. 134, January, Article 106331

This article re-examines the previously documented evidence of crude oil return predictability from several popular economic predictors and technical indicators and their combinations. It shows that monthly average oil returns are forecastable, in line with evidence documented in previous studies. On the contrary, no evidence of predictability is found for end-of-month oil returns. The authors conclude that the evidence of oil return predictability documented in previous studies may be misleading, as it stems from the use of within-month averages of daily oil prices in calculating monthly returns whereas end-of-month returns are more relevant for risk management and investment decision making as reflecting actual change in asset value.

Introduction

This article comprehensively re-examines the ability of popular economic predictors and technical indicators predictor variables to forecast crude oil returns both in-sample and out-of-sample, with particular emphasis on the latter. The article considers two forms of crude oil price data to calculate returns used in predictive regression models: within month averages of daily oil prices (monthly average returns) and end-of-month prices (end-of-month returns). The former price series is used in most studies on crude oil forecasting (*e.g.*, Baumeister *et al*., 2018) while the latter is commonly used in stock, bond, currency, and other commodity return forecasting studies (*e.g.*, Lin *et al*., 2018). The purpose of the article is to compare the inferences on crude oil predictability from a study that relies on average monthly returns vis-à-vis the same study (as regards models and predictors) that relies on end-of-month returns instead.

The authors find that monthly average oil returns are forecastable, in line with evidence documented in previous studies. On the contrary, they find no convincing evidence for the predictability of end-of-month oil returns. They conclude that the evidence of oil return predictability documented previously is largely misleading, and attribute this to the common use of within-month averages of daily oil prices in calculating returns. They show that studies that rely on monthly average returns introduce an upward bias in the first-order autocorrelation and variances of returns. Consequently, predictive regression analyses based on average monthly returns are likely to document spurious oil return forecastability.

Although the inferential biases and econometric issues associated with the use of monthly average returns have been well documented in the literature for a long time (*e.g.*, Working, 1960), it is surprising that the

---

This digest article was contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.) and Associate Editor of the GCARD.

vast majority of the literature examining the predictability of crude oil returns continues to use averaged price data to calculate returns. What argument supports this choice is not exactly clear. It may, perhaps, simply stem from some kind of "herd behaviour" in the choice of monthly average prices.

Relevance of the Research Question

The findings in this paper are relevant for crude oil market participants that rely on past research as a guide for risk management and investment decision making. For example, a research paper on a trading strategy that seeks to exploit a market inefficiency might indicate profitability when using monthly average returns. In practise, however, average returns are not achievable and a similar strategy using end-of-month returns may be unprofitable. This article therefore provides a cautionary tale on how the calculation of monthly returns from daily data can influence the evidence of crude oil return forecastability.

Data, Models, and Performance Evaluation

Daily closing and monthly averages of the daily closing prices of WTI crude oil spot are obtained from the website of the U.S. Energy Information Administration (EIA) from January 1987 to December 2016. From the daily prices, we build end-of-month price series. Inflation-adjusted (real) log returns are calculated.

We consider a set of very popular predictor variables. They include, among others, oil-specific variables such as crude oil production, crude oil product spreads; variables that capture broad economic activity such as industrial production, inflation; the bilateral exchange rate between the U.S. Dollar and currencies of commodity exporting countries such as Australia, and South Africa; and commonly used technical indicators such as moving average and momentum rules.

Following the oil return forecasting literature, the paper begins with the following out-of-sample (OOS) predictive regression approach for real crude oil returns. The models are estimated using an initial in-sample period January 1987 to December 1996, and the estimated coefficients are used to forecast crude oil returns OOS for January 1999. Repeating this process recursively (expanding windows) until the end of the sample period enables a sequence of OOS month-ahead forecasts.

The paper also considers forecast combination methods, motivated by the well documented evidence that individual models suffer from parameter estimation risk and model uncertainty resulting from structural breaks in the data. The combination forecasts are linear combinations that include mean, median, trimmed mean, weighted mean, and discounted mean squared forecast error combinations.

The random walk with drift model (RW) that is associated with the no-predictability hypothesis is the benchmark. Thus, the accuracy of the forecast from a given model versus the historical average (or RW forecast) is assessed via the R^2_{OOS} metric proposed by Campbell and Thompson (2008). Statistical significance of relative forecast accuracy is assessed through the Clark and West (2007) MSFE test.

Results

Some empirical findings of the article are highlighted in Table 1 on the next page. From Panel A, 10 out of the 28 individual economic variables, namely, the futures return, price pressure (PP), spot crack spread (SCS), gasoline spot (GSS), heating oil spot spread (HSS), the exchange rate of Australia, Canada, and South Africa against the U.S. dollar (AUS, CAN, SA), change in the T-bill rate (CTBL), and the Baltic dry index (BDI) contain useful information for predicting future *monthly average* crude oil spot returns. The R^2_{OOS} values for these are positive and range from 1.71% for the Baltic dry index (BDI) predictor to 5.73% for the Futures return predictor. These values are statistically significant indicating superior performance than the benchmark RW forecast.

As regards the forecastability of *monthly average* returns, the results in Panel B of Table 1 indicate that all the combination forecasts of crude oil returns add notable improvements in OOS predictive performance over the RW benchmark as borne out by large R^2_{OOS} values that are statistically significant.

By contrast, only two predictors, the crude oil basis and CTBL, provide OOS forecast improvements versus the RW benchmark for *end-of-month* returns. All other individual forecasts are unable to improve upon the RW forecast. Not even the combination forecasts, which are designed to guard against model uncertainty and parameter instability of individual predictive models, are able to improve upon the RW.

Conclusions

This paper re-examines the evidence of crude oil return predictability reported in previous studies. The empirical results show *monthly average* returns are forecastable out-of-sample, consistent with previous studies. On the contrary, we find no convincing evidence of *end-of-month* oil return forecastability.

The authors argue that the evidence for *monthly average* crude oil return predictability is an artefact from the distorted statistical properties of crude oil spot returns that result from the averaging of crude oil prices. These distortions lead to inferential biases, namely, spurious predictability of crude oil returns.

Table 1
Out-of-Sample Forecasting Results Based on Economic Variables, January 1990 to December 2017

	Monthly average returns			End-of-month returns		
Predictor	MSFE	R^2_{OS} (%)	MSFE-adjusted	MSFE	R^2_{OS} (%)	MSFE-adjusted
RWWD						
Panel A: Individual predictive model forecasts						
Futures return	52.92	29.92	5.73***	91.27	0.26	1.07
Basis	76.01	-0.67	-0.27	90.57	1.02	1.57*
HP	76.79	-1.70	1.22	91.83	-0.35	-0.35
PP	73.47	2.69	2.84***	91.62	-0.13	0.45
OI	75.61	-0.14	-0.28	91.89	-0.41	-1.65
SCS	53.82	28.72	5.67***	91.50	0.01	0.94
GSS	53.80	28.75	5.67***	91.50	0.00	0.94
HSS	53.89	28.63	5.67***	91.50	0.01	0.95
GOI	75.78	-0.36	-0.89	92.14	-0.69	-0.51
GOP	75.67	-0.21	0.14	92.56	-1.15	0.17
AUS	72.03	4.61	2.60***	93.06	-1.69	-0.65
CAN	71.23	5.67	3.20***	92.49	-1.07	-0.87
NZ	75.30	0.27	1.11	93.87	-2.58	-1.56
SA	74.25	1.67	2.29**	92.32	-0.89	-0.53
S&P 500 return	76.96	-1.92	-0.44	92.30	-0.86	-0.22
TBL	76.39	-1.17	-1.34	92.44	-1.02	-1.51
CTBL	74.21	1.72	1.52*	89.69	1.98	1.88**
YS	76.81	-1.72	-0.48	92.93	-1.55	-0.82
DFY	78.40	-3.83	-0.07	93.85	-2.57	-0.31
TMS1Y	76.13	-0.82	-0.75	92.17	-0.73	-1.02
TMS2Y	75.94	-0.58	-1.29	92.06	-0.61	-1.36
TMS5Y	76.74	-1.63	-0.32	92.85	-1.47	-0.60
VIX	75.38	0.17	0.57	92.02	-0.57	0.37
REA	76.60	-1.45	-0.42	92.90	-1.52	-0.89
BDI	73.78	2.29	1.71**	92.91	-1.53	0.10
INFL	76.61	-1.46	-0.29	92.59	-1.19	-1.10
CAPUTIL	76.21	-0.92	0.53	92.42	-0.99	-1.03
INDPRO	76.07	-0.74	-0.81	92.07	-0.61	-1.46
Average	72.39	4.14	1.17	92.19	-0.75	-0.28
Panel B: Combination forecasts						
Mean	68.72	8.99	4.79***	91.47	0.04	0.27
Median	74.55	1.27	2.55***	91.56	-0.06	-0.18
Trimmed mean	69.25	8.29	4.78***	91.44	0.08	0.35
Weighted mean	66.71	11.66	5.06***	91.47	0.04	0.28
DMSFE	66.78	11.56	4.51***	91.49	0.01	0.23
PC	57.83	23.41	5.01***	92.46	-1.04	0.71
Average	67.31	10.86	4.45***	91.65	-0.16	0.28

Notes: MSFE is the mean squared forecast error. The R^2_{OS} statistic measures the proportional reduction in MSFE for the competing forecasts given in the first column relative to the RWWD forecast. Statistical significance for the R^2_{OS} statistic is based on the *p*-value for the MSFE-adjusted statistic of Clark and West (2007). This statistic tests the null hypothesis that the RWWD forecast MSFE is less than or equal to the MSFE of the competing forecast against the one-sided (upper tailed) alternative hypothesis that the RWWD forecast MSFE is greater than the MSFE of the competing forecast. The variable Average is the average of the MSFE, R^2_{OS}, and MSFE-adjusted statistics across the predictors. Results are reported for monthly average returns and end-of-month returns. The out-of-sample forecast evaluation period is 1997:01-2016:12. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Endnote

The *GCARD*'s previous articles on crude oil, including on forecasting, are available here.

References

Baumeister, C., Kilian, L. and X. Zhou, 2018, "Are Product Spreads Useful for Forecasting Oil Prices? An Empirical Evaluation of the Verleger Hypothesis," *Macroeconomic Dynamics*, Vol. 22, No. 3, April, pp. 562-580.

Campbell, J. and S. Thompson, 2008, "Predicting Excess Stock Returns Out of Sample: Can Anything Beat the Historical Average?", *The Review of Financial Studies*, Vol. 21, No. 4, July, pp. 1509-1531.

Clark, T. and K. West, 2007, "Approximately Normal Tests for Equal Predictive Accuracy in Nested Models," *Journal of Econometrics*, Vol. 138, No. 1, May, pp. 291-311.

Lin, H., Wu, C. and G. Zhou, 2018, "Forecasting Corporate Bond Returns with a Large Set of Predictors: An Iterated Combination Approach," *Management Science*, Vol. 64*,* No*.* 9, pp. 4218-4238.

Working, H., 1960, "Note on the Correlation of First Differences of Averages in a Random Chain," *Econometrica: Journal of the Econometric Society*, Vo. 28, No. 4, October, pp. 916-918.

Author Biographies

THOMAS CONLON, Ph.D.
Michael Smurfit Graduate Business School, University College Dublin (UCD), Ireland

Dr. Thomas Conlon is an Associate Professor of Banking and Finance in the UCD School of Business. Previously, he worked within asset management and as a consultant in the area of financial services. He obtained his Ph.D. and M.Sc. from Dublin City University and undergraduate degree from Trinity College Dublin. His main research interests are in asset pricing, risk management and fintech. His recent research has been published in journals such as the *Journal of Banking & Finance*, *Journal of Financial Econometrics*, *European Journal of Operational Research*, the *Journal of Empirical Finance* and the *Journal of Financial Stability*. He is an Associate Editor for the *European Journal of Finance* and *International Review of Financial Analysis*. Dr. Conlon has held visiting positions at the Saïd Business School, University of Oxford and Simon Fraser University (Canada). He is a funded investigator with the Financial Mathematics and Computation Cluster and has received funding from Science Foundation Ireland (SFI) as a principal investigator in the area of fintech. He was also the recipient of a prestigious New Horizons Research Grant from the Irish Research Council and a Dobbin Scholarship.

JOHN COTTER, Ph.D.
Michael Smurfit Graduate School of Business, University College Dublin, Ireland

Dr. John Cotter is Professor in Finance and the Chair in Quantitative Finance at University College Dublin. He is a Research Fellow at the UCLA Ziman Research Center for Real Estate. Dr. Cotter has previously had visiting positions at UCLA, London School of Economics, University of British Columbia (Canada) and ESSEC Business School (France). His research, teaching and consultancy interests are in the areas of volatility modeling and measuring, risk management and investment analysis with applications in equity, currency, derivative, fixed income and real estate markets. He has taught extensively on undergraduate, graduate and executive programs. Dr. Cotter has been awarded a UCD Faculty of Commerce Outstanding Educator Teaching Award. He is the founding Director of the Centre for Financial Markets at University College Dublin. In addition, he is the Director of the Financial Mathematics Computation Research Cluster (FMC2), a multi-university cross-discipline research body in Finance. He is an Associate Editor of the *Journal of Banking and Finance*, the *Journal of International Financial Markets*, *Institutions & Money*, and the *European Journal of Finance*. Dr. Cotter has published many professional papers, including in the *Review of Financial Studies*, the *Journal of Banking* *and Finance*, and the *Journal of International Money and Finance*. He has received many research grants including being a Principal Investigator in the Financial Mathematics Computation Research Cluster (FMC2) funded by Science Foundation Ireland. He was awarded an Outstanding Research Contribution Award at the UCD School of Business, University College Dublin. Dr. Cotter is a member of the Group of Economic Advisers for the European Securities Markets Authority (ESMA), the supra-national supervisor of European financial markets. He has consulted for many organizations both in and outside Ireland and has also served as an expert witness in several financial cases.

EMMANUEL EYIAH-DONKOR, Ph.D.
Michael Smurfit Graduate School of Business, University College Dublin, Ireland

Dr. Emmanuel Eyiah-Donkor is an Assistant Professor of Banking and Finance at the College of Business, University College Dublin (UCD). Previously, he was Assistant Professor of Finance at Rennes School of Business in France. He holds a Ph.D. in Finance from UCD, an M.Sc. in Financial Mathematics from Uppsala University (Sweden), and a B.Sc. in Mathematics from the Kwame Nkrumah University of Science and Technology (Ghana). Dr. Eyiah-Donkor's research interests include asset return predictability, dynamic portfolio choice, empirical asset pricing, financial econometrics and, more recently, financial data science. His research has been published in international peer-reviewed journals including the *Journal of Banking and Finance*, *Journal of Commodity Markets*, and the *International Review of Financial Analysis*. He has taught courses in Financial Theory, Quantitative Finance, Corporate Finance, Financial Modeling, Portfolio Choice, and Risk Management at the undergraduate and graduate levels at Rennes School of Business and UCD. At UCD, he currently teaches Portfolio and Risk Management and Programming for Financial Data Science at the graduate level.

A Bayesian Perspective on Commodity Style-Integration

Ana-Maria Fuertes, Ph.D.
Bayes Business School, City, University of London, U.K.

Nan Zhao, Ph.D.
Bayes Business School, City, University of London, U.K.

Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4112383

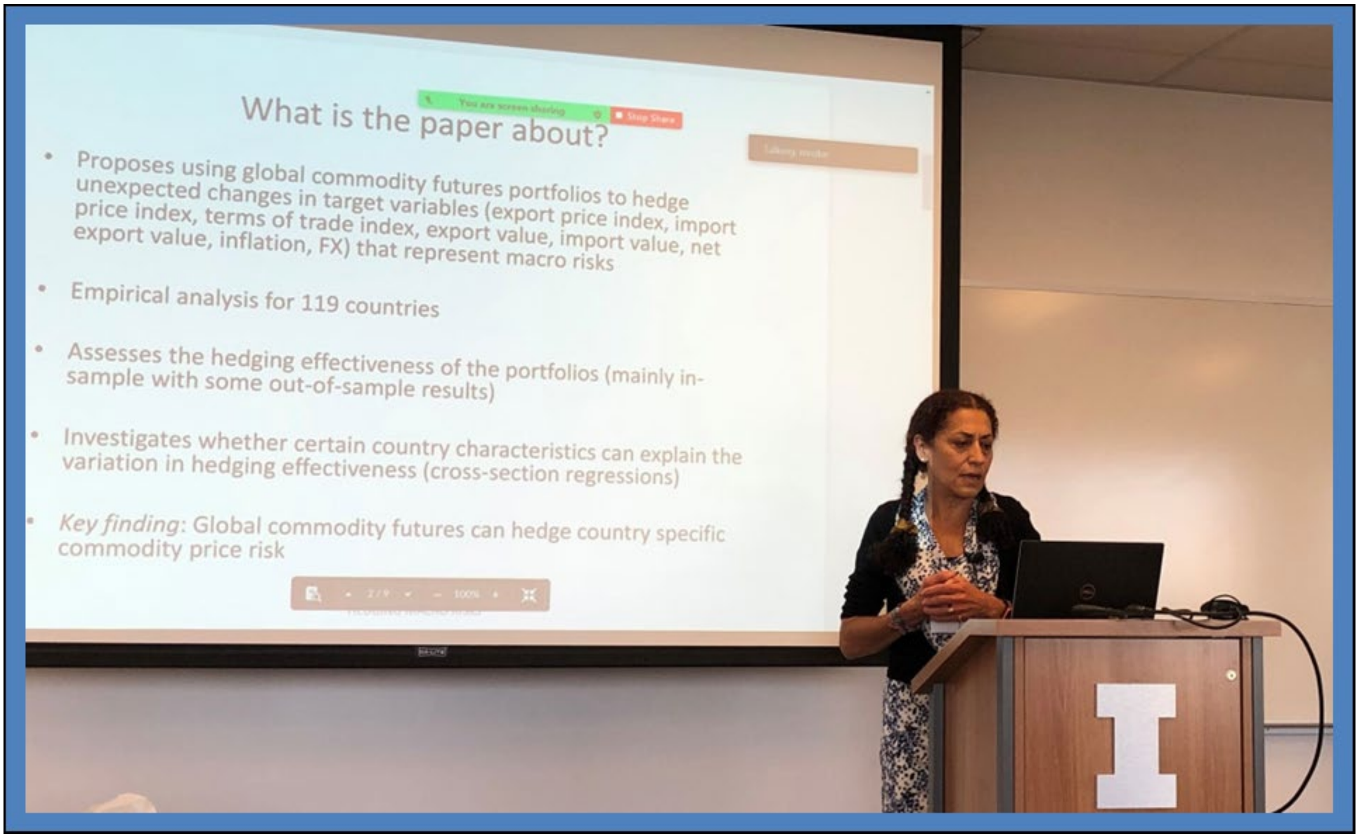
Commodity style-integration is appealing because by forming a unique long-short portfolio with simultaneous exposure to mildly correlated factors, a larger risk premium can be captured over time than with any of the underlying standalone styles. A practical decision that a commodity style-integration investor faces at each rebalancing time is the relative weight of the predictive- or sorting-signal that underlies each standalone style. The authors of this paper develop a new Bayesian optimized integration (BOI) method that accounts for estimation risk in the style-weighting decision. Focusing on the problem of a commodity investor that seeks exposure to the carry, hedging pressure, momentum, skewness, and basis-momentum factors, they demonstrate that the BOI portfolio outperforms not only a battery of parametric style-integrations motivated by the portfolio optimization literature, but also the highly effective equal-weight integrated portfolio. The findings survive the consideration of transaction costs, alternative commodity scoring schemes, and long estimation windows.

Introduction

Individual factors can undergo time-variation or be arbitraged away; namely, styles that have captured a sizeable premium over a period of time may weaken or completely fade away due to "factor crowding" (see *e.g.*, Bhattacharya *et al*., 2017). One way to mitigate this problem is by constructing a long-short portfolio or style-integrated portfolio according to a combination of predictive signals which is also known as the multi-factor approach. Style-integration is in essence the old adage of *don't put all your eggs in the same basket* applied to factor exposure or style investing. The key idea is to harness the diversification of predictive signals towards capturing a larger and more resilient risk premia over time. A key decision that a style-integration investor faces is the relative weight to give to the styles at each portfolio rebalancing time. With a history of returns on each of the styles, the investor can estimate the style-weights that are defined as "optimal" according to some criteria. However, these optimized style-integrations (OIs) suffer from parameter uncertainty, which is the main reason why the naive equal-weight style integration (EWI) has stood out as very effective. In a structured contest among the EWI method and a battery of sophisticated style-integrations, Fernandez-Perez *et al*. (2019) show that the former is not outperformed by the latter. The authors of this paper thus believe it is worthwhile to pursue the research question of whether embedding the style-integration problem within a Bayesian framework that accounts for estimation risk can be fruitful for investors.

This digest article was contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.) and Associate Editor of the GCARD.

The authors develop a Bayesian optimized style-integration (BOI) method that expands the parametric mean-variance optimized integration by allowing investors to incorporate their prior beliefs or knowledge about the merit of the different standalone styles. The priors on the style-weights distribution can then be conveniently mapped into priors on the distribution of excess returns for the candidate commodity futures contracts. In an empirical exercise, the authors compare the reward-to-risk and crash risk profiles of the BOI method with those of the challenging EWI benchmark and of several sophisticated parametric optimized integrations (OI).



Professor Ana-Maria Fuertes of Bayes Business School, City, University of London, U.K., lecturing during the Commodities & Energy Markets Association (CEMA) conference at the University of Illinois' Illini Center in Chicago. This conference took place on June 21st and 22nd, 2022.

Why the Paper's Research Question is Important

Research over the last few years has established that a number of factors can explain return performance in commodity futures but the corresponding style premia are not constant over time. Rewarding factors over specific periods can temporarily weaken. Improving the return profile through mixing styles is, in fact, currently the critical issue for many commodity investors. This paper seeks to assist investors by developing a BOI strategy that seeks efficiently (that is, with a low noise-to-signal ratio) to construct a unique long-short portfolio with exposure to multiple commodity risk. The BOI approach is flexible enough to facilitate integration of any number of styles using an investor-chosen criteria for the optimal estimation of the style-exposures. The research question is also relevant for academics because it allows the authors to advance the Bayesian statistics literature towards commodity style-integration.

Style-Integration Methodology

The investor's decision at portfolio formation time *t* about the relative wealth to allocate to each commodity futures and the nature of the position, long versus short, can be represented by the $N \times 1$ commodity allocation vector $\boldsymbol{\phi}_t$ obtained as

$$\boldsymbol{\phi}_t \equiv \boldsymbol{\Theta}_t \times \boldsymbol{\omega}_t = \begin{pmatrix} \theta_{1,1,t} & \cdots & \theta_{1,K,t} \\ \vdots & \ddots & \vdots \\ \theta_{N,1,t} & \cdots & \theta_{N,K,t} \end{pmatrix} \begin{pmatrix} \omega_{1,t} \\ \vdots \\ \omega_{K,t} \end{pmatrix} = \begin{pmatrix} \phi_{1,t} \\ \vdots \\ \phi_{N,t} \end{pmatrix} \tag{1}$$

where $\boldsymbol{\Theta}_t$ is the $N \times K$ *score* matrix (*N* is the number of assets and *K* the number of standalone styles) and $\boldsymbol{\omega}_t$ is the $K \times 1$ signal- (or style-) weighting vector. The sign of the *i*th commodity allocation weight $\phi_{i,t}$ dictates the type of position (long or short). The element $\theta_{i,k,t}$ is the score assigned to the *i*th commodity futures contract according to the *k*th sorting signal (or style) at portfolio rebalancing time *t*. Alternative scoring schemes are plausible such as defining $\theta_{i,k,t}$ as the signals (appropriately standardized) or standardized rankings or binary long-versus-short signals {+1, -1}.

A key element in the integration is the style-weights vector $\boldsymbol{\omega_t} = (\omega_{1,t}, \dots, \omega_{K,t})$ where the weight $\omega_{k,t}$ reflects the relative importance given to the *k*th individual investment style (or factor) in the integrated portfolio. The naïve EWI strategy assigns equal importance to the *K* styles, *i.e.*, $\boldsymbol{\omega_t} = \left(\frac{1}{K}, \dots, \frac{1}{K}\right)'$, at each rebalancing time and thus it is parameter-free. Besides the EWI, various OIs have been deployed in the literature.

In an OI strategy the style-weight decision hinges on solving an optimization problem; namely, at each portfolio rebalancing time *t* the investor ought to find the weights that minimize or maximize a property of the style-integrated portfolio return distribution. For instance, quadratic utility or mean-variance maximization (MV), MV maximization with shrinkage (MVshrinkage), variance minimization (MinVar), diversification-ratio maximization (MaxDiv), power utility maximization (PowerU), PowerU with disappointment aversion (PowerDU) or on style-volatility timing (StyleVol); see, *e.g.,* Ledoit and Wolf (2003), Choueifaty and Coignard (2008), Brandt *et al*. (2009), Kirby and Ostdiek (2012) and Fernandez-Perez *et al*. (2019). A common denominator to these OIs is that albeit they can potentially discriminate better among the *K* styles because they allow for time-varying, heterogeneous exposures to the different styles, such an advantage can be largely contaminated by parameter estimation uncertainty.

The key idea behind the BOI method proposed by the authors is to mitigate uncertainty about the parameters describing the distribution of commodity returns by forming priors that are subsequently updated. Investors do not need to directly form a prior on $\boldsymbol{\mu}_t$, the $N \times 1$ commodity mean excess returns. They can instead harness their beliefs (or information) on the past relative performance of the styles to form a prior on $\boldsymbol{\omega}_t$ which can be mapped onto a prior for $\boldsymbol{\mu_t}$. Given the success of the equal-weight rule in portfolio allocation (DeMiguel *et al*., 2009) and in style-integration (Fernandez-Perez *et al*., 2019), the authors adopt $1/K$ as the informative prior for the mean of the distribution of $\boldsymbol{\omega}_t$ which is assumed Gaussian. A history of commodity excess returns over a window of L months is used to update the priors in order to obtain the posterior density of $\boldsymbol{\mu_t}$ using the Gibbs sampling approach that belongs to the family of Markov Chain Monte Carlo (MCMC) methods. With the posterior density of $\boldsymbol{\mu_t}$ at hand, the MV optimization problem is solved at each portfolio rebalancing time *t* to obtain the BOI style-weights $\boldsymbol{\omega}_t$.

Results

The authors carry out an empirical analysis of style-integration methods in the context of data for a cross-section of 28 commodity futures contracts from January 1992 to December 2021. Without loss of generality, the focus is on five fairly well-known commodity investment styles that exploit as predictive- or sorting-signals, respectively, the basis, hedgers' net short positions, momentum, skewness, and basis-momentum.

The naïve EWI strategy outperforms each of the standalone styles in terms of risk-reward (Sharpe ratio, Omega ratio, and Sortino ratio) and crash risk (semi-deviation, 99% Value-at-Risk, and maximum drawdown). This finding confirms the diversification benefits of style-integration. Another important confirmation result is that the naïve EWI portfolio is not challenged by any of the sophisticated OI portfolios.

The key novel evidence in this paper is that the BOI approach is able to significantly improve upon the challenging EWI benchmark. With a Sharpe ratio of 1.060, maximum drawdown of -0.174, and 99% of VaR of -0.051, the BOI portfolio is a more attractive proposition than any of the alternative OI portfolios, and also the challenging EWI portfolio as regards both reward-to-risk and crash risk profiles; see Table 1 on the next page.

Table 1
Performance of Commodity Style-Integrated Portfolios

		Optimized Style-Integrations (OI)							
	EWI	MV	MVshrinkage	MinVar	StyleVol	MaxDiv	PowerU	PowerDA	BOI
Panel A: *Static portfolio evaluation*									
Mean	0.080	0.054	0.051	0.075	0.082	0.083	0.052	0.052	0.092
StDev	0.101	0.094	0.094	0.084	0.102	0.096	0.093	0.094	0.087
Semi-deviation	0.272	0.258	0.258	0.209	0.275	0.248	0.258	0.262	0.212
Max Drawdown	-0.243	-0.297	-0.287	-0.158	-0.255	-0.219	-0.296	-0.296	-0.174
99% VaR	-0.061	-0.058	-0.058	-0.050	-0.062	-0.057	-0.058	-0.059	-0.051
Sharpe Ratio (SR)	0.815	0.606	0.577	0.904	0.823	0.886	0.588	0.587	1.060
Sortino ratio	1.393	1.012	0.960	1.677	1.400	1.566	0.976	0.970	1.987
Omega ratio	1.900	1.599	1.563	2.041	1.918	2.023	1.576	1.574	2.309
ΔSR (gain versus EWI)		-0.209	-0.239	0.089	0.008	0.071	-0.227	-0.229	0.245
Ledoit-Wolf test p-value		0.883	0.931	0.222	0.383	0.128	0.902	0.901	0.005
Opdyke test p-value		0.199	0.128	0.888	0.915	0.774	0.173	0.101	0.042
Panel B: *Dynamic Sharpe ratio (style ranking)*									
Jan 1992 - Dec 1997	1.108(7)	1.296(3)	1.107(8)	1.293(4)	1.103(9)	1.265(6)	1.278(5)	1.300(2)	1.373(1)
Jan 1998 - Dec 2003	0.999(4)	1.000(3)	0.860(8)	0.671(9)	1.002(2)	0.902(7)	0.923(6)	0.931(5)	1.005(1)
Jan 2004 - Dec 2009	1.115(2)	0.378(9)	0.464(6)	1.058(5)	1.113(3)	1.076(4)	0.411(7)	0.398(8)	1.314(1)
Jan 2010 - Dec 2015	0.979(4)	0.513(9)	0.604(6)	1.042(3)	0.977(5)	1.055(2)	0.547(8)	0.558(7)	1.180(1)
Jan 2016 - Dec 2021	0.193(5)	0.116(6)	0.089(7)	0.496(2)	0.194(4)	0.381(3)	0.081(8)	0.072(9)	0.583(1)

Notes: The table reports summary statistics for the excess returns of the equal-weight style integrated (EWI) portfolio and optimized style-integrated (OI) portfolios with the style-weight vector estimated at each portfolio rebalancing time by quadratic utility maximization (mean variance; MV), mean-variance with shrinkage maximization (MVshrinkage), variance minimization (MinVar), style-volatility timing (StyleVol), diversification-ratio maximization (MaxDiv), power utility maximization (PowerU), maximization of power utility with disappointment aversion (PowerDA), and Bayesian optimized integration (BOI). The length of the rolling estimation window is 60 months. The style-integrations are based on standardized signals as commodity scores. The reported mean and standard deviation are annualized. The hypotheses of the Ledoit and Wolf (2008) and Opdyke (2007) tests are $H_0: SR_i - SR_{EWI} \leq 0$ vs $H_A: SR_i - SR_{EWI} > 0$ where *i* is an OI strategy.

Panel A reports statistics over the full sample period January 1992 to December 2021. Panel B reports Sharpe ratios over 6-year non-overlapping subperiods and corresponding style-integrated portfolio ranking in parentheses.

Adding statistical significance to these results, the Ledoit and Wolf (2008) and Opdyke (2007) tests suggest at the 5% significance level or better that the Sharpe ratio of the BOI portfolio is notably larger than that of the naive EWI portfolio. These key findings are obtained both with fixed-length rolling windows of $L = 60$ months to determine the style-weights, and also with long estimation such fixed $L = 120$ months (rolling) or expanding windows starting from 60 months. Likewise, the superiority of the BOI portfolio survives the consideration of transaction costs and the use of alternative scoring schemes.

Conclusions

A large number of factor models have been suggested to explain returns in commodity markets. Forming a unique long-short portfolio with simultaneous exposure to mildly correlated risk factors is an intuitive “style diversification” idea but it requires a choice of style-weights at each portfolio rebalancing time. To date, the different sophisticated style-integrations attempted have not been as effective as the naïve equal-weights style integration. The reason is that, by contrast with parametric methods, the EWI is not contaminated by estimation risk. This paper develops a novel Bayesian optimized style-integration that alleviates estimation risk. Focusing on well-known commodity styles – basis, hedging pressure, momentum, skewness, and basis momentum – the authors provide evidence to suggest that the BOI portfolio significantly outperforms a battery of sophisticated OIs and the challenging EWI. The main take away of this research is that embedding extant OI methods into a Bayesian framework to account for estimation risk allows investors to harness multiple commodity factor exposures more efficiently towards capturing a larger and more resilient risk premium over time.

References

Bhattacharya, D., Li, W.-H. and G. Sonaer, 2017, “Has Momentum Lost Its Momentum?”, *Review of Quantitative Finance and Accounting*, Vol. 48, No. 1, January, pp. 191-218.

Brandt, M., Santa-Clara, P. and R. Valkanov, 2009, “Parametric Portfolio Policies: Exploiting Characteristics in the Cross-Section of Equity Returns,” *Review of Financial Studies*, Vol. 22, No. 9, September, pp. 3411-3447.

Choueifaty, Y. and Y. Coignard, 2008, “Toward Maximum Diversification,” *Journal of Portfolio Management*, Vol. 35, No. 1, Fall, pp. 40-51.

DeMiguel, V., Garlappi, L. and R. Uppal, 2009, “Optimal Versus Naive Diversification: How Inefficient is the 1/N Portfolio Strategy?”, *Review of Financial Studies*, Vol. 22, No. 5, May, pp. 1915-1953.

Fernandez-Perez, A., Fuertes, A.-M. and J. Miffre, 2019, “A Comprehensive Appraisal of Style-Integration Methods,” *Journal of Banking and Finance*, Vol. 105, August, pp. 134-150.

Kirby, C. and B. Ostdiek, 2012, “It’s All in the Timing: Simple Active Portfolio Strategies that Outperform Naive Diversification,” *Journal of Financial and Quantitative Analysis*, Vol. 47, No. 2, April, pp. 437-467.

Ledoit, O. and M. Wolf, 2003, “Improved Estimation of the Covariance Matrix of Stock Returns with an Application to Portfolio Selection,” *Journal of Empirical Finance*, Vol. 10, No. 5, December, pp. 603-621.

Ledoit, O. and M. Wolf, 2008, “Robust Performance Hypothesis Testing with the Sharpe Ratio,” *Journal of Empirical Finance*, Vol. 15, No. 5, December, pp. 850-859.

Opdyke, J. D., 2007, “Comparing Sharpe Ratios: So Where are the p-Values?”, *Journal of Asset Management,* Vol. 8, No. 5, December, pp. 308-336.

Author Biographies

ANA-MARIA FUERTES, Ph.D.
Bayes Business School, City, University of London, U.K.

Dr. Ana-Maria Fuertes is a Professor in Finance and Econometrics at Bayes Business School, City, University of London. Her research interests are in commodity markets, financial forecasting, empirical asset pricing and credit risk modelling. Dr. Fuertes' articles have been published in the *Review of Finance*, *Journal of Banking and Finance, International Journal of Forecasting* and the *Journal of International Money and Finance*. She has been awarded research grants by the Economic and Social Research Council (ESRC), British Academy/Leverhulme Trust, and INQUIRE U.K. Her research has been featured in practitioner and policy-oriented publications such as *Hedge Funds Review*, *Investment & Pensions Europe*, CEPR *VoX*, CEPS.eu and on the Bank of England's website.

Dr. Fuertes' previous articles for the *GCARD* are available here.

NAN ZHAO, Ph.D.
Bayes Business School, City, University of London, U.K.

Dr. Nan Zhao is a Research Fellow at Bayes Business School, City, University of London. He is also an algorithm trading quant at Barclays corporate and investment bank. His research focuses on empirical asset pricing and financial econometrics.

A Trend Factor in Commodity Futures Markets: Any Economic Gains from Using Information over Investment Horizons?

Yufeng Han, Ph.D.
Belk College of Business, University of North Carolina at Charlotte

Lingfei Kong, Ph.D.
Olin School of Business, Washington University in St. Louis

Published in: *Journal of Futures Markets,* 2022*,* Vol. 42, No. 5, May, pp. 803-822

This paper identifies a trend factor that exploits the short-, intermediate-, and long-run moving averages of settlement prices in commodity futures markets. The trend factor generates statistically and economically large returns during the post-financialization period 2004-2020. It outperforms the well-known momentum factor by more than nine times the Sharpe ratio and has less downside risk. The trend factor is not encompassed by extant factors and is priced cross-sectionally. An analysis of macroeconomic and other market-wide drivers suggests that this trend factor is stronger in periods of low funding liquidity as measured by the TED spread. Overall, the results indicate that there are significant economic gains from exploiting the information content of long histories of commodity futures prices.

Introduction

Trend-following strategies have been widely used by commodity trading advisors (CTAs) and have received extensive attention from academics. Momentum, which utilizes intermediate-term trend signals (usually 6 months or 12 months), is one of the most extensively studied trend-following strategies in the literature (*e.g.*, Erb and Harvey, 2006; Miffre and Rallis, 2007; Moskowitz *et al*., 2012; Huang *et al*., 2020). Researchers also find evidence that the momentum factor is a priced factor and generates a significant risk premium cross-sectionally (e.g., Bakshi *et al*., 2019; Sakkas and Tessaromatis, 2020).

However, the momentum factor ignores short-term and long-term price signals, which also help predict commodity futures returns. For example, Han *et al.* (2016) find that 5-day moving average signals can outperform the buy-and-hold benchmark. A combination of short- and long-term trend signals can also be profitable. For instance, Narayan *et al.* (2015) find that multiple trading strategies based on the difference between the short- and long-term moving averages perform well. Bianchi *et al.* (2016) find that a double-sort strategy based on momentum and long-term reversal generates significant returns.

This paper studies the cross-sectional predictive ability of a composite trend signal that incorporates short-, intermediate-, and long-term trend signals in commodity futures markets. The authors evaluate the performance of the trend factor by comparing it with the traditional momentum factor (constructed from past 12-month cumulative returns) that also exploits cross-sectional predictability. We also use time-series and cross-sectional tests to examine the predictive power of the trend factor. Last but not least, we examine how macroeconomic and other market-wide variables affect the profitability of the trend factor.

This digest article was contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.) and Associate Editor of the GCARD.

The sample period for the analysis is January 2004–December 2020 intentionally because since 2004, speculators (financial institutions and individual investors with no physical exposure to the underlying commodities that trade commodity futures to capture a risk premia) have increased their participation in commodity futures markets. This phenomenon is referred to as the "financialization" of commodity futures (*e.g.*, Tang and Xiong, 2012; Basak and Pavlova, 2016). Algorithmic trading has also gained prevalence.[1] Researchers find that during the post-financialization period, commodity futures markets have been more liquid and have experienced increasing speculative trading (e.g., Gong *et al*., 2021). The highly liquid commodity futures markets during the post-financialization period make the proposed long-short trading strategy more feasible. A further motivation for focusing on the most recent decade is that many factors in the stock market have attenuated in recent years because of increased turnover and liquidity (referred to as "factor crowding"); for instance, the average return of long-short momentum portfolios becomes insignificant after 2001 (Chordia *et al*., 2014).

The paper confirms that the well-known momentum factor has also disappeared in commodity futures markets during the sample period, but the trend factor remains strong. The results suggest that the trend factor performs better when there is lower funding liquidity (as suggested by a wider TED spread) and thus, factor arbitrage is more costly. Kang *et al*. (2021) find that an increase in arbitrage costs (measured both by the TED spread and the repo rate) makes factors less crowded and increases factor returns. Correspondingly, a larger TED spread hinders commodity futures trading strategies based on the trend factor and increases the corresponding return. Our results thus indicate that commodity futures can be attractive alternative assets when funding liquidity in the credit market is low.

Relevance of the Research Question

The research question is important as it relates to ongoing debates about using commodity futures as investment assets, common risk factors in commodity futures markets, and factor crowding. The new trend factor identified by the authors that outperforms the well-studied momentum factor and is not subsumed by extant factors in commodity futures markets ought to be of interest to commodity futures market participants, speculators predominantly but also selective hedgers, and more generally for empirical asset pricing. This is the first study to apply the Han *et al.* (2016) method to commodity futures markets, which jointly considers the short-, intermediate-, and long-term trend signals. The paper contributes to the literature on the source of predictability of trend-based trading strategies by identifying a link between funding liquidity and the profitability of the trend factor.

Data and Methodology

The empirical analysis is based on settlement prices, aggregated open interests, and commercial traders' long and short positions of 35 commodity futures from Bloomberg that cover four main sectors: agriculture (grains and softs), energy, livestock, and metal. There are 8 grains futures (soybean oil, corn, Kansas wheat, oats, rough rice, soybean, soybean meal, wheat), 8 softs futures (cocoa, cotton, ethanol, milk, orange juice, coffee, lumber, sugar), 3 livestock futures (feeder cattle, live cattle, lean hogs), 6 energy futures (WTI crude oil, heating oil, natural gas, gasoline, Brent crude oil, gas oil), and 10 metal futures (aluminum, copper, gold, lead, nickel, palladium, platinum, tin, silver, zinc) in the sample.

The methodology closely follows Han *et al.* (2016). The authors first calculate moving averages (MA) of past settlement prices from 3 days to as many as 600 days (roughly three trading years) for each commodity futures contract. They then run sequential cross-sectional regressions for monthly returns on the different normalized moving averages over a past 5 years. The expected returns for each commodity futures are then obtained as the expected coefficient of the short-, medium- or long- MA signals (where the expectation is proxied by the 60-month window average of the sequential cross-sectional regression coefficient estimates) multiplied by the corresponding commodity-specific normalized moving averages. The trend factor is then constructed by taking long positions in the commodity futures with the highest expected returns and shorting those with the lowest expected returns to exploit cross-sectional predictability.[2] The commodity futures are equally weighted in the long and short portfolios.

The authors conduct time-series and cross-sectional tests to assess whether multifactor models can explain the performance of the trend factor. These include multi-factor models based on portfolio sorts, GRS tests, Fama-MacBeth regressions and panel regressions. To explain the source of predictability of the trend factor, the authors regress the trend factor contemporaneously on the monthly growth rate in industrial production, default spread, term spread, CBOE Volatility Index, liquidity (the TED spread), various stock market factors, and the Baker and Wurgler (2006) investor sentiment proxy.

Main Results

The annualized mean return of the trend factor from January 2004 to December 2020 is 17.19% which is both economically and statistically significant at the 1% level. By contrast, the annualized mean of the well-known momentum factor is 1.9% and is statistically insignificant. Time-series pricing tests reveal that the return of the trend factor cannot be explained by the benchmark multifactor models as borne out by significant risk-adjusted returns (or alphas) of the trend factor. For example, the annual alpha with respect to the Sakkas and Tessaromatis (2020) six-factor model is 15.96% (1.33%×12=15.96%). The GRS tests provide additional support in a joint-regression setting, with F statistics rejecting the null hypothesis that the alphas of the trend portfolios are jointly equal to zero. Additionally, two-pass cross-sectional regressions suggest that the trend factor is priced cross-sectionally. Overall, the results show that the trend signal contains predictability for the cross-section of commodity futures returns.

Multivariate regressions of the trend factor on macroeconomic and other market-wide variables suggests that the TED spread is a significant driver at the 5% level with a positive coefficient. This indicates that when the TED spread is large, there is lower funding liquidity in the credit market which increases arbitrage costs, the trading of the trend factor decreases and the profitability of the trend factor becomes greater. This is in line with the argument in Kang *et al*. (2021) that an increase in arbitrage costs (measured by the TED spread and the repo rate) makes factors less crowded and increases factor returns.

Conclusions

In this paper, the authors put forward a trend signal constructed from the short-, intermediate-, and long-run moving averages of settlement prices in commodity futures markets. A long-short portfolio analysis reveals that the trend strategy proposed outperforms the well-known momentum strategy by generating statistically and economically larger excess returns and exhibiting less downside risk. Time-series and cross-sectional pricing tests suggests that the trend factor is not subsumed by other extant factors such as the slope of the term structure (or basis), hedging pressure, basis-momentum, and value. Overall, the results indicate that long histories of futures prices contain important predictive information for the cross-section of commodity futures returns.

Endnotes

1 See Haynes and Roberts (2019).

2 A time-series trading strategy involves taking positions based on the security's own past returns. In contrast, the positions in a cross-sectional trading strategy are based on the relative performance of securities. See Goyal and Jegadeesh (2018) for a detailed examination of the difference between time-series and cross-sectional tests of predictability. Miffre (2016) also has an excellent summary of the trend literature categorized by the time-series and cross-sectional tests.

References

Baker, M. and J. Wurgler, 2006, "Investor Sentiment and the Cross-Section of Stock Returns," *Journal of Finance*, Vol. 61, No. 4, August, pp. 1645-1680.

Bakshi, G., Gao, X. and A. Rossi, 2019, "Understanding the Sources of Risk Underlying the Cross Section of Commodity Returns," *Management Science*, Vol. 65, No. 2, pp. 619-641.

Basak, S. and A. Pavlova, 2016, "A Model of Financialization of Commodities," *Journal of Finance*, Vol. 71, No. 4, August, pp. 1511-1556.

Bianchi, R., Drew, M. and J. Fan, 2016, "Commodities Momentum: A Behavioral Perspective," *Journal of Banking & Finance*, Vol. 72, November, pp. 133-150.

Chordia, T., Subrahmanyam, A. and Q. Tong, 2014, "Have Capital Market Anomalies Attenuated in the Recent Era of High Liquidity and Trading Activity?", *Journal of Accounting and Economics*, Vol. 58, No. 1, pp. 41-58.

Erb, C. and C. Harvey, 2006, "The Strategic and Tactical Value of Commodity Futures," *Financial Analysts Journal*, Vol. 62, No. 2, March-April, pp. 69-97.

Gong, Y., Gozluklu, A. and G. Kim, 2021, "Speculator Spreading Pressure and the Commodity Futures Risk Premium," WBS Finance Group Research Paper.

Goyal, A. and N. Jegadeesh, 2018, "Cross-Sectional and Time-Series Tests of Return Predictability: What is the Difference?", *Review of Financial Studies*, Vol. 31, No. 5, May, pp. 1784-1824.

Han, Y., Hu, T. and J. Yang, 2016, "Are There Exploitable Trends in Commodity Futures Prices?", *Journal of Banking & Finance*, Vol. 70, September, pp. 214-234.

Han, Y., Zhou, G. and Y. Zhu, 2016, "A Trend Factor: Any Economic Gains from Using Information over Investment Horizons?", *Journal of Financial Economics*, Vol. 122, No. 2, November, pp. 352-375.

Haynes, R. and J. Roberts, 2019, "Automated Trading in Futures Markets – Update #2," White Paper, Office of the Chief Economist, U.S. Commodity Futures Trading Commission, March 26. Accessed via website: https://www.cftc.gov/sites/default/files/2019-04/ATS_2yr_Update_Final_2018_ada.pdf on December 5, 2022.

Huang, D., Li, J., Wang, L. and G. Zhou, 2020, "Time Series Momentum: Is it There?", *Journal of Financial Economics*, Vol. 135, No. 3, March, pp. 774-794.

Kang, W., Rouwenhorst, K. and K. Tang, 2021, "Crowding and Factor Returns," SSRN 3803954, March 15. Accessed via website: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3803954 on December 5, 2022.

Miffre, J., 2016, "Long-Short Commodity Investing: A Review of the Literature," *Journal of Commodity Markets*, Vol. 1, No. 1, pp. 3-13.

Miffre, J. and G. Rallis, 2007, "Momentum Strategies in Commodity Futures Markets," *Journal of Banking & Finance*, Vol. 31, No. 6, June, pp. 1863-1886.

Moskowitz, T.J., Ooi, Y. and L. Pedersen, 2012, "Time Series Momentum," *Journal of Financial Economics*, Vol. 104, No. 2, May, pp. 228-250.

Narayan, P., Ahmed, H. and S. Narayan, 2015, "Do Momentum-Based Trading Strategies Work in the Commodity Futures Markets?", *Journal of Futures Markets*, Vol. 35, No. 9, September, pp. 868-891.

Sakkas, A. and N. Tessaromatis, 2020, "Factor Based Commodity Investing," *Journal of Banking and Finance*, Vol. 115, June, Article 105807.

Tang, K. and W. Xiong, 2012, "Index Investment and the Financialization of Commodities," *Financial Analysts Journal*, Vol. 68, No. 6, November-December, pp. 54-74.

Author Biographies

YUFENG HAN, Ph.D.
Belk College of Business, University of North Carolina at Charlotte

Dr. Yufeng Han joined the Belk College faculty as an Associate Professor of Finance in 2016. Prior to joining UNC Charlotte, he served as a faculty member at the University of Colorado Denver and Tulane University. Dr. Han's primary research interests are empirical asset pricing, investment, mutual funds, and econometrics. He has published in the *Review of Financial Studies, Journal of Financial Economics, Journal of Financial and Quantitative Analysis, Journal of Banking and Finance, Real Estate Economics* and many other finance and economics journals. Dr. Han received a Bachelor's degree from Tsinghua University (China) and a Ph.D. from Washington University in St. Louis.

LINGFEI KONG, Ph.D.
Olin School of Business, Washington University in St. Louis

Dr. Lingfei Kong is a Postdoctoral Research Associate in Finance at the Olin School of Business, Washington University in St. Louis. Dr. Kong received her Ph.D. in Finance from the University of North Carolina at Charlotte. Her research focuses on empirical asset pricing, return predictability, big data analytics, commodity futures, and product innovation.

The Hedging Pressure Hypothesis and the Risk Premium in the Soybean Reverse Crush Spread

Ziran Li, Ph.D.
School of Public Finance and Taxation, Southwestern University of Finance and Economics, Chengdu Sichuan, China

Dermot J. Hayes, Ph.D.
Department of Economics and Finance, Iowa State University

Published in: *Journal of Futures Markets*, 2022, Vol. 42, No. 3, March, pp. 428-445

This article develops a theory of multiproduct hedging which serves to formalize Keynes's hedging pressure hypothesis that the need to attract speculative capital to match hedgers' trades creates a difference between the futures and expected maturity price. The authors test the theory empirically in the context of the soybean complex which has speculators and hedgers in soybeans, soybean meal and soybean oil. The focus is on the crush spread because it is unlikely that hedgers will want to make simultaneous trades on the opposite side of soybean crushers in all three markets. The findings reveal that there is a significantly positive return to speculators for providing this liquidity.

Introduction

Keynes (1930) postulated that hedgers in futures markets ought to compensate speculators for bearing the risk of price movements. This compensation, also referred as risk premium, if it exists, suggests that the futures contract price deviates from the expected maturity price. There is little consensus in the literature regarding the existence of hedging pressure, in part because it is impossible to know the expected maturity price.

Soybean processors buy soybeans, crush them, and sell the resulting soybean meal and oil. The soybean "crush" thus represents the price difference between the appropriately weighted value of the soybean meal and oil futures, and the purchase of soybean futures, in other words it is a forward-looking measure of their expected margin. They can hedge this margin by buying soybean futures and selling oil and meal futures. Soybean processors commonly use this soybean crush spread as a hedge. Speculators can take "reverse crush" positions, long oil and meal and short soybeans, in order to take advantage of a potential risk premium paid by the crusher. There is no prior research examining whether the soybean crush spreads exhibit properties consistent with the hedging pressure hypothesis. This would happen if the speculators, who routinely take the reverse crush make consistent positive profits, i.e., earn a risk premium. The purpose of this paper is to determine if these profits exist.

Why the Paper's Research Agenda is Important

The price risk insurance role of futures markets remains a controversial debate. The authors contend that the crush spread is an ideal "laboratory" to test the hedging pressure hypothesis for five distinct reasons.

This digest article was contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.) and Associate Editor of the GCARD.

First, the spread itself is small relative to the underlying soybean price. A one- or two-cent risk premium might be detectable in the spread even if undetectable in the flat price of soybeans. Second, when crushers place their hedges in the relevant futures they buy soybeans, pushing their input prices up, and sell oil and meal, thereby putting downward pressure on their output prices. In both cases, their activity works to reduce the crush spread (increase the reverse crush) as measured in the futures markets. Third, crushers have information about the equilibrium size of the spread, which may come from measuring the historic spread for each month or by measuring the average fixed costs that the spread is covering. The appropriate size of the spread is not relevant to those who hedge or speculate in only one of the markets. Therefore, crushers can respond quickly to market conditions that provide them with a favorable spread. Conditions that are favorable to one crusher might lead other crushers to place similar spreads. Fourth, commodities such as corn and soybeans have natural longs and shorts. With natural hedgers on both sides of the market, it is hard to separate hedging pressure from other market forces. Any other market participant is very unlikely to *simultaneously* take the opposite side of the soybean crush for hedging purposes. On days when crushers place large hedges, having natural hedgers in all three underlying futures markets to offset the crush hedge is unlikely. Instead, speculative capital may be needed to provide liquidity in one or more markets; and incentives to attract speculative capital are what may allow us to detect the risk premium.

Theoretical Framework

Each of the three underlying futures markets studied does have natural hedgers on the opposite side of the crusher, which motivates the authors to develop a general theory of how producer-hedgers, processor-hedgers, and speculators in all three markets interact. The authors setup a model under just two types of players – a soybean producer (farmer) and a speculator. They initially leave out the commodity processor because this may take the opposite side from the producer. The speculator serves to clear the futures market by taking the opposite of the producer's desired short position. Net they set up a model in a more realistic scenario with producers, processors and speculators.

The theoretical framework suggests that without the offsetting positions from producer-hedgers, crushers will pay a risk premium to hedge the crush spread. Since there is no natural hedger for the reverse crush, they authors hypothesize that passively taking the reverse crush will yield significant positive returns.

Empirical Analysis

They authors test the aforementioned hypothesis by calculating sample moments of the returns of the soybean reverse crush spread. The main data are futures prices for soybean, soybean meal and soybean oil from *Barchart*. The key control variable is the carryover, which measures the available crop on December 1st from the United States Department of Agriculture to account for both the ending stocks from the previous marketing year as well as the new crop.

To execute a soybean crush hedge, the crusher sells 9 contracts of soybean oil, 11 contracts of soybean meal, and buys 10 contracts of soybeans. This "9-11-10" spread closely replicates the proportions governed by the soybean crushing technology (less 10,000 lbs out of 550,000 lbs of soybean oil, which is left unhedged). Thus, we calculate the reverse crush spread (*rcs*) in month $j < J$ maturing in month J as:

$$rcs_{j,J} \equiv \log\left(2.2 * meal_{j,J} + 10.8 * oil_{j,J}\right) - \log\left(soybean_{j,J}\right) \text{ with } J = 1, 3, 5, 7, 9, 11 \quad (1)$$

The excess return of the soybean futures reverse crush spread is obtained as $\Delta rcs_{j,J} \equiv rcs_{J-1,J} - rcs_{j,J}$ with the reverse crush trade closed one month prior to the maturity month to avoid liquidity and calendar date problems in months when contracts expire.

Table 1 provides details on the average return of the reverse crush spread by contract maturity from 1962 to 2019. There is evidence of a risk premium—the November soybean futures crush spread price with more than three months to maturity overestimated the realized crush margin by approximately 1.5%. The crush spread per bushel of soybeans purchased is typically 20% of the price of one bushel, which, for $10 per bushel soybeans, corresponds to $2 per bushel used. A 1.5% reverse crush margin means that the crusher is paying about $0.03 per bushel crushed and appropriately hedged.

Table 1
Reverse Crush Spread Return by Contract Maturity and by Month to Maturity, 1962–2019

	Holding Period (month)									
Maturity Month	1	2	3	4	5	6	7	8	9	10
Jan	0.004	0.008	0.014	0.015	0.017	0.018	0.018	0.021	0.023	0.021
Mar	0.000	0.000	0.003	0.005	0.010	0.010	0.011	0.013	0.013	0.016
May	0.001	-0.001	0	0.001	0.002	0.004	0.007	0.007	0.007	0.010
July	0.000	0.002	0.004	0.001	0.001	0.003	0.003	0.005	0.009	0.005
Sep	0.005	0.008	0.005	0.007	0.010	0.010	0.011	0.012	0.009	0.005
Nov	0.008	0.010	0.013	0.014	0.013	0.015	0.018	0.018	0.017	0.012

Note: The reverse crush spread is closed one month prior to the maturity month, thus we construct the January reverse crush spread using January contracts closed in December of the preceding year. The November reverse crush spread consists of the November soybean contract and December contracts of soybean meal and oil. The November reverse crush is closed in October.

The sample averages for different maturity and duration combinations are overwhelmingly positive. If the futures forecasts are truly unbiased with equal probability of over- and under-predicting the realized spot prices in a given month, then the Bernoulli probability of observing 59 positive forecast errors out of 60 is very small at $\frac{1.73}{10^{18}}$.

Table 2 summarizes the reverse crush spread by contract maturity of the returns with less than 12 months to maturity. The skew is positive for contracts maturing in January, March, May and November. Chen's (1995) upper-tailed test for the mean of positively skewed distributions indicates these sample averages are significant at the 1% level.

Table 2
Summary Statistics of Reverse Crush Spread Return

	Maturity Month					
	Jan	**Mar**	**May**	**Jul**	**Sep**	**Nov**
Mean	0.0157***	0.0080***	0.0038***	0.0033	0.0083	0.0137***
(p-value)	<0.0001	<0.0001	0.0003	\	\	<0.0001
Median	0.0102	0.0019	-0.0001	0.0019	0.0084	0.0099
Std. Dev	0.0354	0.0363	0.0279	0.0272	0.0244	0.0254
Min	-0.0692	-0.0551	-0.0738	-0.1197	-0.0608	-0.0493
Max	0.1443	0.1991	0.1489	0.0838	0.0795	0.0876
Skewness	0.8774***	2.5297***	1.6973***	0.0510	0.1626	0.4894***
(p-value)	<0.0001	<0.0001	<0.0001	0.6221	0.1210	<0.0001
Excess Kurtosis	4.1284***	12.7040***	9.3400***	4.2315***	3.2514	3.0825
(p-value)	0.0002	<0.0001	<0.0001	0.0001	0.2159	0.5939

Note: The table reports statistics for the reverse crush spread of different maturities with less than 12 months to maturity. The sample period is 1962 to 2019. p-values are reported for the mean, skewness, and excess kurtosis are reported. Asterisks denote significance levels as follows: *10%; ** 5%; and ***1% significance.

Conclusions

In this paper, the authors start by arguing that the crush spread represents an ideal laboratory to test Keynes's hedging pressure hypothesis. They develop a general equilibrium model that includes speculators, producer hedgers, commodity processor-hedgers, and hedgers who take the opposite side of the processor in the output market. Testing hypothesis that arise from the model, they provide evidence of hedging pressure in the soybean reverse crush spread. The size of the spread is modest – about $0.03 per bushel hedged – relative to whole soybean prices. This modestly sized risk premium, coupled with a lack of information on what the true expected maturity price is in other futures markets, may explain why support for Keynes's hedging pressure hypothesis has proven so elusive. The results suggest that in markets where net hedging is long, the futures prices will be biased upwards. The opposite is true in markets where net hedging is short. The implications for traders in the soybean pits is that there is likely a small negative bias in new crop soybean futures and a small positive bias in meal and oil futures.

References

Chen, L., 1995, "Testing the Mean of Skewed Distributions," *Journal of the American Statistical Association,* Vol. 90, No. 430, June, pp. 767-772.

Keynes, J.M., 1930, A Treatise on Money, Vol. II, London: MacMillan.

Author Biographies

ZIRAN LI, Ph.D.
School of Public Finance and Taxation, Southwestern University of Finance and Economics, Chengdu Sichuan, China

Dr. Ziran Li is an Associate Professor at the School of Public Finance and Taxation at Southwestern University of Finance and Economics in Chengdu Sichuan, China. He received both a Bachelor of Applied Science in Economics and Math and a Ph.D. in Agricultural Econimics and Behavioral Economics from Iowa State University. His research papers have been published in journals including *Agricultural Finance Review*, *American Journal of Agricultural Economics*, *Agricultural Policy Review*, and the *Journal of Futures Markets.*

DERMOT J. HAYES, Ph.D.
Department of Economics and Finance, Iowa State University

Dr. Dermot Hayes is the Charles F. Curtiss Distinguished Professor in Agriculture and Life Sciences in the Department of Economics and Professor and Pioneer Hi-Bred International Chair in Agribusiness in the Ivy School of Business at Iowa State University. His areas of expertise include U.S. farm policy and international agricultural trade, agribusiness, crop insurance, financial derivatives and the potential impact of China on commodity markets.

In 2006, Dermot received a "Publication of Enduring Quality" award from the Agricultural and Applied Economics Association. AAEA named him a Fellow in 2007, its highest recognition for distinction in the discipline. Since 1995 he has been a consulting trade economist for the National Pork Producers Association.

Commodities, Crude Oil, and Diversified Portfolios

Hilary Till
Contributing Editor, *Global Commodities Applied Research Digest*; Solich Scholar, J.P. Morgan Center for Commodities (JPMCC), University of Colorado Denver Business School

Hilary Till (right), Contributing Editor of the *GCARD*, with Dr. Lutz Kilian, Ph.D. (left), Senior Economic Policy Adviser, Federal Reserve Bank of Dallas and Member of the JPMCC's Research Council, at a JPMCC international commodities symposium.

With concerns on inflation flaring up, there has been renewed interest in potentially including commodities in diversified portfolios. This article will build off prior research in examining which commodities to include and in what size. After briefly reviewing the relevant literature, we will propose a novel and uncomplicated portfolio solution, which takes into consideration both historical results and plausible new paradigms. In addition, an investor would be able to implement this portfolio solution through deeply liquid futures markets.

Literature Review

Commodities for Inflation-Hedging

Neville *et al.* (2021) provides an updated look into inflation hedges with a long-term dataset of monthly commodity futures prices from 1946 through 2020. The constituents of the paper's commodity baskets vary according to when the main commodity sectors had liquidly traded U.S. futures contracts. The authors find that "traded commodities have historically performed best during high and rising inflation."

All views expressed in the *GCARD* are those of the individual authors and not of the JPMCC, its sponsors, or donors.

In addition, their dataset's commodity baskets had "a perfect track record of generating positive real returns" across inflationary regimes in the U.S., "averaging an annualized +14% real return." This striking historical feature provides a good starting point for considering commodities in a diversified equity-and-bond portfolio, given (a) that the recent "unprecedented monetary and fiscal interventions" have arguably increased the risk of inflation and (b) that since 1926, "neither equities nor bonds perform well in real terms during inflationary regimes," as summarized by Neville *et al.* (2021).

The Special Role of Energy Futures Contracts

Diversification

As a next step in considering a commodity investment, we should directly examine which commodities have provided the best portfolio diversification. Froot (1995) found that "almost any combination of commodities does at least reasonably well in protecting bond portfolios against inflation." This result was based on analyzing annual returns from 1947 to 1992. "However, *oil* (with or without other energy prices) *is needed to effectively hedge stock portfolios*." (Italics added.) For the latter conclusion, the author used the following two time horizons in his empirical work: he examined quarterly returns from the first quarter of 1973 to the second quarter of 1993, and he also analyzed quarterly returns from the first quarter of 1983 to the second quarter of 1993. In the 1973-to-2Q1993 analysis, Froot (1995) used spot oil prices before 1983, after which he was able to use West Texas Intermediate (WTI) crude oil futures prices, given that the WTI contract began trading in 1983.

Erb and Harvey (2006) provided further empirical evidence that is relevant to the portfolio diversification question. These authors noted that "the non-energy sector has a statistically significant, but small equity risk premia beta." Their study included monthly data from December 1982 to May 2004. Therefore, over the time horizon of the Erb and Harvey (2006) study, the commodity markets within the non-energy sector would have *amplified* equity risk.

Persistent Sources of Return

We should also consider which commodity markets would be expected to provide persistent sources of return before adding them to a portfolio. Bouchouev and Zuo (2020) pointed out that energy futures contracts contribute a disproportionately large share of the "performance of many systematic commodity investments." And "[f]or many [published] strategies, the main contribution of most non-energy commodities was in adding diversification and improving the denominator of the portfolio Information Ratios." In other words, the role of non-energy commodities has been to reduce the volatility of commodity portfolios rather than to provide returns.

Energy-Focused Positions for Portfolio Diversification

Collectively, the Erb and Harvey (2006) article and the Bouchouev and Zuo (2020) paper indicate that we should consider *avoiding* non-energy commodities (a) so as not to add to equity risk exposures and (b) because there are not obvious structural sources of return in these markets. In addition, the Froot (1995) paper provides evidence that *oil-weighted commodities* had historically exhibited "strong hedging properties" for "broadly diversified portfolios."

Crude Oil Futures Markets and a Timing Indicator

Based on our brief literature review thus far, we could conclude that in order to add to returns *and* diversify an equity-and-bond portfolio that we should focus on the crude oil markets. Now, an empirical analysis of returns is useful only in so far as the state-of-the-world that occurred historically continues to be the case. If one understands an investment's economic source of returns, then one can decide whether it is plausible that the investment's historical returns will continue. Accordingly, we will adopt such a perspective in deciding upon how to take positions within the crude oil futures markets.

There are two deeply liquid oil futures markets: the WTI futures contract and the Brent futures contract. One difficulty in performing a historical study with the WTI market is that this contract has periodically detached from the global oil market, resulting in anomalous pricing of the front-month contract as compared to other markets' crude oil prices. This has happened when there have been storage difficulties at the WTI contract's hub, which impacts the market-clearing price of WTI, especially as the contract nears its maturity date, since it is a physically delivered contract. Similar issues have not been as severe for Brent futures contracts since, in contrast with WTI futures contracts, the Brent contracts can be cash-settled.

As noted above, we would like our commodity position-taking to not only provide portfolio diversification, but also be additive to returns. To achieve the latter ambitious goal, is there a relatively simple indicator for understanding when a commodity is scarce and therefore could be an indicator for taking on long positions? The short answer is yes, and for this goal we need to understand the importance of a contract's "curve shape." The term structure of a commodity futures market is classified as a "curve" because each delivery-month contract is plotted on the x-axis with their respective prices on the y-axis: thus, tracing out a curve. When the near-month futures contracts trade at a discount to further-delivery contracts, one terms the futures curve as being in *contango*. When the near-month futures contracts instead trade at a premium to further-delivery contracts, one terms the futures curve as being in *backwardation*.

With monthly data, Gorton *et al.* (2013) examined 31 commodity futures over the period, 1971 to 2010 and were able to link relatively backwardated futures contracts with relatively low inventories (and correspondingly, relatively more scarcity.) Tchilinguirian (2003) provided a conceptual explanation for why a futures curve would be backwardated during times of scarcity. By having lower prices in further-delivery contracts relative to the spot month, the market provides no return for storing the commodity. Instead, during times of scarcity, the futures market incentivizes the delivery of the commodity for immediate use. Therefore, a relatively simple indicator for scarcity is if the futures contract's front-month trades at a premium to the next delivery month's contract.

At this point in on our literature review, we have made progress in deciding upon which commodity contracts to include in a diversified equity-and-bond portfolio. We have narrowed our choice of commodity futures instruments to solely be Brent futures contracts and to only enter positions in this market when the Brent futures curve trades in backwardation.

Sizing of Commodity Positions

How large should one's potential positioning be in diversifying commodities? Levine *et al.* (2016) examined what sizing would have been best historically. In a 1946-to-2015 mean-variance optimization, which included monthly data on various commodity futures contracts as they became available, the researchers found that the optimal portfolio would have been weighted 39% in bonds, 29% in commodities, and 31% in stocks. (We assume that the weights do not add up to 100% due to rounding error.) From these results, one would conclude that a commodity position as large as about 30% could be advisable, and we can check such a portfolio's results out-of-sample: that is, post-2015.

A Structural Break in the Oil Markets

There is a further advantage to examining a commodity strategy post-2015. Bouchouev and Zuo (2020) warn that "[b]y and large, any systematic [*oil*] strategies based on data prior to 2016 must be taken with a great amount of skepticism. While the shale revolution … started gradually impacting the energy trading landscape much earlier, … [a] structural break might have occurred around the end of 2015 when the ban on U.S. oil exports was eliminated."

Potential Value of Historical Studies

Even though the various historical studies on the statistical properties of commodity prices use different commodity baskets, time frames, data sources, weighting schemes, and rebalancing strategies, they may still be collectively useful in distilling what the most important properties are for investigating new commodity-oriented strategies. This supposition will be tested in the next section of this article.

Dynamic Portfolio Construction

Study Description

We will now examine whether it might be possible to systematically improve upon a classic balanced portfolio of 60% U.S. equities and 40% U.S. Treasuries. Unless there are solid reasons otherwise, such a portfolio will be our default allocation: it is our neutral benchmark. We will choose an alternative allocation of 30% U.S. equities, 30% commodities, and 40% Treasuries, which is near the historically optimal asset allocation in Levine *et al.* (2016) with several noteworthy differences. Our commodity allocation, as would be expected from our literature review, will solely be in Brent futures contracts, and we will only invest in the alternative allocation when the Brent contracts are trading in backwardation. In addition, this study will use liquid futures contracts for readily gaining exposure not only to the Brent market but also for taking positions in U.S. equities and U.S. Treasuries. In contrast, Levine *et al.* (2016)'s financial asset classes were drawn from "long-term U.S. government bonds and the aggregate U.S. stock market" and whose total returns were provided by Global Financial Data.

Our study's specific trading rules are as follows: if the previous trading day's Brent front-month-to-back-month spread is trading at a premium, take positions amounting to 30% in U.S. equities, 30% in Brent contracts, and 40% in 10-Year Treasuries. Otherwise, invest in the default portfolio of 60% U.S. equities and 40% 10-Year Treasuries. We will compare this trading rule's results to the following two portfolios: (1) a balanced 60% equity / 40% 10-Year Treasury portfolio, and (2) an unconditional allocation to 30% in equities, 30% in commodities, and 40% in 10-Year Treasuries. We will gain exposure to each of the study's asset classes through fully collateralized positions in their corresponding futures markets.

Data

Our study will use daily data from December 31, 1999 through December 31, 2020. The trading days will follow the New York Stock Exchange's holiday calendar. For the Brent oil futures contract's front-to-back spread, we will use the Brent settlement prices that are available from Bloomberg. For our study's asset class returns, we will use total return series that are calculated by S&P Dow Jones Indices and which are available from Bloomberg. For the calculation of the study's Sharpe Ratios, we will use excess return series that are also calculated by S&P Dow Jones Indices and are available from Bloomberg.

Table 1 provides the Bloomberg tickers for the Brent front-to-back spread; the table also displays the Bloomberg tickers for both the total return series and the excess return series for Brent futures contracts, U.S. 10-Year Treasury Notes futures contracts, and E-Mini S&P 500 futures contracts. With one exception, each of these return series are described at their respective S&P Dow Jones Indices websites; Table 2 provides the links for five of the six return series.

Table 1
Data Sources with Bloomberg Tickers

Reference Asset	Data	Bloomberg Ticker
	Brent Futures Front-to-Back Spread	CO1 Comdty - CO2 Comdty
U.S. Large-Capitalization Equities	S&P 500 Futures Total Return S&P 500 Futures Excess Return	SPXFTR Index SPXFP Index
U.S. 10-Year Treasury Notes	U.S. 10-Year Treasury Note Futures Total Return U.S. 10-Year Treasury Note Futures Excess Return	SPUSTTTR Index SPUSTTP Index
Brent Crude Oil	S&P GSCI Brent Crude Total Return S&P GSCI Brent Crude Excess Return	SPGSBRTR Index SPGSBRP Index

Table 2
Websites for S&P Dow Jones Indices

Data	S&P Dow Jones Indices Website (as of May 31, 2021)
S&P 500 Futures Total Return S&P 500 Futures Excess Return	https://www.spglobal.com/spdji/en/indices/strategy/sp-500-futures-index/#overview *Same as above*
U.S. 10-Year Treasury Note Futures Total Return	https://us.spindices.com/indices/fixed-income/sp-10-year-us-treasury-note-futures-total-return-index
S&P GSCI Brent Crude Total Return S&P GSCI Brent Crude Excess Return	https://us.spindices.com/indices/commodities/sp-gsci-brent-crude *Same as above*

The sixth return series, the U.S. 10-Year Treasury Notes Futures Excess Return, is described in Citigroup Global Markets Holdings (2021).

Results

Table 3 provides the 2000-to-2020 yearly performance of (1) the neutral portfolio (60% equities and 40% Treasuries), (2) the static allocation across the three asset classes (30% equities, 30% oil, and 40% Treasuries), and (3) the conditionally determined strategy (the dynamic allocation portfolio). Table 4 provides the summary statistics for the three portfolios.

Over the full dataset, the "dynamic allocation" portfolio's compound annual growth rate (CAGR) was 10.0%, which outperformed the two static allocation portfolios' returns. The traditional portfolio earned 6.6% while the 30% equities/30% oil/40% Treasuries portfolio earned 6.7%. The dynamic allocation portfolio's Sharpe Ratio came in at 1.0 while the other two portfolios had Sharpe Ratios of 0.5.

Over the 2016-to-2020 timeframe, the dynamic allocation portfolio still outperformed the classic balanced portfolio with the former portfolio having a CAGR of 12.3% and the latter portfolio earning 10.8%. The 30% equities/30% oil/40% Treasuries portfolio had the lowest returns of the three portfolios with a CAGR of 8.7%. The dynamic portfolio's Sharpe Ratio was 1.3 while the classic balanced portfolio's Sharpe Ratio was 1.1. The Sharpe Ratio of the 30% equities/30% oil/40% Treasuries portfolio was the lowest of the three portfolios at 0.7.

Table 3
Yearly Returns

	60% Equities / 40% Treasuries	30% Equities / 30% Oil / 40% Treasuries	Dynamic Allocation
2000	0.4%	13.3%	10.7%
2001	-6.2%	-4.1%	3.9%
2002	-7.2%	14.1%	0.3%
2003	18.0%	18.3%	18.4%
2004	8.8%	19.8%	23.7%
2005	4.1%	13.3%	10.5%
2006	10.6%	5.2%	8.3%
2007	7.5%	20.4%	21.1%
2008	-17.3%	-22.3%	-9.0%
2009	13.9%	16.4%	15.0%
2010	12.5%	12.0%	12.5%
2011	7.0%	12.3%	9.2%
2012	10.9%	9.3%	9.4%
2013	16.3%	9.5%	9.0%
2014	10.6%	-12.1%	8.8%
2015	1.5%	-14.3%	1.5%
2016	7.5%	14.2%	6.8%
2017	13.0%	12.1%	20.2%
2018	-2.2%	-4.8%	0.9%
2019	20.9%	23.8%	21.7%
2020	16.0%	0.4%	13.3%

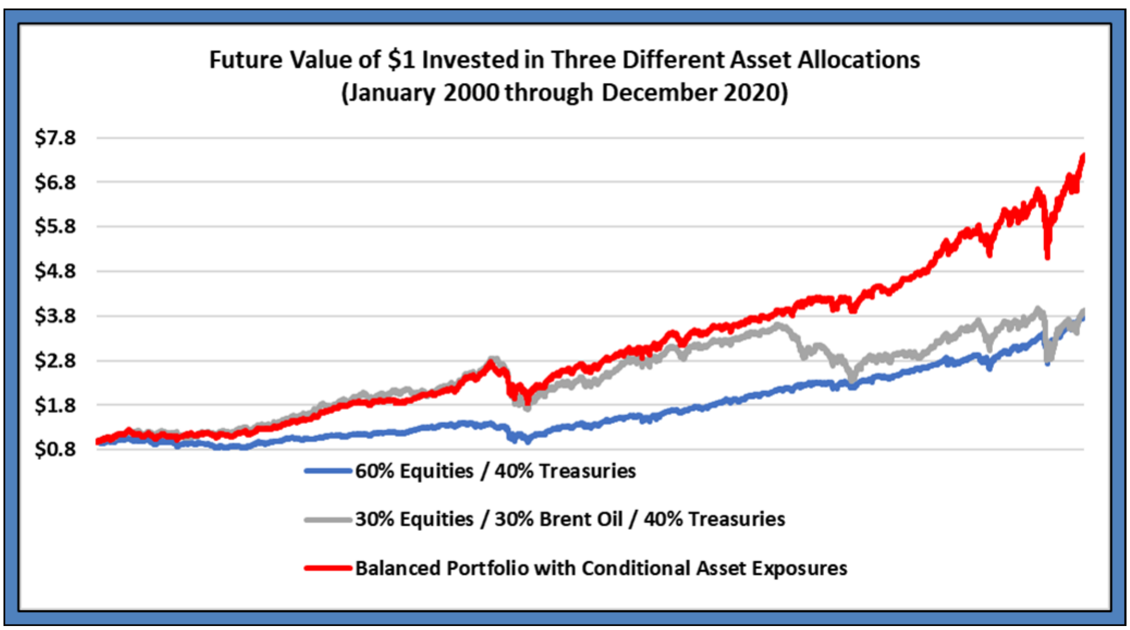
Table 4
Summary Statistics

Full Dataset: 2000 to 2020	60% Equities / 40% Treasuries	30% Equities / 30% Oil / 40% Treasuries	Dynamic Allocation
Geometric Average Annual Return:	6.6%	6.7%	10.0%
Sharpe Ratio:	0.5	0.5	1.0
Worst Year:	-17.3%	-22.3%	-9.0%
2000 to 2015			
Geometric Average Annual Return:	5.3%	6.1%	9.3%
Sharpe Ratio:	0.4	0.4	1.0
Worst Year:	-17.3%	-22.3%	-9.0%
2016-2020			
Geometric Average Annual Return:	10.8%	8.7%	12.3%
Sharpe Ratio:	1.1	0.7	1.3
Worst Year:	-2.2%	-4.8%	0.9%

Note: The Sharpe Ratios are calculated from the yearly data in Table 3.

Figure 1 shows the growth of $1 in each of the three asset allocations from January 2000 through December 2020.

Figure 1



Note: The performance of the classic balanced portfolio is represented by the blue line; the performance of the static allocation portfolio across the three assets is shown in the grey line; and the performance of the dynamic allocation strategy is displayed in the red line.

Source: Premia Research LLC.

Impact of Publishing a Trading or Investment Strategy

The study's results are highly suggestive of how to potentially improve upon a default allocation of 60% in equities and 40% in Treasuries, which is of heightened interest because of the renewed concerns of possibly entering into an inflationary era. That said, one risk of publicly identifying investment or trading strategies that have historically had superior returns is that they will stop working as capital flows into them, a concern noted in Cochrane (1999). But it may be that the particular dynamic asset allocation that is outlined in this article is sufficiently unusual as to prevent overcrowding in the strategy.

Impact of a New Paradigm in the Energy Markets on Portfolio Construction

Another concern with this paper's results is its reliance on crude oil futures returns. What will happen to such a strategy if crude oil no longer remains a crucial fuel in the global economy, given how, in the words of Neville *et al*. (2021), "electric vehicle technology [is] developing fast"?

Dale and Fattouh (2018) provide a framework for the prospect of "peak oil demand." Even if oil demand levels off, "[t]he world is likely to demand large quantities of oil for many decades to come." The key paradigm shift under a "peak oil demand" scenario is that there would be a break from "a past dominated by concerns about adequacy of supply." The world would be an entering an "age of [oil] abundance."

The utility of our dynamic allocation's strategy signal is that it is a proxy measure of oil inventory scarcity. And when there is a signal of surplus, the dynamic strategy does not include oil futures within its asset allocation. Under a new paradigm of oil abundance, the strategy would be expected to default to the classic balanced portfolio of equities and Treasuries. As a result, even with "peak oil demand," an investor in the dynamic allocation strategy would plausibly be no worse off than solely investing in a classic balanced portfolio. And then however long the current paradigm holds, the investor in the dynamic allocation strategy could potentially earn superior returns relative to a neutral portfolio of equities and Treasuries.

Conclusion

This article provided a brief (and therefore, not exhaustive) review of papers that are relevant to including commodities in traditional portfolios. The topic has once again come to the fore over concerns on potentially entering into an era of inflationary surprises, which would not bode well for portfolios solely invested in stocks and bonds.

Based on insights in prior research, this paper suggests a dynamic asset allocation into crude oil (and namely, into Brent futures contracts) when there is a (historically) reliable signal of scarcity. Such a portfolio, which consists entirely of collateralized futures contracts, would have had a Sharpe Ratio of 1.0 from 2000-to-2020 and a Sharpe Ratio of 1.3 from 2016-to-2020.

A key concern with such a strategy is if the demand for crude oil is supplanted by alternative fuels. Because the strategy is relying on the markets to provide a signal of oil scarcity or surplus, an investor can potentially be agnostic on when an energy transition could occur. When a surplus in oil is signaled, the rules-based investment strategy defaults to a classic balanced portfolio.

As always, one must sound a cautionary note on the paper's historical results since past performance is no guarantee of future results. One hopes, though, that this article stimulates further interest in designing efficient hedges for the corrosive effect that inflationary surprises can have on traditional portfolios.

Endnotes

This article originally appeared in the July 2021 *GCARD Newsletter*.

The author gratefully acknowledges research assistance from Mark Shore, Chief Research Officer, Shore Capital Research and Adjunct Professor, DePaul University in Chicago. Shore is also an Editorial Advisory Board member of the *GCARD*.

Of note also, the Premia Research Bancor Index employs amongst other economically based signals, the insights from this article. The index, which was co-developed by the author and Joseph Eagleeye, is calculated by S&P Dow Jones Indices, and its Bloomberg ticker is PRBITR Index. The Bancor index was launched on August 11, 2015.

References

Bouchouev, I. and L. Zuo, 2020, "Oil Risk Premia under Changing Regimes," *Global Commodities Applied Research Digest*, Editorial Advisory Board Analysis, Vol. 5, No. 2, Winter, pp. 49-59. [Dr. Bouchouev is a member of the *GCARD*'s Editorial Advisory Board.]

Citigroup Global Markets Holdings Inc., 2021, "Market-Linked Notes Based on the Citi Dynamic Asset Selector 5 Excess Return Index Due May 31, 2028," Medium-Term Senior Notes, Series N, Pricing Supplement No. 2021-USNCH7499, Filed Pursuant to Rule 424(b)(2), Registration Statement Nos. 333-255302 and 333-255302-03, May 25. Accessed via website: https://sec.report/Document/0000950103-21-008047/dp151852_424b2-us2142507.htm on May 31, 2021.

Cochrane, J., 1999, "New Facts in Finance," *Economic Perspectives*, Federal Reserve Board of Chicago, Third Quarter, pp. 36-58.

Dale, S. and B. Fattouh, 2018, "Peak Oil Demand and Long-Run Oil Prices," *Energy Insight: 25*, Oxford Institute for Energy Studies, January.

Erb, C. and C. Harvey, 2006, "The Tactical and Strategic Value of Commodity Futures: Unabridged Version," Trust Company of the West and Duke University Working Paper, January 12.

Froot, K., 1995, "Hedging Portfolios with Real Assets," *Journal of Portfolio Management*, Vol. 21, No. 4, Summer, pp. 60-77.

Gorton, G., Hayashi, F. and G. Rouwenhorst, 2013, "The Fundamentals of Commodity Futures Returns," *Review of Finance*, European Finance Association, Vol. 17, No. 1, January, pp. 35-105. [Dr. Rouwenhorst is a member of the JPMCC's Research Council.]

Levine, A., Ooi, Y. and M. Richardson, 2016, "Commodities for the Long Run," National Bureau of Economic Research Working Paper No. 22793, November.

Neville, H., Draaisma, T., Funnell, B., Harvey, C. and O. van Hemert, Man Group Working Paper, 2021, "The Best Strategies for Inflationary Times," May 25. Available at SSRN: https://ssrn.com/abstract=3813202 as of May 31, 2021.

Tchilinguirian, H., 2003, "Stocks and the Oil Market: Low Stocks, Volatility, Price Levels, and Backwardation," International Energy Agency – Oil Industry & Markets Division Presentation, Berlin, September 19.

Author Biography

HILARY TILL
Contributing Editor, *Global Commodities Applied Research Digest*; Solich Scholar, J.P. Morgan Center for Commodities, University of Colorado Denver Business School

Hilary Till is the Solich Scholar at the J.P. Morgan Center for Commodities (JPMCC), University of Colorado Denver Business School and Contributing Editor of the JPMCC's Global Commodities Applied Research Digest (*GCARD*). Her articles for the *GCARD* are available here. Till is also a principal of Premia Capital and a consultant with Premia Research LLC. Among Till's professional roles, she has served as the Head of Portfolio Analysis at BNY Mellon Wealth Management | Risk. In addition, Till was the Chief of Derivatives Strategies at Putnam Investments where she oversaw the strategy development and execution of about $90 billion annually in derivatives strategies. Till's additional academic affiliation includes her membership in the North American Advisory Board of the London School of Economics (LSE). She formerly served as a Fellow and an Advisory Board member of DePaul University's Arditti Center for Risk Management and also as a Research Associate at the EDHEC-Risk Institute (Nice, France and Singapore). In addition, while with DePaul and EDHEC-Risk, she was a lecturer for their respective Executive Education programs. She has been a panel member at the U.S. Energy Information Administration's (EIA's) workshops on financial and physical energy market linkages, including the EIA's workshop on the dynamics of oil, natural gas, and LNG markets. In addition, she is the Co-Editor of the Risk Book (London) bestseller, "Intelligent Commodity Investing," and is a Fellow of the Royal Statistical Society (U.K.). She has a B.A. with General Honors in Statistics from the University of Chicago with Concentrations in Economics and Computer Science and an M.Sc. degree in Statistics from the LSE where she studied under a private fellowship administered by the Fulbright Commission.

Disclaimers

This article is not intended to be a recommendation or investment advice, does not constitute a solicitation to buy, sell or hold a security or an investment strategy, and is not provided in a fiduciary capacity. The information provided does not take into account the specific objectives or circumstances of any particular investor or suggest any specific course of action. Investment decisions should be made based on an investor's objectives and circumstances and in consultation with his or her advisors. The views and opinions expressed are for informational and educational purposes only as of the date of production/writing and may change without notice at any time based on numerous factors, such as market or other conditions, legal and regulatory developments, additional risks and uncertainties and may not come to pass. This article may contain "forward-looking" information that is not purely historical in nature. Such information may include, among other things, projections, forecasts, estimates of market returns, and proposed or expected portfolio composition. Any changes to assumptions that may have been made in preparing this article could have a material impact on the information presented herein by way of example. Past performance is no guarantee of future results. Investing involves risk; principal loss is possible. All information has been obtained from sources believed to be reliable, but its accuracy is not guaranteed. There is no representation or warranty as to the current accuracy, reliability or completeness of, nor liability for, decisions based on such information, and it should not be relied on as such.

All investments carry a certain degree of risk and there is no assurance that an investment will provide positive performance over any period of time. Commodity Trading Involves Substantial Risk of Loss.

China Natural Gas Domestic Production and Imports Reached Record-High in 2021 but Declined in 2022

Faouzi Aloulou
Senior Industry Economist, U.S. Department of Energy, Energy Information Administration (EIA); and Editorial Advisory Board Member, *Global Commodities Applied Research Digest*

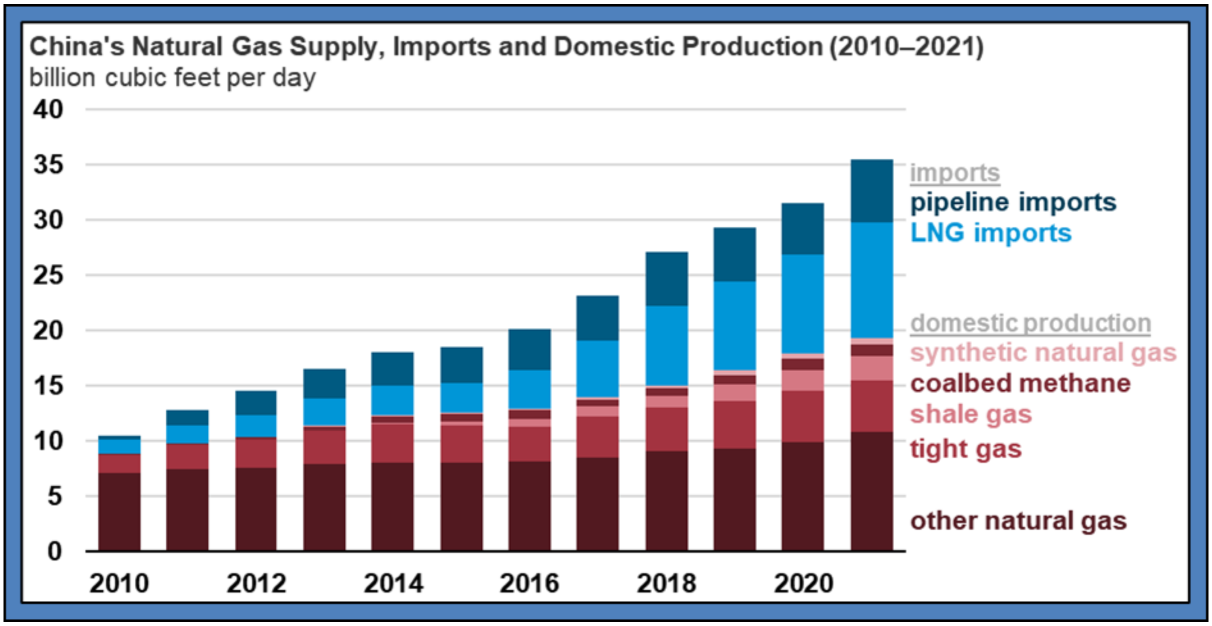
Victoria Zaretskaya
Lead Industry Economist, U.S. Department of Energy, Energy Information Administration

From left to right: Governor Li of Guangdong; Faouzi Aloulou of the U.S. DOE's EIA; President Daren of Sun Yat-Sen University (SYSU); and Professor Guo, SYSU Director of the Center for LNG Education, Training and Research, Guangzhou City, Guangdong, China, November 27, 2005, after the release of the Mandarin version of the EIA's *International Energy Outlook* 2005.

China Increased Both Natural Gas Imports and Domestic Production in 2021

In 2021, an average 35.5 billion cubic feet per day (Bcf/d) of natural gas was consumed in China, more natural gas than in any previous year. More than half of the natural gas consumed in China in 2021 came from domestic production, but China also imported record amounts of natural gas by pipeline and as liquefied natural gas (LNG), based on data from Global Trade Tracker and China's General Administration of Customs.

Figure 1



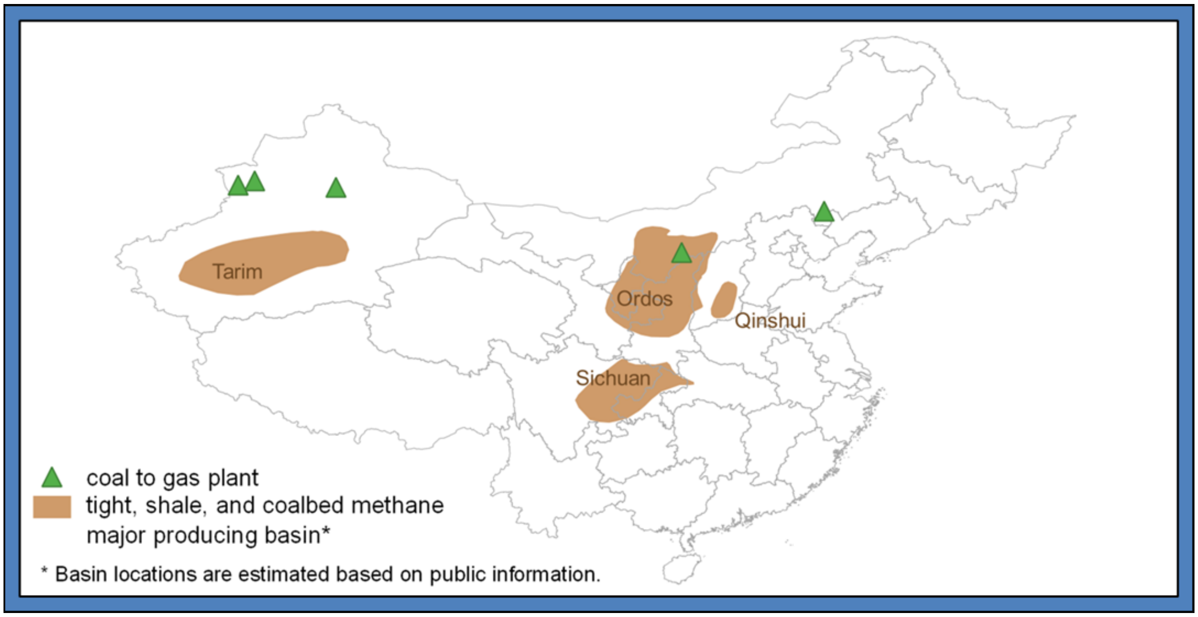
Source: Graph by the U.S. Energy Information Administration, based on China's National Bureau of Statistics, China's General Administration of Customs, Global Trade Tracker, and IHS Markit.

Note: *Other natural gas* refers to natural gas that is produced from discrete gas reservoirs and associated gas from oil production.

Government policies promoting coal-to-natural-gas switching to reduce air pollution and meet emissions targets have been a major factor in the rapid growth of both domestic natural gas production and natural gas imports in China. In March 2022, China's government released its 14th Five-Year Plan (2021–25), which sets the domestic natural gas production target at 22.3 Bcf/d by 2025, or 3.0 Bcf/d more than domestic production in 2021.

In 2021, 56% of domestic natural gas production in China was natural gas produced from discrete gas reservoirs and associated natural gas from oil production. Production of natural gas from tight gas, shale gas, and coalbed methane collectively accounted for 44% of domestic natural gas production in China during 2021. Various government subsidy programs supported these projects. China's development of natural gas from sources that use hydraulic fracturing is a key part of the government's strategy to secure domestic natural gas supply.

Figure 2
China's Tight Gas, Shale Gas, Coalbed Methane, and Synthetic Gas Producing Areas



Source: U.S. Energy Information Administration.

Tight gas production in China has grown since 2010, when companies initiated an active drilling program that lowered the drilling cost per vertical well and improved well productivity (Aizhu, 2013). In 2021, China produced 4.6 Bcf/d from tight gas formations, compared with 1.6 Bcf/d of tight gas produced in 2010.

Shale gas development in China has increased steadily in the past few years, growing 21% annually since 2017 (Aloulou, 2015). In 2021, shale gas production totaled 2.2 Bcf/d, which was below the government target of 2.9 Bcf/d by 2020.

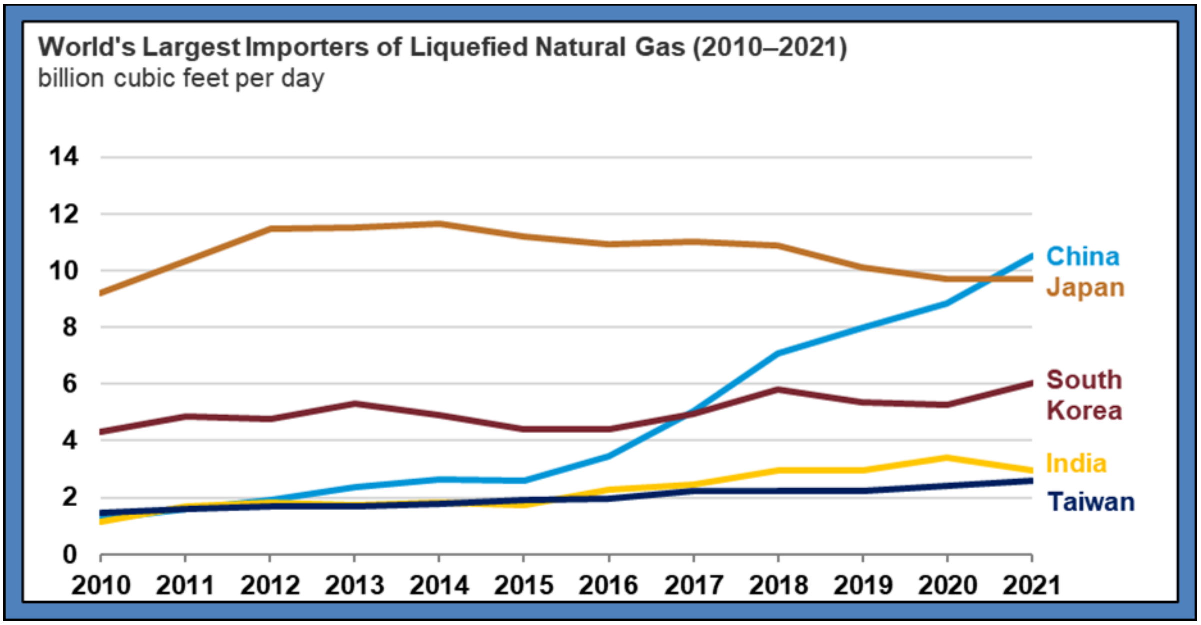
Coalbed methane development in China faces significant challenges, including relatively low well productivity and relatively high production costs. Last year, coalbed methane production reached 1.0 Bcf/d, or 5% of China's total natural gas production.

In China, production of synthetic natural gas from coal, which involves gasifying coal into methane at five available plants, totaled 3% of domestic production in 2021.

As of 2021, China Imports More Liquefied Natural Gas than any Other Country

In 2021, China imported more liquefied natural gas (LNG) than any other country, according to data from Global Trade Tracker and China's General Administration of Customs. Prior to 2021, Japan had been the world's largest LNG importer for decades, according to data from Cedigaz.[1]

Figure 3

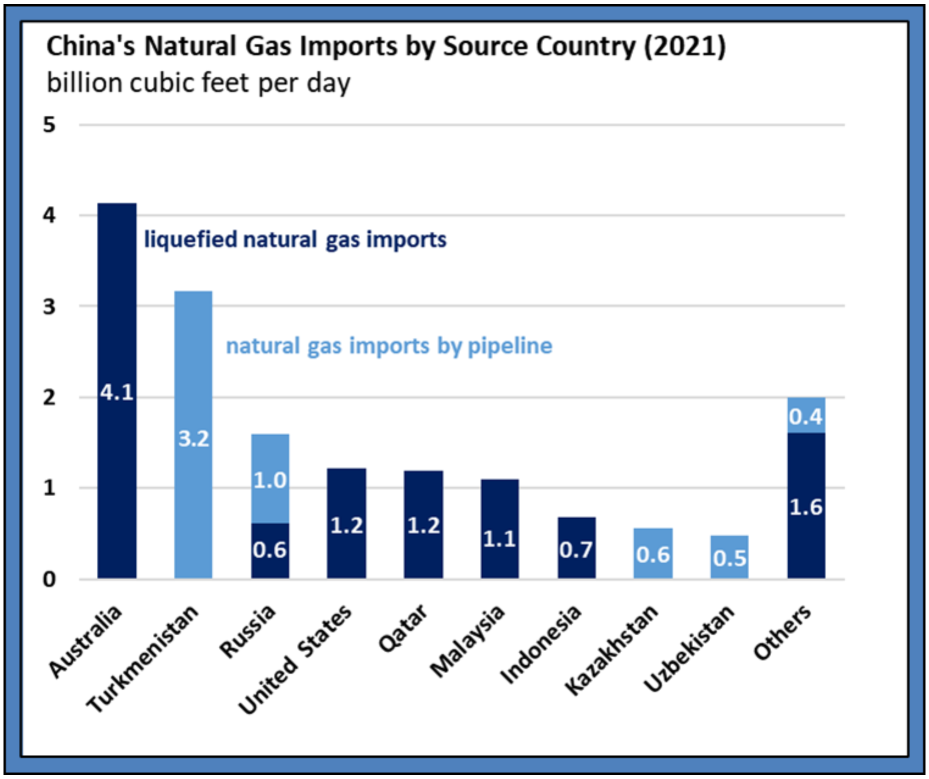


Source: Graph by the U.S. Energy Information Administration, based on data from Japan's Ministry of Finance, China's General Administration of Customs, South Korea's Customs Institute, India's Directorate General of Commercial Intelligence and Statistics, and Taiwan's Ministry of Finance via Global Trade Tracker.

China's LNG imports averaged 10.5 billion cubic feet per day (Bcf/d), a 19% increase compared with 2020. LNG imports accounted for more than half of China's overall natural gas imports and 30% of China's total natural gas supply in 2021 (Aloulou and Zaretskaya, 2022a).

China began importing LNG in 2006 and, with the exception of 2015 (EIA, 2016), has imported more LNG each year since then. China has rapidly expanded its LNG import capacity, which was estimated at 13.9 Bcf/d in 2021. By the end of 2022, China's regasification capacity could increase by 2.8 Bcf/d to 16.7 Bcf/d, according to data from S&P Global Platts.[2] In 2021, China imported LNG from 25 countries. The largest six suppliers—Australia, United States, Qatar, Malaysia, Indonesia, and Russia—provided 8.9 Bcf/d, or 85%, of China's total LNG imports.

Figure 4

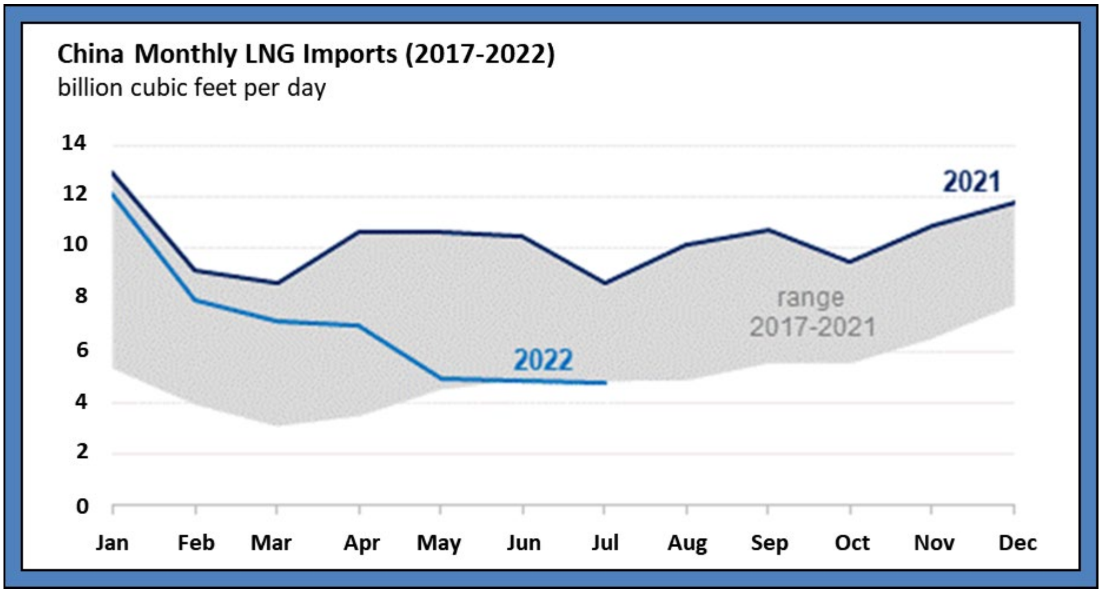


Source: Graph by the U.S. Energy Information Administration, based on data from China's General Administration of Customs and Global Trade Tracker.

Since China lowered tariffs on LNG imports from the United States from 25% to 10% in 2019, U.S. LNG exports to China have increased and in 2021 averaged 1.2 Bcf/d (Jaganathan and Aizhu, 2020). The United States was the largest supplier of spot LNG volumes to China last year.

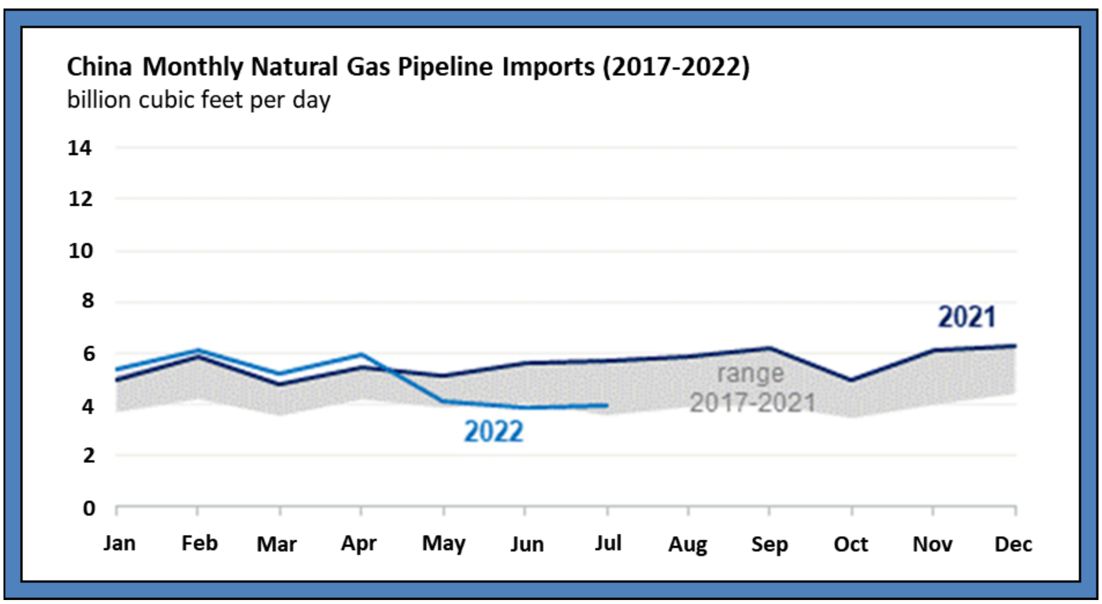
During 2022 and 2023, several new long-term contracts between China and the United States are expected to start from the Sabine Pass and Corpus Christi terminals for a combined estimated volume of up to 0.5 Bcf/d. The new U.S. LNG export terminal at Calcasieu Pass will supply China's two national energy companies—Sinopec with 0.13 Bcf/d (Jaganathan and Aizhu, 2021) and CNOOC with 0.2 Bcf/d (Venture Global LNG, 2021)—starting next year.

Figure 5



Source: Global Trade Tracker.

Figure 6



Source: Global Trade Tracker.

After becoming the world's largest LNG importer in 2021, China reduced its LNG imports by approximately one-third in the first seven months of this year. From January through July 2022, China's LNG imports averaged 7.0 Bcf/d, a 34% decline compared with 10.5 Bcf/d 2021 annual average. LNG imports in China have decreased this year for the first time since 2015. The decline in LNG imports was driven in part by the slower economic growth, high spot LNG prices, robust growth in hydro and non-hydro renewable power generation that displaced more expensive gas-fired power-generation, as well as government policies, which this year reprioritized supply security and economic stability over emissions targets.

China's natural gas imports by pipeline have also declined in the first seven months of this year (January through July) by 11% compared to 2021 annual average. From January through April 2022, China's pipeline imports averaged 5.7 Bcf/d, and were higher than the 5-year average, but declined from May through July and averaged 4 Bcf/d, trending at the 5-year minimum level.

Overall so far this year (January through July) China has reduced natural gas imports by both pipeline and LNG by about a quarter (26%), with imports averaging 12 Bcf/d over this period, compared with 16 Bcf/d annual average in 2021.

Endnotes

This article draws from Aloulou and Zaretskaya (2022a) and Aloulou and Zaretskaya (2022b).

1 https://www.cedigaz.org/

2 https://www.spglobal.com/commodityinsights/en

References

Aizhu, C., 2013, "Tight Gas: China's Unsung Unconventional Energy Revolution," *Reuters*, July 8. Accessed via website: https://www.reuters.com/article/china-tightgas/tight-gas-chinas-unsung-unconventional-energy-revolution-idUSL3N0EG2BF20130708 on December 1, 2022.

Aloulou, F., 2015, "Shale Gas Development in China Aided by Government Investment and Decreasing Well Cost," *Today in Energy*, U.S. Energy Information Administration, September 30. Accessed via website: https://www.eia.gov/todayinenergy/detail.php?id=23152 on December 1, 2022.

Aloulou, F. and V. Zaretskaya, 2022a, "China Increased Both Natural Gas Imports and Domestic Production in 2021," *Today in Energy*, U.S. Energy Information Administration, April 22. Accessed via website: https://www.eia.gov/todayinenergy/detail.php?id=52139 on December 1, 2022.

Aloulou, F. and V. Zaretskaya, 2022b, "As of 2021, China Imports More Liquefied Natural Gas than any Other Country," *Today in Energy*, U.S. Energy Information Administration, May 2. Accessed via website: https://www.eia.gov/todayinenergy/detail.php?id=52258 on December 1, 2022.

EIA, 2016, "Natural Gas Weekly Update," Natural Gas, U.S. Energy Information Administration, February 4. Accessed via website: https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2016/02_04/ on December 1, 2022.

Global Trade Tracker, 2022, https://www.globaltradetracker.com/

Jaganathan, J. and C. Aizhu, 2020, "U.S. LNG Cargoes Heading to China after Beijing Awards Tax Waivers," *Reuters*, April 7. Accessed via website: https://www.reuters.com/article/us-usa-china-lng/u-s-lng-cargoes-heading-to-china-after-beijing-awards-tax-waivers-idUSKBN21P128 on December 1, 2022.

Jaganathan, J. and C. Aizhu, 2021, "China Signs Huge LNG Deals with U.S. Supplier Venture Global," *Reuters*, October 20. Accessed via website: https://www.reuters.com/business/energy/us-venture-global-signs-lng-deals-with-chinas-sinopec-documents-2021-10-20/ on December 1, 2022.

Venture Global LNG, 2021, "Venture Global LNG and CNOOC Gas & Power Announce LNG Sales and Purchase Agreements," Press Release, December 21. Accessed via website: https://venturegloballng.com/press/venture-global-lng-and-cnooc-gas-power-announce-lng-sales-and-purchase-agreements/ on December 1, 2022.

Author Biographies

FAOUZI ALOULOU
Senior Industry Economist, U.S. Energy Information Administration

Faouzi Aloulou is a Senior Industry Economist at the Energy Information Administration (EIA) of the U.S. Department of Energy in Washington, DC since 2001. Currently, Aloulou has been involved in addressing provisions directed at EIA from the Bipartisan Infrastructure Investment and Jobs Act 2021, regarding carbon dioxide emissions data harmonization, and provisions from the Inflation Reduction Act 2022 regarding hydrogen production and its impact on EIA modeling energy consumption in the manufacturing sector. Starting 2010 he has been the Project Manager of EIA's Global Shale Resources and Activities' research effort, for which he regularly authors analytical reports on shale gas and tight oil in the U.S. and the rest of the world. Aloulou initiated the monthly EIA Energy Forecasting Forum in 2002, now called the monthly EIA Energy Data Science Speakers Series, an activity he still is responsible for organizing. Additionally, from 2014 to 2016, he was the Project Manager of EIA's Global Hydrocarbon Supply Model.

Prior to the EIA's re-organization in 2010, Aloulou was the EIA China and Middle East expert, monitoring the two regions' energy resources, supply and consumption patterns, trade, technology use and investment strategies, information provided to the World Energy Projections System (WEPS), the EIA's international energy model. In this capacity, Mr. Aloulou took the initiative to have the EIA's *International Energy Outlook* translated into Chinese and Arabic. In the period, June 2007 to June 2008, Mr. Aloulou was seconded from the U.S. Department of Energy to the Riyadh-based International Energy Forum (IEF) where he developed the early prototypes of country surveys used to extend the Joint Oil Data Initiative (JODI) to natural gas. He also compiled and edited the IEF book, From Confrontation to Dialogue, which was released at the Third Summit of OPEC Heads of State on November 13, 2007.

Prior to joining EIA in 2001, he was a Research Associate at Cambridge Energy Research Associates (CERA), Massachusetts, where he worked with the CERA Refined Products team that produced the quarterly *World Refined Products Watch.* While at CERA he authored reports on the taxation of petroleum products, corporate strategies of the national oil companies, and Japan's activities in the Middle East oil and gas sectors. Aloulou interviewed the Prime Minister and the Finance Minister of Malaysia for the 1998 CERA book project co-authored by Daniel Yergin and Joseph Stanislaw: The Commanding Heights: The Battle between Government and the Marketplace That Is Remaking the Modern World. Aloulou subsequently served as Energy Advisor at the Prime Minister's Department in Malaysia and reviewed Malaysia's investment programs and energy policies (Vision 2020) as well as working as an independent energy group consultant in Singapore.

Aloulou has a Bachelor of Arts from University of California at Berkeley and a Master's in Public Administration from the Kennedy School of Government at Harvard University. His thesis, "The European Commission Proposal on Carbon/Energy Tax and the OPEC Response," was nominated for the Kennedy School's Don K. Price award. He was granted a fellowship at the Harvard Business School where he continued his research on pricing options and derivatives for tradable permit schemes as an alternative to energy taxation while assisting in teaching courses on negotiation analysis, leadership and authority at Harvard's Kennedy School of Government.

Faouzi Aloulou is an Editorial Advisory Board member of the *GCARD*, and his previous article for the digest covered "U.S. Haynesville Shale Gas Production."

VICTORIA ZARETSKAYA
Lead Industry Economist, U.S. Energy Information Administration

Victoria Zaretskaya is a Lead Industry Economist at the U.S. Energy Information Administration, Office of Energy Analysis. She monitors emerging trends in international natural gas markets and is responsible for analysis and modeling of short- and long-term market fundamentals. Her recent research includes analyzing the global natural gas trade (with a focus on LNG trade), and modeling of global demand-supply balances and prices. She is the author of numerous EIA publications on international natural gas and transportation sectors, including *International Energy Outlook*, *Short-Term Energy Outlook*, *Natural Gas Weekly Update*, and *Today in Energy*. Prior to joining EIA, Zaretskaya was a Principal Fuels Analyst with the Exelon Power Team, where she led fundamental analysis of North American and international natural gas markets to support origination, trading, budgeting, and project evaluation activities. Earlier Zaretskaya worked with consulting firms ICF International, PFC Energy, and Pace Global Energy, where she was responsible for market research and management consulting, contributing to a variety of projects for major oil and gas and power companies, investment banks, and governmental agencies.

Victoria Zaretskaya received an undergraduate degree in Economics (with high distinction) from George Mason University, and a Master's degree in International Public Policy from Johns Hopkins School of Advanced International Studies (SAIS).

The Effects of Russian Sanctions on Global Commodity and Financial Markets: A GVAR Analysis

Jennifer Considine, Ph.D.
Senior Research Fellow, Centre for Energy, Petroleum and Mineral Law & Policy (CEPMLP), University of Dundee, United Kingdom; and Editorial Advisory Board Member, *Global Commodities Applied Research Digest*

We use a GVAR model to forecast the response of the global economy to Russian sanctions, and a continuation of the Russia-Ukraine War. We find that the effects of sanctions on Russia and the unintended consequences for Saudi Arabia and European allies depend on the type of sanctions, i.e., whether they are trade sanctions targeting Russian oil production or financial sanctions targeting Russian GDP. We find that sanctions targeting Russian oil flows are inflationary but have fewer unintended consequences for global equity markets. Financial sanctions are more effective, with fewer adverse implications for global inflation levels. Our analyses also indicate that possible Russian measures to preempt further Western sanctions by implementing trade embargoes of products including natural gas and oil of their own will be counterproductive for the Russian economy.

Introduction

On February 24, 2022, Russia began a "special military operation" in Ukraine, which quickly has escalated into a militarized conflict occurring across multiple fronts. The act drew immediate disapproval from the United Nations and led most members of the Western alliance to impose sanctions on Russia with negative spillover effects for the world economy.

We investigate how various types of sanctions on Russia (imposed, or under design) may impact global economy, oil markets and inventories with a special focus on regional impacts. Russia plays a critical role in the global economy; it produces 14% of the world's oil with exports averaging 4.7 MMB/d before the onset of the Ukraine conflict. Russian gas also plays a critical role for the global economy, especially for European manufacturing and services industries. The European Union has obtained 40% of its annual gas demand from Russia, most of which had been transported via pipelines with little opportunity for seamless substitution of Russia as a supplier (IEA, 2022).

Since the escalation of the Russia-Ukraine conflict, Western countries have threatened or imposed various types of sanctions. Some of these sanctions included trade sanctions, i.e., embargoes and other types of mechanisms to prevent the flow of certain commodities into and from Russia. For instance, the U.S. prevented the export of U.S. made construction equipment that was critical to finish the remaining Nord Stream 2 project. (After this article was written, Russia's Nord Stream 1 and Nord Stream 2 pipelines suffered suspected sabotage on September 26, 2022, and the G7 and Australia have agreed on a $60.00/Bbl price cap on seaborne Russian crude oil flows.) Similarly, the EU has banned imports of Russian coal to Europe. Others featured restrictions in the financial sector, such as restriction of certain Russian banks' access to primary and secondary capital markets in EU markets, or the prevention of the extension of any loan or financial assistance by international financial institutions to Russia, enforced by the United States International Financial Institutions Act.[1]

All views expressed in the *GCARD* are those of the individual authors and not of the JPMCC, its sponsors, or donors.

Accordingly, we simulate a series of trade and financial shocks to various aspects of the Russian economy. For trade sanctions, we simulate a shock to Russian oil production and GDP. For financial sanctions, we shock short-term interest rates, inflation, and equity prices. Then, we assess the effects these sanctions may have on Russia in the short- and medium-term. We also trace the (unintended) spillover effects these simulated sanctions may have on the global economy.

In doing so, we employ KAPSARC's Global Vector Autoregression (GVAR) model (Considine *et al*., 2021). Our model simulations suggest three critical insights:

1. Asia seems to benefit notably from oil sanctions on Russia.

2. The slowdown in the European economy due to Russian sanctions spills negatively over to macroeconomic indicators of Middle Eastern oil exporters.

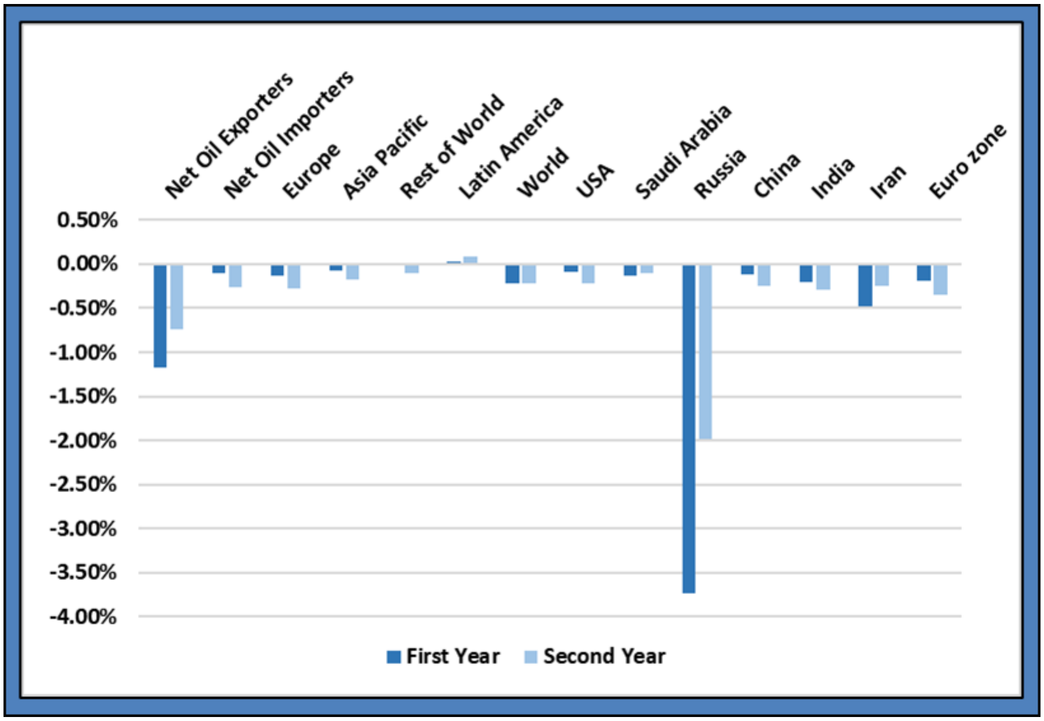
3. Oil sanctions on Russia will cause a small but notable bump (5% per annum from its baseline equilibrium price of oil) over the course of next two years.

GVAR Simulation Results: Effects of Sanctions on Global GDP, Oil Price, Inflation, Equity Prices, and Exchange Rates

<u>Real GDP</u>

Economic sanctions: The initial imposition of "economic sanctions" results in an immediate reduction in real Russian GDP of approximately 0.8%. The effects are long-lived and Russian GDP continues to fall throughout the forecast period. The total shock to the Russian GDP is equal to a 12% with sanctions triggering a recession that lasts for 25 quarters before a gradual recovery begins in just over 5 years. India and the Eurozone are most effected by the sanctions as their real GDP relative to the baseline falls by approximately 0.5% in the first two years of the sanctions. The U.S., Latin America and the Asia Pacific are the least affected regions by the sanctions, with Latin American experiencing a slight increase in GDP.

Figure 1
Effect of Sanctions on Russian GDP on Real Global GDP



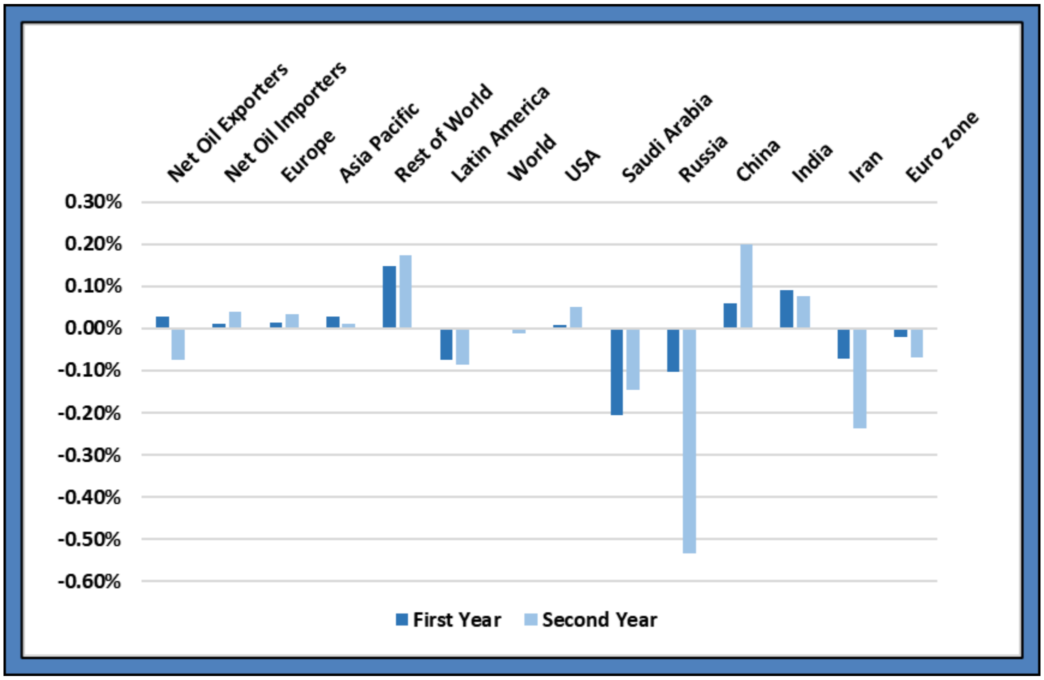
Note: The shock represents a single—one standard deviation shock from a baseline, and not a sustained sanction regime lasting for more than one quarter. As a result, the simulation is likely to underestimate the effects of sanctions.

Source: KAPSARC Global oil market simulation, June 2022.

Oil Sanctions: We simulate "oil sanctions" by imposing an exogenous negative shock (approximately 1%) on real Russian oil production. The shock is long-lasting and severe, and Russian crude oil flows continue to fall relative to the baseline, resulting in a significant 27% shortfall over 25 quarters.

Russia, and Saudi Arabia are most effected by the sanctions as their real GDP relative to the baseline falls significantly in the first two years of the sanctions. The net importers, China, India, Europe, and the rest of the world benefit from the sanctions experiencing increases in real GDP.

Figure 2
Effect of Sanctions on Russian Oil on Real Global GDP



Source: KAPSARC Global oil market simulation, June 2022.

Table 1
Effect of Financial Sanctions in Tight Market Conditions

Impact	Russian Financial Sanctions GDP		Inflation		Exchange Rate	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Net Oil Exporters	-1.18%	-0.74%	0.51%	-0.67%	-3.17%	-3.26%
Net Oil Importers	-0.10%	-0.26%	-0.09%	-0.12%	0.13%	1.51%
Europe	-0.13%	-0.27%	0.00%	-0.06%	-0.13%	0.18%
Asia Pacific	-0.08%	-0.18%	0.03%	0.00%	-0.42%	-0.15%
Rest of World	0.01%	-0.11%	-0.24%	-0.13%	-0.61%	0.01%
Latin America	0.02%	0.08%	0.03%	-0.10%	-0.07%	-0.27%
World	-0.22%	-0.22%	0.06%	-0.17%	-0.79%	-0.63%
USA	-0.09%	-0.21%	0.00%	-0.03%		
Saudi Arabia	-0.14%	-0.10%	0.03%	0.01%	-0.10%	-0.17%
Russia	-3.73%	-1.98%	1.68%	-2.65%	-12.81%	-13.52%
China	-0.12%	-0.25%	0.05%	-0.06%	-0.40%	-0.65%
India	-0.21%	-0.30%	0.04%	0.01%	-0.50%	-0.38%
Iran	-0.48%	-0.24%	-0.07%	-0.15%	-0.04%	0.26%
Euro zone	-0.20%	-0.35%	-0.01%	-0.03%	-0.86%	0.05%

Source: KAPSARC Global oil market simulation, June 2022.

Table 2
Effect of Oil Sanctions in Tight Market Conditions

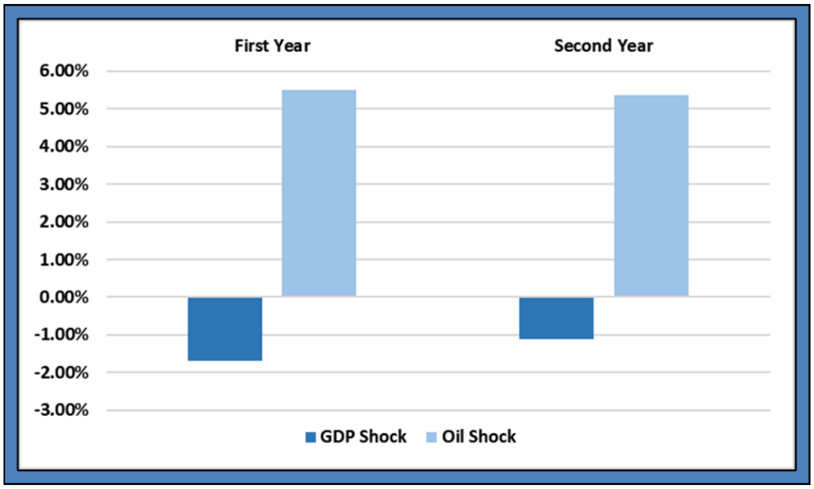
	Russian Oil Sanctions					
Impact	GDP		Inflation		Exchange Rate	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Net Oil Exporters	0.03%	-0.07%	0.38%	0.31%	-3.54%	-4.69%
Net Oil Importers	0.01%	0.04%	0.10%	0.04%	-0.21%	0.20%
Europe	0.01%	0.04%	0.00%	0.01%	0.62%	0.77%
Asia Pacific	0.03%	0.01%	0.04%	0.03%	-0.09%	-0.13%
Rest of World	0.15%	0.18%	0.05%	0.01%	-0.22%	-0.30%
Latin America	-0.07%	-0.09%	0.01%	-0.01%	0.07%	0.20%
World	0.00%	-0.01%	0.10%	0.07%	-0.71%	-0.87%
USA	0.01%	0.05%	-0.02%	0.02%		
Saudi Arabia	-0.20%	-0.15%	-0.04%	0.01%	-0.16%	-0.24%
Russia	-0.10%	-0.53%	-1.43%	1.18%	-13.12%	-17.11%
China	0.06%	0.20%	0.09%	0.01%	-0.21%	-0.14%
India	0.09%	0.08%	-0.07%	0.04%	-0.21%	-0.28%
Iran	-0.07%	-0.24%	0.13%	-0.07%	-0.67%	-0.82%
Euro zone	-0.02%	-0.07%	0.01%	-0.01%	0.50%	0.79%

Source: KAPSARC Global oil market simulation, June 2022.

Oil Price

The implications for global oil prices are significantly different according to the nature of sanctions. As expected, a GDP shock results in a reduction in world oil prices of approximately 1%, due to the reduction in Russian oil demand. Oil markets enter a period of backwardation and are expected to decline relative to the baseline throughout the forecast period. Sanctions on Russian oil production on the other hand result in a significant 5% increase in Brent oil prices.

Figure 3
Effect of Sanctions on Brent Oil Price

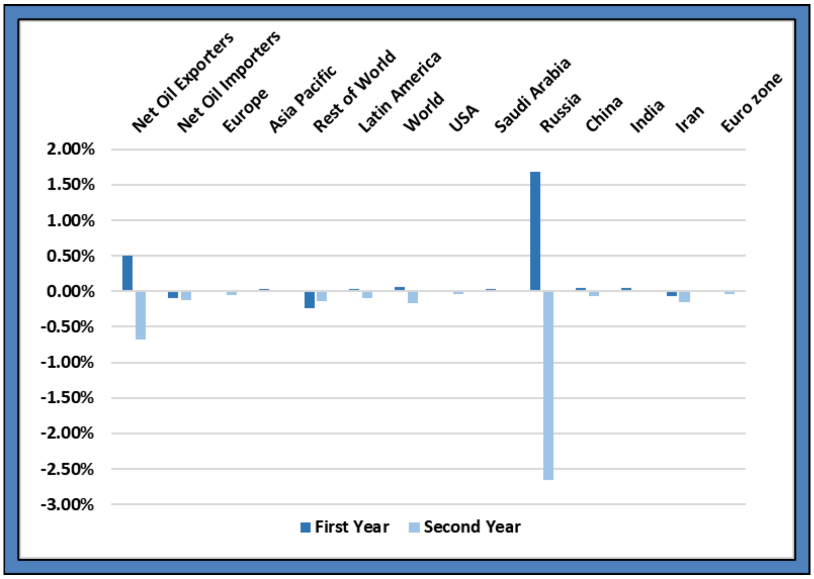


Source: KAPSARC Global oil market simulation, June 2022.

<u>Inflation</u>

The imposition of economic sanctions on Russian GDP result in an immediate increase in domestic inflation followed by a sustained period of deflation and economic contraction. The effects on the global inflation rate are minimal, with the world registering only a slight increase in inflationary pressures from the baseline throughout the forecast period.

Figure 4
Effect of Sanctions on Russian GDP on Inflation

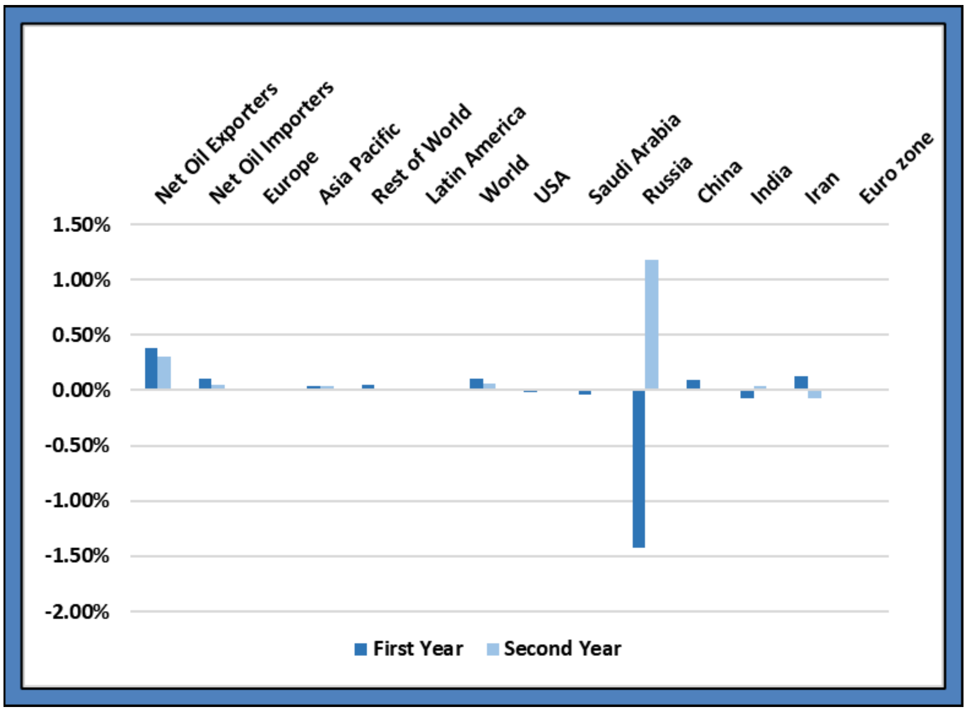


Source: KAPSARC Global oil market simulation, June 2022.

Sanctions on Russian oil production, on the other hand, have the opposite effect. In this case Russia experiences an initial deflationary period, followed by years in which inflation is elevated by a full percent above baseline levels. As expected, the increase in world oil prices leads to a slight and sustained increase in inflationary pressures for net oil exporting countries, and globally.

There are clear signs of deflation in the Russian economy, as the Russian State Statistics Service (Rosstat) reports that the rate of increase in prices has fallen to zero in mid-May 2022 (Rosstat, 2022). Deflation is generally attributed to reduced demand in an economy and is often followed by recession or even depression in the months and years to come (Latypova, 2022).

Figure 5
Effect of Sanctions on Russian Oil on Inflation



Note: Aggregate response over 8 quarters.

Source: KAPSARC Global oil market simulation, June 2022.

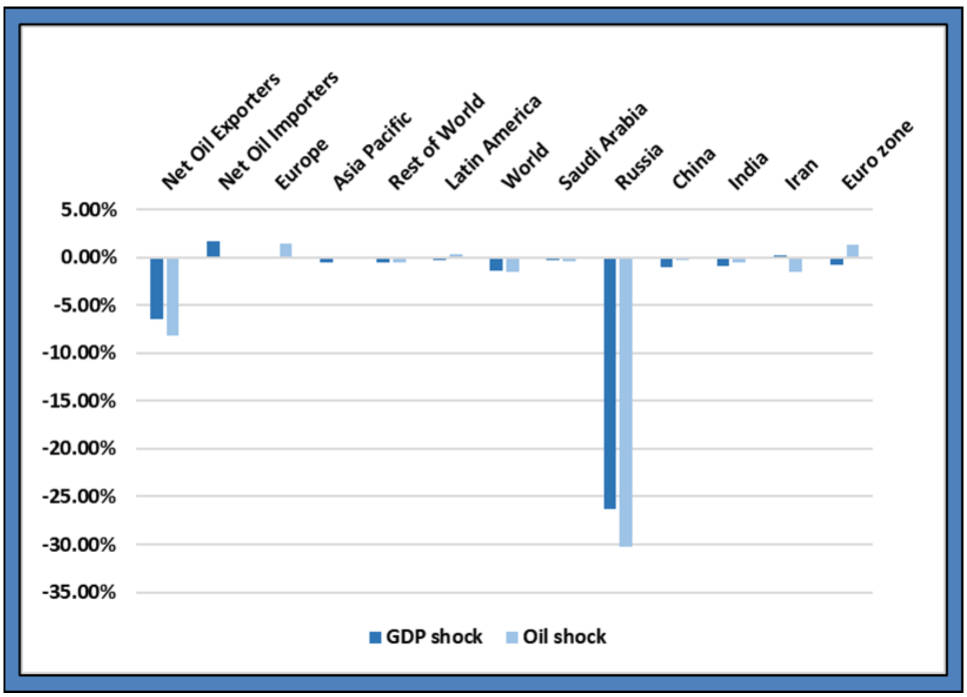
Exchange Rates

The effects on real exchange rates are remarkably similar for both pure economic sanctions affecting GDP, and those levied on Russian oil production. In both cases the Russian-US$ exchange rate falls by nearly 30% relative to the baseline. This is almost exactly the response witnessed immediately following the imposition of sanctions in February 2022 (Hotten, 2022).

Since then, the Russian Federation has taken extreme measures to defend the ruble, including (i) a reduction in official interest rates from 20% to 11%; (ii) an announcement by the Russian Finance Ministry that debt service interest and maturity payment will be made in Rubles; and (iii) a request that all gas payments be made in Rubles (*Bloomberg News*, 2022; Davis *et al*., 2022)

The Central Bank actions to defend the Rubles fall are similar, but far more severe, than those imposed in response to Western sanctions levied against Russia because of the annexation of the Crimea in 2014. The 2014 sanctions included a massive sale of foreign currency reserves and a sharp increase in domestic interest rates. The current round of Western sanctions is considerably more severe, freezing the accounts of the Russian central bank to prevent Russian intervention in its exchange rate. Russia responded immediately with strict capital controls and limits on the currency that Russian citizens can remove from central banks (Davis et al., 2022).

Figure 6
Effect of Sanctions on Exchange Rates



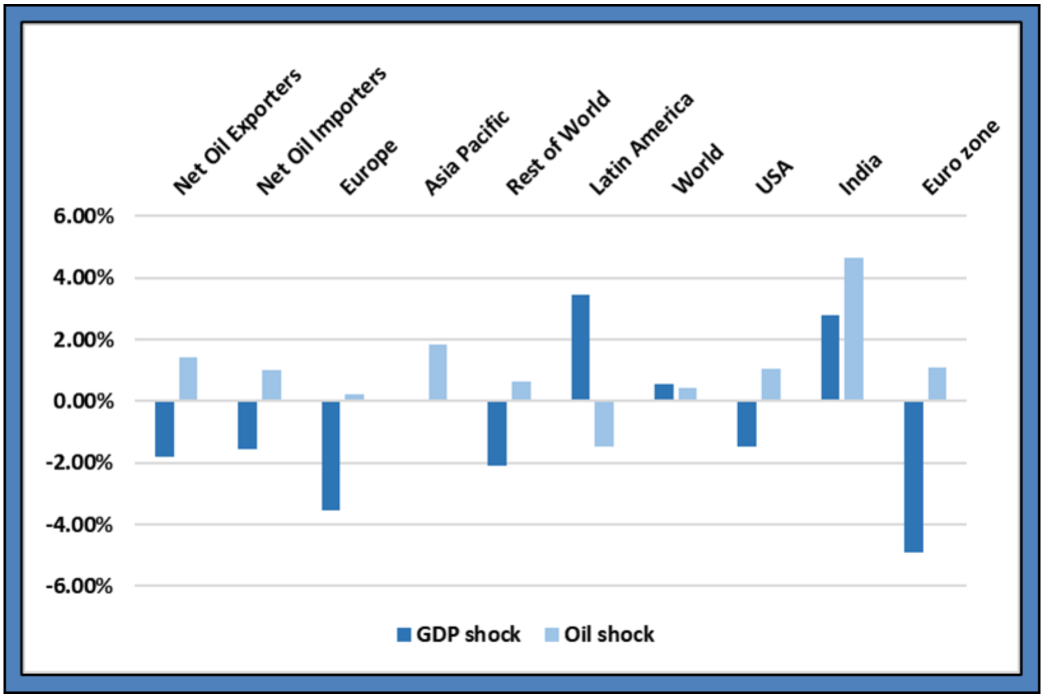
Note: Aggregate response over 8 quarters.

Source: KAPSARC Global oil market simulation, June 2022.

Equity Prices

The implications for global equity markets are neutral, with equity markets rising slightly for both GDP and oil sanctions. In the case of economic sanctions affecting Russian GDP, Latin America and India are the clear beneficiaries with equity markets rising at the expense of the U.S. and the Eurozone. When oil is sanctioned, on the other hand, equity markets in India, the Eurozone and the United States gain. In this case, Latin America is the only region to experience losses due to Russian oil sanctions.

Figure 7
Effect of Sanctions on Equity Prices



Note: Aggregate response over 8 quarters.

Source: KAPSARC Global oil market simulation, June 2022.

Discussion and Alternative Futures

The unanticipated effects of sanctions on neighboring countries and major trading partners differ significantly depending on the source of the exact nature of the sanctions, specifically a shock to Russian oil production or financial sanctions that have a direct effect on Russian GDP. We find that a sanction on Russian oil production has fewer adverse implications for global equity markets. Economic sanctions affecting Russian GDP have fewer adverse implications for global inflation rates. We find that Russian measures to combat shocks by preempting further sanctions by implementing its own trade embargo are counter productive

The implications of sanctions on Russian oil production are noteworthy. As expected, the impact of lower oil income to Russia is significant, especially in the second year, with more than a half percent negative deviation from its expected course of GDP growth. The adverse effects of these sanctions on Saudi Arabia and Iranian GDP are also notable as the Eurozone, one of their main customers, suffers.[2] The immediate implications for Saudi Arabia are a short-term loss in market share in India and China, due to the sudden and unexpected global shift in crude oil supplies.[3] This is reflected in a small -0.1%-0.2% reduction in Saudi

Arabian GDP relative to the GDP growth rates the Kingdom would have experienced had the shock to Russian oil production not occurred. While we expect the oil price to increase following sanctions, India and China GDP are expected to benefit as these two countries now have access to discounted oil. The overall effect on global GDP, however, is minimal.

Appendix A
The KAPSARC Global Oil Model: A Primer to GVAR

We use KAPSARC's GVAR model, designed to analyze the implications of economic shocks on world oil markets, to gauge the effect of Russian sanctions on crude oil prices, global GDP, equity markets, inflation, exchange rates and inventories.

Two characteristics of the model make it particularly suited to this analysis. The first is that the GVAR framework is designed to account for the interaction between many countries, each with their own political and legislative systems. This is important because the effects of severe shocks and global imbalances, such as a global trade war, are contagious and cannot be contained to one country or region.

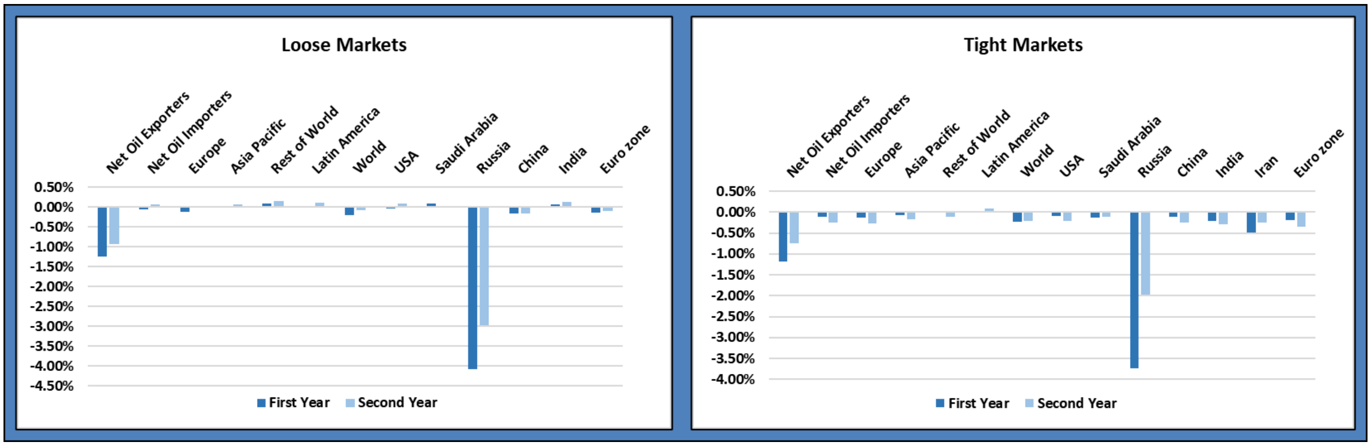
The second is that the world oil market, production, and inventories are modeled jointly with key macroeconomic variables, including short- and long-term interest rates, inflation, equity prices and real GDP. This enables the model to capture the nuances of complex economic interrelationships.

To project the effects of Russian sanctions, we first established a baseline simulation, taking the end of September 2018 as a reference point. This timing coincides a relatively stable period of tight oil markets. We simulated Russian sanctions in our model by shocking several variables separately:

1) Real global GDP by one standard error, which amounts to a 3.73% reduction in GDP during the first year of the shock, from the baseline forecast of approximately 5 % (CEIC, 2022). The total shock to the Russian GDP is equal to 12%. The size of this shock is roughly in line with the estimates of various industry analysts (Pestova *et al*., 2022; Mahlstein *et al.,* 2022).

2) The initial "oil sanctions" shock results in a reduction in real Russian oil production of approximately 1% immediately upon the imposition of economic sanctions. The shock is long-lasting and severe, and Russian crude oil flows continue to fall relative to the baseline, resulting in a significant 27% shortfall over 25 quarters.

Figure 8
Effects of Financial Sanctions on Real Global GDP in Tight and Loose Oil Markets



Note: The simulations were performed on tight world oil markets, like the conditions existing prior to the implementation of economic sanctions in 2022. The shock to GDP in the case of loose market conditions, with ample inventories and lower oil prices, would be far more severe with Russian GDP falling by an additional 1.3% in the first two years after the initial shock.

Endnotes

The author would like to thank Emre Hatipoglu, Colin Ward, and Abdullah Al Dayel for their valuable contributions to the article.

1 Other types of sanctions imposed on Russia include travel bans and asset freezes imposed on certain Russian individuals. Due to their minimal effect on the global economy, our analyses do not factor these sanctions that primarily carry a diplomatic/symbolic significance.

2 See Mint (2022) and *Middle East Monitor* (2022).

3 It is important to mention that the results reported are relative to our base case or reference case, which reflected a high price, tight market environment that existed before the initial shock to Russian crude oil flows.

References

Bloomberg News, 2022, "Four European Gas Buyers Made Ruble Payments to Russia," April 27.
Accessed via website:
https://www.bloomberg.com/news/articles/2022-04-27/four-european-gas-buyers-made-ruble-payments-to-russia
on October 19, 2022.

CEIC, 2022, "Russia Real GDP Growth, 1996 – 2022 | CEIC Data," June. Accessed via website:
https://www.ceicdata.com/en/indicator/russia/real-gdp-growth on October 19, 2022.

Considine, J., Hatipoglu, E. and A. Aldayel, 2021, "The Sensitivity of Oil Price Shocks to Preexisting Market Conditions: A GVAR Analysis," *Journal of Commodity Markets*, Vol. 27, November, 100225.
https://doi.org/10.1016/j.jcomm.2021.100225

Davis, S., Fujiwara, Wang, H. and J. Wang 2022, "Russia Counters Sanctions' Impact with Currency Controls, Averts Crisis (for Now)," Federal Reserve Bank of Dallas, May 31.
Accessed via website: https://www.dallasfed.org:443/research/economics/2022/0531 on October 19, 2022.

Hotten, R., 2022, "Ukraine Conflict: Russia Doubles Interest Rate after Rouble Slumps," *BBC News*, February 28. Accessed via website: https://www.bbc.com/news/business-60550992 on October 19, 2022.

IEA 2022, "Energy Fact Sheet: Why Does Russian Oil and Gas Matter? – Analysis," International Energy Agency, March 21. Accessed via website: https://www.iea.org/articles/energy-fact-sheet-why-does-russian-oil-and-gas-matter on October 19, 2022.

Latypova, L., 2022, "Explainer: What Does Russia's 'Zero-Inflation' Mean?" *The Moscow Times*, June 10.
Accessed via website:
https://www.themoscowtimes.com/2022/06/10/explainer-what-does-russias-zero-inflation-mean-a77952
on October 19, 2022.

Mahlstein, K., McDaniel, C., Schropp, S. and M. Tsigas, 2022, "Potential Economic Effects of Sanctions on Russia: An Allied Trade Embargo," Center for Economic Policy Research, *VoxEU*, May 6.
Accessed via website: https://cepr.org/voxeu/columns/potential-economic-effects-sanctions-russia-allied-trade-embargo
on October 19, 2022

Middle East Monitor, 2022, "Saudi Arabia Cuts Back Oil Supplies to China, Amid Global Shift in Energy Supplies," June 12.
Accessed via website:
https://www.middleeastmonitor.com/20220612-saudi-arabia-cuts-back-oil-supplies-to-china-amid-global-shift-in-energy-supplies on October 19, 2022.

Mint, 2022, "Russia Supersedes Saudi Arabia to Become Second-Biggest Crude Supplier to India," August 6.
Accessed via website:
https://www.livemint.com/news/india/russia-supersedes-saudi-arabia-to-become-second-biggest-crude-supplier-to-india-11659746351857.html on October 19, 2022.

Pestova, A., Mamonov, M. and S. Ongena, 2022, "The Price of War: Macroeconomic Effects of the 2022 Sanctions on Russia," Center for Economic Policy Research, *VoxEU*, April 15.
Accessed via website: https://cepr.org/voxeu/columns/price-war-macroeconomic-effects-2022-sanctions-russia
on October 19, 2022.

Rosstat, 2022, "Федеральная Служба Государственной Статистики. Federal State Statistics Service, Russian Federation," Library of Congress, June. Accessed via website: https://www.loc.gov/item/lcwaN0015756/. on October 19, 2022.

Author Biography

JENNIFER CONSIDINE, Ph.D.
Senior Research Fellow, Centre for Energy, Petroleum and Mineral Law & Policy (CEPMLP), University of Dundee, United Kingdom

Dr. Jennifer Considine is a senior research fellow at the Centre for Energy, Petroleum and Mineral Law & Policy (CEPMLP) in Dundee, Scotland and a KAPSARC (KSA) visiting researcher. She has worked with a number of international energy companies including Ecopetrol, Chevron, TransCanada Pipelines, Westcoast Energy, Coastal Corporation, Duke Energy, Javelin Global Commodities, Pieridae Energy, Husky Energy, and ANR Pipeline Company. She is currently chief editor of *Energy Politics*, an energy newsletter dealing with commercial strategies and strategic planning in the global energy industry. Dr. Considine is a former member of the Board of Directors for Canada Post and founding member of several initiatives to promote Scottish-Canadian relations including the Canadian Friends of Scotland.

Dr. Considine is also a member of the *Global Commodities Applied Research Digest's* Editorial Advisory Board. Her previous co-written articles for the *GCARD* covered (1) "Volatility, Contango, and Crude Oil Inventories: A Complex Relationship" and (2) "The G7 Pricing Scheme Proposal, an Exercise in Monopsony Power."

Blockchain Decentralized Clearing of Environmental Credits

Deborah Cernauskas, Ph.D.
Professor of Business Analytics and Finance, Benedictine University (Retired)

Steve Josephs, PE
Consultant on Alternative Energy Projects

Andrew Kumiega, Ph.D.
Assistant Professor of Analytics, Illinois Institute of Technology, Stuart School of Business

The focus of this research is commoditizing environmental credits into standardized units by guaranteeing the provenance of the credit through the application of blockchain technology. The commoditization occurs by creating a decentralized clearing process using blockchain for the environmental credit market. The cleared standardized commodity units can then potentially be traded without the risk of rejection by the U.S. Environmental Protection Agency (EPA) because of production fraud or errors. The removal of the rejection risk would allow for small farmers, municipal wastewater plants and landfills to enhance their profitability by producing green electricity from biogas and receiving market tradable environmental credits. The complexity of the pathway requires blockchain, which creates an immutable ledger holding production and distribution data for the environmental credit. This immutable ledger supplies provenance that can eliminate counterparty risk when combined with the concept of decentralized clearing of the credits.

Introduction

The United States is currently planning to transition to electric vehicles (EVs) while trying to reduce the production of greenhouse gases (GhGs) for electricity generation. To date, twelve states have adopted legislation requiring increased sales of EVs over the next decade. The increase in green baseload electricity generation will be necessary to achieve this dual goal.

The Energy Policy Act of 2005 created the Renewable Fuel Standard Program in the United States. The U.S. EPA uses Renewable Volume Obligations (RVOs) to express the percentage of renewable fuels that refiners and fuel importers must blend into motor fuel per the law. Renewable Identification Numbers (RINs) are tradable securities representing a standardized renewable unit. Obligated parties deliver RINs to the Environmental Protection Agency (EPA) to fulfill their RVO requirements. eRINs are RINs that complete the energy pathway by powering EVs for transportation.

The biogas for the RIN can come from many feedstocks including manure. The process from manure to natural gas or electricity relies on self-regulation with independent process audits leading to the opportunity for fraud or unacceptable documentation that creates a failure to deliver (FTD) risk.

In this paper, we detail the application of blockchain to remove risk of rejection by the EPA, which is effectively a FTD risk in commodities and, by extension, the creation of an alternative clearing structure. This alternative clearing structure can be applied to the production of all environmental credits to remove

All views expressed in the *GCARD* are those of the individual authors and not of the JPMCC, its sponsors, or donors.

the FTD risk and ensure the provenance of the credit from creation to destruction, allowing for multiple non-traditional products to be commoditized.

Blockchain

Blockchain stores information about transactions in an immutable ledger. The objective of a blockchain is to create a distributed platform focused on efficiency, quality, speed, flexibility and risk reduction (Kshetri, 2018). A private blockchain can reduce operational costs, and reduce/eliminate counterparty risk (Kamble *et al*., 2019). The proposed solution in this paper uses Hyperfabric Ledger, which eliminates the lack of privacy common in most public blockchain (Cong and He, 2019).

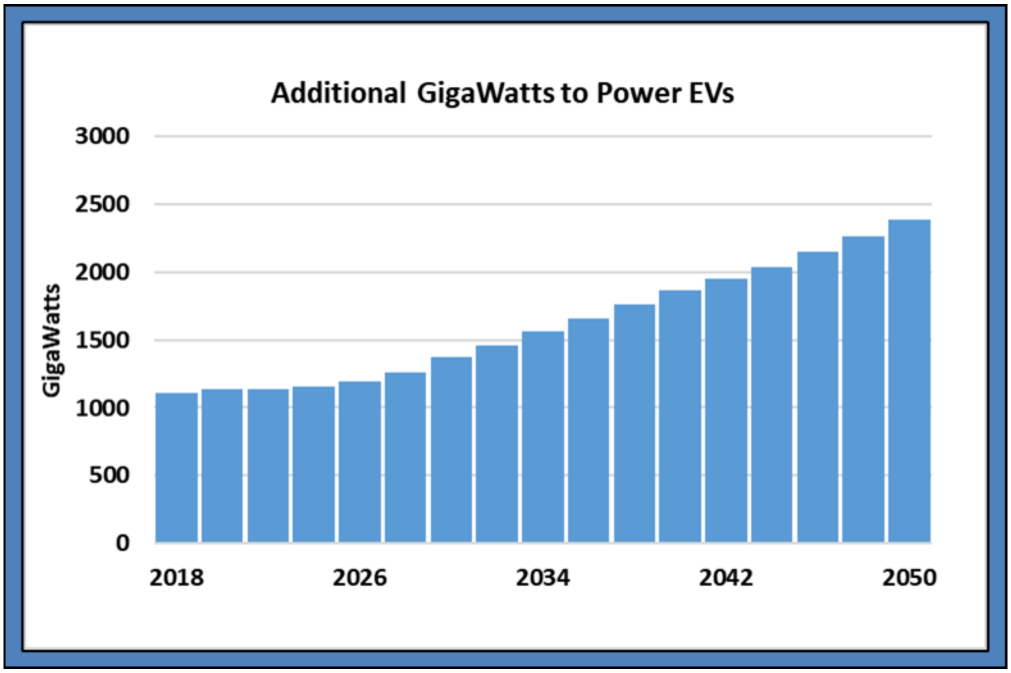
Embedded smart contracts are programmed to provide assurance to one party that the counterparty will fulfill the promise (Allen *et al*., 2021). The FoodTrust organization has successfully applied blockchain to certify food commodities such as grain, fruits, and even orange juice which is a listed commodity (Mendi, 2022). FoodTrust mainly focuses on immediate transactions so the FoodTrust blockchain structure is not proper for exchange-traded commodity products for various reasons including holding periods.

A unique benefit of applying blockchain technology to the environmental credits space is the standardization of the process across multiple producers and users. The standardization of production can revolutionize how an industry functions (Davenport, 2005). The standardization of issuing environmental credits through a Blockchain Clearing System (BCS) will commoditize the digital asset (Markus and Loebbecke, 2013). Using this standardized process will allow a producer to claim multiple credits using one set of data. A producer could legally reap the known benefits from investing in a California Carbon Allowances project (Johnson and Thuerbach, 2022) along with obtaining RINs.

Importance of Environmental Credits

Twelve states have adopted the Zero Emission Vehicle (ZEV) Program (California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont and Washington), which requires increasing sales of ZEVs over the next decade (Vermont DEC, 2022). A U.S. Department of Energy study found that increased electrification across all sectors of the economy could boost national consumption by as much as 38 percent by 2050, largely because of EVs. The environmental benefit of EVs depends on the electricity being generated by renewables (Brown, 2020). Figure 1 on the next page provides an estimate of the new gigawatts of electricity needed by year including increases for space and water heating, and industrial power needs by 2050 with vehicle electrification dominating incremental demand growth (Murphy *et al*., 2021).

Figure 1
Additional Gigawatts Needed Mainly to Power EVs

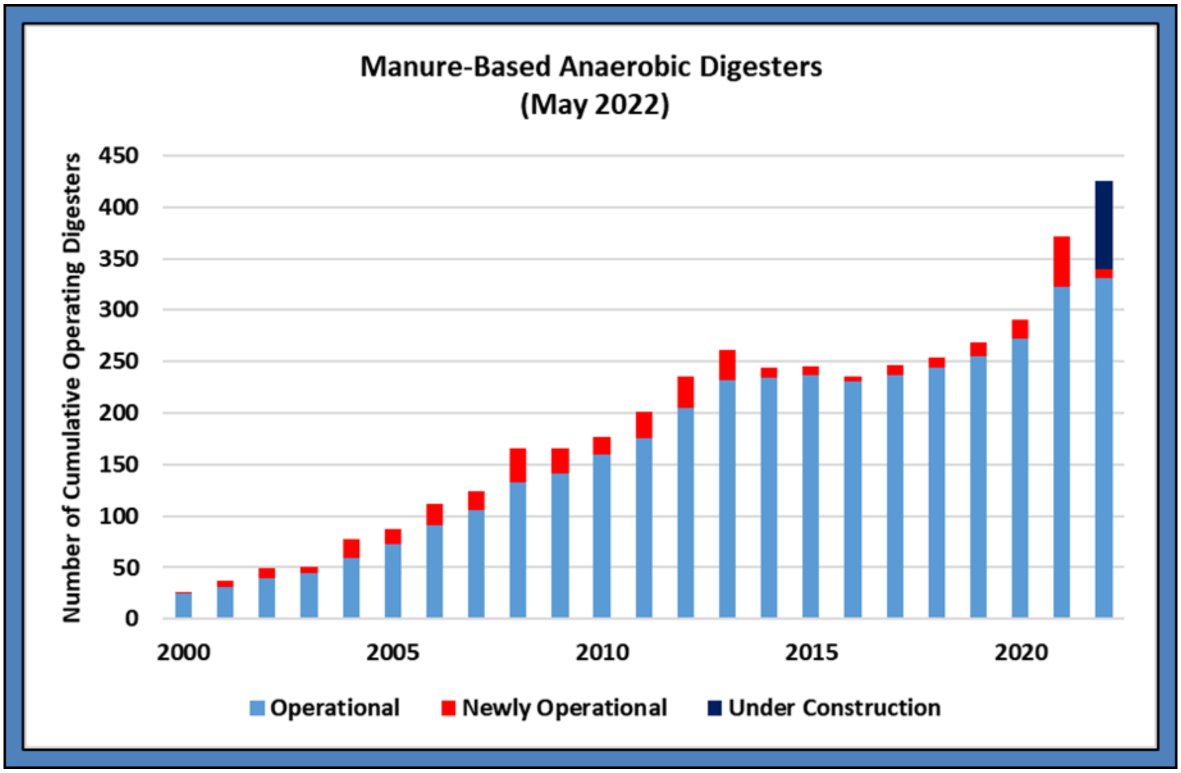


Sources: *Reuters Graphics* (2021) and Murphy *et al.* (2021).

Baseload green electricity will be needed to power the increasing number of EVs, which will reduce GhG from both the vehicles and the electricity production. Bioelectricity is produced from waste products (livestock manure and food waste) that generate biogas through anaerobic digestion and is then turned into electricity. This electricity is a potential source of baseload electricity that can power EV's.

Large dairy farms have been using anaerobic digesters to produce natural gas and electricity for years. In 2021, energy generation from manure-based anaerobic digesters was around 1.76 million megawatt-hours (MWh) equivalent. In calendar-year 2021, manure-based anaerobic digesters reduced Green House Gas (GhG) emissions by 6.09 million metric tons of CO2 equivalent (MMTCO2e) (U.S. EPA, 2022d).

Figure 2
Manure Digesters



Source: U.S. EPA (2022d).

The main obstacle to increasing the production of green energy through the application of anaerobic digestion is profitability due to infrastructure costs for small to mid-sized farms. The initial capital expenditures to build a digester is prohibitively expensive for small and mid-sized farms (Cernauskas *et al*., 2022). Another obstacle to funding a digester product is that the dairy business has profitability volatility due to government regulation of agricultural production (Almering *et al*., 2021). The added revenue from the creation of RINs credits can make the investment in the pollution reduction facilities due to government regulations profitable. A hurdle for the eRIN pathway is the complexity of the audit process that spans from the creation of the biogas to the electricity to miles driving by EVs.

FTD Risk from Fraud or Poor Record Keeping

One of the key hurdles in all RIN pathways is the potential of fraud. History includes cases of large-scale fraud in the renewable energy space. An illustrative list of RIN fraud using the D4 pathway is listed below in Table 1 on the next page.

Table 1 Fraudulent RIN Examples

Company	QTY of Invalid RINs	Fuel Code	Year
Elliot Global Partners	5,800,000	D4	2021
NGL Crude Logistics, LLC	36,000,000	D4	2018
Triton	39,000,000	D4	2017
Western Dubuque Biodiesel, LLC	36,000,000	D4	2016
Chemoil Corporation	72,700,000	D4	2016
Montgomery Recycling Corporation	12,500,000	D4	2016
Gen-X Energy Group, Inc. or Southern Resources and Commodities	7,700,000	D4	2015
New Energy Fuels Inc	10,200,000	D4	2015
Chieftain Biofuels LLC	4,800,000	D4	2015
Washakie Renewable Energy, LLC	7,200,000	D4	2015
Global E Marketing, LLC	6,000,000	D4	2014
Green Diesel, LLC	60,000,000	D4	2014
Imperial Petroleum, Inc. and e-Biofuels, LLC	33,500,000	D4	2013
Absolute Fuels, LLC	48,100,000	D4	2013
Clean Green Fuels	6,800,000	D4	2013
Total	386,300,000		

Source: U.S. EPA (2022c).

The examples in Table 1 illustrate fraud involving the largest number of biodiesel D4 RINs. Fraud is perpetrated by those creating and selling invalid RINS deliberately. The Quality Assurance Plan (QAP) is a voluntary program administered by the EPA where independent third parties may audit and verify that RINs have been properly generated and are valid for compliance. Only RINs verified under a QAP can submitted by obligated parties to meet their renewable fuel obligations. A voluntary program based on periodic site visits will reduce fraud but cannot eliminate fraud due to the periodic nature of the audits (U.S. House of Representatives, 2012).

The EPA requires the RIN production facilities to be audited by third-party auditors to ensure the data presented to the EPA for the RIN was valid (U.S. EPA, 2022a). The EPA has effectively ruled that if the producer of the RIN is insolvent and fraud is identified later that the auditor of the facility can be held responsible for the fraud (U.S. EPA, 2022b). However, this EPA ruling does not mitigate the FTD risk since the auditor must be proven negligent in the performance of the audit. As discussed in the next section, applying blockchain technology to RINs captures production data in an immutable ledger used to provide provenance, standardization and a financial guarantee.

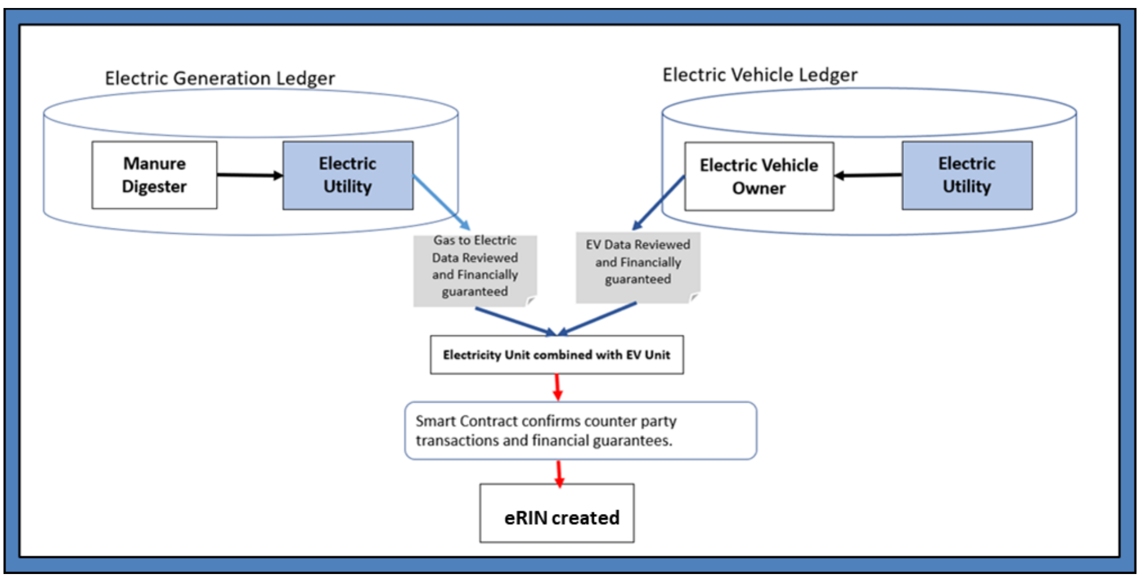
The current EPA process of issuing RINs to the producers of biogas relies on a traditional audit structure. Farmers are generally the producers of the RIN and obtain a RIN by submitting data through an online EPA form. The EPA audit review may result in the invalidation of the credit several years after its issuance due to fraud or improper documentation which has led to FTD risk for the purchasers of the RINs. The EPA prosecution of a RIN auditor (Genscape) for replacement of invalid RINs has established that an audit firm has clearing agent responsibilities. The EPA and Greenspace settlement also established a negligent auditor has FTD risk if the producer is insolvent. In this precedent setting case, the auditor was negligent and ordered to replace 24,000,000 RINs (U.S. EPA, 2022b). The assignment of this risk to the auditor has created the need for a formal clearing structure.

Unlike traditional exchange-traded commodities, in which a clearing firm guarantees delivery, environmental credits not certified by an auditor do not have a guarantor. The EPA's right to invalidate the credit does not have a time limit and can occur many years after delivery, subjecting both the producer and the user of the credit to the risk of FTD.

Decentralized Guaranteeing (Clearing) of RINs via Blockchain

The Blockchain Clearing System (BCS) creates the financial guarantees to the eRIN purchaser that protects against the risk that the EPA invalidates the eRIN due to fraud or record keeping. The concept of using a BCS mechanism to financially guarantee a security for its life using a decentralized clearing mechanism is a new financial structure for commodities. As shown in Figure 3, the biogas/electricity producer, and the block EV operators counterparty risk to each other for fraud or errors has been eliminated.

Figure 3
eRIN Creation From Ledger Data and Smart Contracts



The unique decentralized framework where the provenance of the commodity is guaranteed based on immutable data will allow insurance firms, banks and other high credit firms to provide the financial guarantees to their customers that own small farms. The price of the financial guarantee is the price of a knockout option calculated by using the immutable data stored in the BCS. The immutable data is available both to the guarantor and the current owners of the eRIN so the risk can be calculated by all parties that own, trade or create an eRIN. Additionally, the BCS structure restricts the access of data to only approved participants for agreed upon data sets. This anonymization of the production data protects all network participants privacy along with all production data (Dunn, 2020). The application of a BCS to this product will create a structure like traditional clearing since all parties are covered by insurance, the insurance is active, and the insurance will cover the eRINs total life until the eRIN is considered valid by the EPA after a formal audit.

The BCS directly addresses the veracity and the harmonization of production/market data. The BCS ensures that standardized units of the commodity are produced. The BCS ensures that counterparty risk and FTD risk is eliminated. These features are required for all commodity markets to grow and eventually evolve into exchange-traded products listed on derivative exchanges.

Conclusion

All commodities are a tangible product with standardized delivery features. It is the standardization of the product along with guarantee of a product for delivery that allows a product to become a liquid commodity that can be efficiently traded. As shown in this paper, a private blockchain can be used to both guarantee the provenance and to standardize the product. The application discussed in the paper was eRINs; however, the concept in this paper could be applied to a wide range of products.

The process to convert a tangible product into a commodity using blockchain is straightforward. First, the blockchain needs to document the provenance of the product. The environmental credit space requires that key production data is captured continually during the time of production and is available for review by all parties. The immutableness of the data allows for semi-real time quality inspection of the process to document potential fraud or an out-of-specification process such as adding too much alternative waste being placed into the manure process.

The smart contracts embedded in the blockchain will only allow product that passes the continuous quality inspection to be converted into standardized units. The standardized units are then guaranteed by a third-party against FTD risk. The role of the guarantor is like a clearing firm in futures where the counter party risk between buyers and the sellers is replaced by a AAA credit rated firm with the ability to make either party whole in the unlikely case that the EPA revokes this credit.

The blockchain process detailed in this paper expands the concept of commoditization into multiple non-traditional products through the ability to standardize and guarantee non-traditional products such as environmental credits. The commoditization of these products could allow for practical derivatives markets in these products since the FTD risk has been removed. Finally, the example used for the application of blockchain can create a new source of green baseload of electricity that can power EVs.

References

Allen, F., Gu, X. and J. Jagtiani, 2021, "A Survey of Fintech Research and Policy Discussion," Federal Reserve Bank of Philadelphia Working Paper 20-21, February. Accessed via website: https://www.philadelphiafed.org/-/media/frbp/assets/working-papers/2020/wp20-21.pdf on December 2, 2022.

Almering, V., Rijken, H. and F. Cleton, 2021, "Volatility in Dairy Markets: Towards a Dynamic Value at Risk Model for Dairy Commodity Trading," *Global Commodities Applied Research Digest*, Vol. 6, No. 1, Summer, pp. 121-136.

Brown, A., 2020, "Electric Cars Will Challenge State Power Grids," The PEW Charitable Trusts, January 9. Accessed via website: https://pew.org/2QYQsWE on December 2, 2022.

Cernauskas, D., Josephs, S., Kumiega, A. and D. Waterloo, 2022, "Economic Benefit of Using a Blockchain to Allow for Small Dairy Farmers to Use an Electric Vehicle D3 RIN Pathway," ResearchGate Working Paper, October.
Accessed via website: https://www.researchgate.net/publication/364151458_Econ_Benefit_9-7-2022 on December 2, 2022.

Cong, L. W. and Z. He, 2019, "Blockchain Disruption and Smart Contracts," *The Review of Financial Studies*, Vol. 32, No. 5, May, pp. 1754-1797.
https://doi.org/10.1093/rfs/hhz007

Davenport, T., 2005, "The Coming Commoditization of Processes," *Harvard Business Review*, Vol. 83, No. 6, June, pp. 100-108.

Dunn, J., 2020, "8 No-Nonsense Use Cases Based on Hyperledger Fabric Blockchain," Espeo Blockchain, September 17. Accessed via website: https://espeoblockchain.com/blog/8-no-nonsense-blockchain-use-cases-for-2022/ on December 2, 2022.

Johnson, N. and K. Thuerbach, 2022, "Carbon Cap-and-Trade: We See a Compelling Opportunity," *Global Commodities Applied Research Digest*, Vol. 7, No. 1, Summer, pp. 62-66.

Kamble, S., Gunasekaran, A. and H. Arha, 2019, "Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context," *International Journal of Production Research*, Vol. 57, No. 7, pp. 2009-2033.
https://doi.org/10.1080/00207543.2018.1518610

Kshetri, N., 2018, "Blockchain's Roles in Meeting Key Supply Chain Management Objectives," *International Journal of Information Management*, Vol. 39, April, pp. 80–89.
https://doi.org/10.1016/j.ijinfomgt.2017.12.005

Markus, M. L. and C. Loebbecke, 2013, "Commoditized Digital Processes and Business Community Platforms: New Opportunities and Challenges for Digital Business Strategies," *MIS Quarterly*, Vol. 37, No. 2, June, pp. 649-653. https://www.jstor.org/stable/43825930

Mendi, A. F., 2022, "Blockchain for Food Tracking," *Electronics*, Vol. 11, No. 16.
https://doi.org/10.3390/electronics11162491

Murphy, C., Mai, T., Sun, Y., Jadun, P., Muratori, M., Nelson, B., and R. Jones, 2021, "Electrification Futures Study: Scenarios of Power System Evolution and Infrastructure Development for the United States," National Renewable Energy Lab, Technical Report NREL/TP-6A20-72330, Golden, CO. Accessed via website: https://www.nrel.gov/docs/fy21osti/72330.pdf on December 2, 2022.

Reuters Graphics, 2021, "Estimated U.S. Capacity if 66% of All Cars are EVs by 2050," March 5. Accessed via website: https://graphics.reuters.com/USA-WEATHER/GRIDS-AUTOS/xegvbwxzlpq/index.html on December 2, 2022.

[U.S. EPA] U.S. Environmental Protection Agency, 2022a, "Quality Assurance Plans under the Renewable Fuel Standard Program," June 27. Accessed via website: https://www.epa.gov/renewable-fuel-standard-program/quality-assurance-plans-under-renewable-fuel-standard-program on December 2, 2022.

U.S. EPA, 2022b, "Revised Final Determination and Settlement Agreement in Genscape, Inc. v. EPA 19-3705 (6th Cir.)," September 30. Accessed via website:
https://www.epa.gov/fuels-registration-reporting-and-compliance-help/revised-final-determination-and-settlement on December 2, 2022.

U.S. EPA, 2022c, Civil Enforcement of the Renewable Fuel Standard Program, "Enforcement Actions," November 7. Accessed via website: https://www.epa.gov/enforcement/civil-enforcement-renewable-fuel-standard-program on December 2, 2022.

U.S. EPA, 2022d, AgSTAR Data and Trends, "Anaerobic Digester Facts and Trends, November 15. Accessed via website: https://www.epa.gov/agstar/agstar-data-and-trends on December 2, 2022.

U.S. House of Representatives, 2012, "RIN Fraud: EPA's Efforts to Ensure Market Integrity in the Renewable Fuels Program," Hearing Before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, One Hundred Twelfth Congress, Second Session, Serial No. 112-161, July 12. Accessed via website: https://www.govinfo.gov/content/pkg/CHRG-112hhrg81890/html/CHRG-112hhrg81890.htm on December 2, 2022.

Vermont [DEC] Department of Environmental Conservation, 2022, "Zero Emission Vehicles," Agency of Natural Resources. Accessed via website: https://dec.vermont.gov/air-quality/mobile-sources/zev on October 6, 2022.

Author Biographies

DEBORAH CERNAUSKAS, Ph.D.
Professor of Business Analytics and Finance, Benedictine University (Retired)

Dr. Cernauskas is a retired tenured Professor of Business Analytics and Finance. She is a noted author, editor, researcher, writer, and consultant with expertise in automated machine learning, statistical methods, blockchain design, and finance. Dr. Cernauskas' additional areas of proficiency include business process modeling, GIS and location analytics, econometrics, time series analysis, simulation modeling, agent-based modeling, and financial risk management. Her current research focus is primarily on building machine learning models and designing blockchain process model systems.

STEVE JOSEPHS, PE
Consultant on Alternative Energy Projects

Steve Josephs is a consultant who specializes in renewable and alternative energy projects. He is currently providing engineering and business advice to several biogas-to-transportation-fuel projects at farms and landfills. Prior to these projects, Josephs was a co-founder of AMP Americas and served as V.P. of Engineering. In this role, he led engineering for construction and operation of multiple farm Renewable Natural Gas (RNG) Facilities and Compressed Natural Gas (CNG) Stations. Before AMP, Josephs was the Chief Technology Officer at Infinium Capital Management, a Chicago-based proprietary trading firm.

Steve Josephs received his Bachelor of Science degree in Engineering from Princeton University and his M.B.A. from the University of Chicago. He is a licensed Professional Engineer (PE) in the State of Illinois and was Licensed by the Texas Railroad Commission to Manage CNG Station Operations.

ANDREW KUMIEGA, PH.D., CQE, CQA CSQE, CISA, CISM, CGEIT, CRISC
Assistant Professor of Analytics, Illinois Institute of Technology, Stuart School of Business

Dr. Andrew Kumiega has applied his Ph.D. in Industrial Engineering to research positions in both the manufacturing and the financial industry over the last 30 years. He has held multiple director and partner-level positions in financial services firms. At most of these firms, Dr. Kumiega was responsible for Information Technology (IT) Governance/Risk including model governance and overall IT systems reliability management.

Dr. Kumiega is a faculty member at the Illinois Institute of Technology. His current industry research interests include governance utilizing blockchain, multi-factor stock selection models utilizing autoML, quality, IT risk management, and project management for the fintech industry.

Dr. Andrew Kumiega's previous co-authored article for the *GCARD* covered "Negative Oil Prices, Options, and the Bachelier Model."

Risk Premia in Commodity Futures Markets – An Out-of-Sample Test

Rajkumar Janardanan
SummerHaven Investment Management

The empirical work in this digest article is based on: https://doi.org/10.1016/j.jcomm.2020.100157

The authors of the comprehensive paper document the properties of the first diversified commodity futures index introduced by the Dow Jones & Company in 1933 and use its live track record to study the properties of the asset class in an experimental setting that does not suffer from backfill, selection, or survivorship biases. Despite the setbacks posed by contract failure and trading suspensions of several index constituents, the index appreciated by 3.7% per year between 1933 and 1998, while an investment in collateralized front-month futures returned 4.5% in excess of the risk-free rate. The authors quantify the impact of trading suspensions and contract failure on estimates of the risk premium.

Do Commodities Futures Contain a Risk Premium?

The existence of a risk premium in commodity futures markets continues to be the focus of debate among academics and practitioners. Theoretical arguments have been made both in favor of and in opposition to such an idea. For the detractors, commodity futures contracts are in zero net supply. Each seller of a futures contract has a buyer, so there is no reason to believe that the risk premium consistently goes either way.

Famed financial economist Kenneth French presented this view against a positive commodity risk premium in no uncertain terms:[1]

"*The claims that, going forward, commodity funds (i) will have the same Sharpe ratio as the stock market, (ii) will be negatively correlated with the returns on stocks and bonds, and (iii) will be a good hedge against inflation can't all be true. Who would want the other side of this trade*?"

Proponents of a positive commodity risk premium go back at least to John Maynard Keynes. Decades prior to Modern Portfolio Theory, Keynes hypothesized that futures contracts are set at a discount relative to expected futures prices to compensate speculators for taking on price risk (Keynes, 1930). In a similar vein, Working (1933) and Kaldor (1939) develop the Theory of Storage, which posits a positive risk premium as a function of convenience yield.

Early empirical studies yielded mixed results. In a review paper, Gray and Rutledge (1971) question the existence of a risk premium. In contrast, Bessembinder (1992) documents a link between commercial hedging demand for futures contracts and positive risk premia. Gorton and Rouwenhorst (2006), using a much larger set of commodities, find strong evidence of a risk premium at the commodity index level of a comparable magnitude to the equity premium, although Erb and Harvey (2006) ascribe that premium to the periodic rebalancing of the index.

More recent empirical analysis offers more persuasive support for the existence of commodity risk premia. Using significantly enlarged data sets that start in the 19th century, Levine *et al*. (2018) and Bhardwaj *et al*. (2019) document that commodities have a positive risk premium going back 150 years.

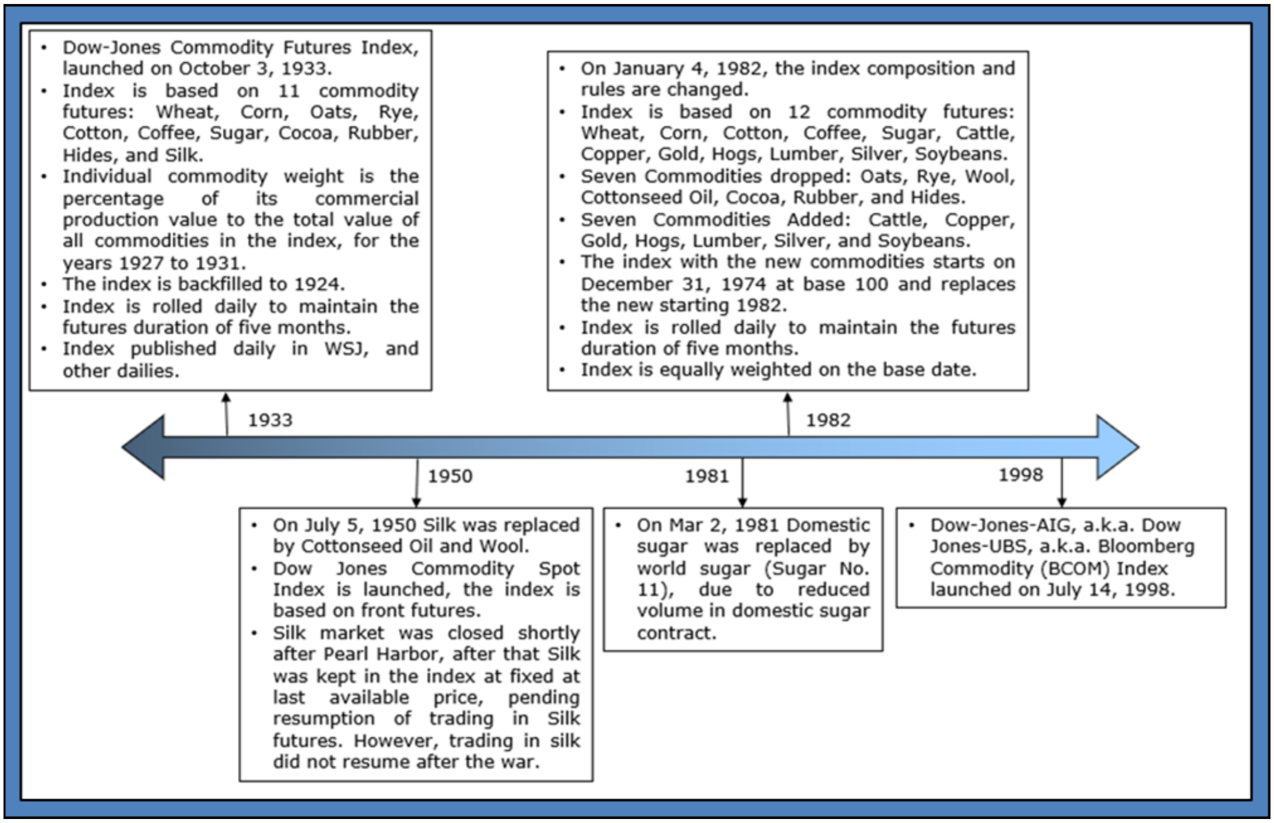
Empirical studies investigating risk premia feature prominently back-tested portfolio returns. The aphorism, "I have never seen a bad back test," captures the skepticism among investment practitioners when evaluating the merit of hypothetical portfolios, an issue also recognized by academic researchers (*e.g.*, Lo and MacKinlay, 1990; McLean and Pontiff, 2016; Harvey *et al*., 2016).

Not accounting for contract failure can lead to an upward bias in estimates of risk premia (Bhardwaj *et al*., 2019). With mounting evidence of a positive commodity risk premium, the question becomes whether the observed risk premium truly reflects a commensurate compensation for investors or is merely a result of selection bias. Does a positive commodity risk premium only account for the results of successful futures contracts and relegate the contract failures to be quietly forgotten? Would we still observe a positive risk premium if commodity futures were chosen with no forward knowledge? Bhardwaj *et al*. (2021) tackle the above questions using a portfolio formed in real time under the prevailing market conditions – an investable index of commodities.

The Dow Jones Commodity Index of 1933

What can the Dow Jones Commodity Index (DJCI) contribute to the risk premium debate? For one, it represents a long (60+ years) track record of a portfolio of commodities selected by an expert index provider dating back to 1933. The index constituents were selected to be representative of the overall commodity market over time, in the same way shares of a small group of industrial companies were selected for the Dow Jones Industrial Average (DJIA). The portfolio was determined in real time, without the benefit of hindsight, *i.e.*, a focus on commodities that would survive to become important today. Just as the DJIA included companies that eventually went bankrupt, the DJCI included commodity contracts that failed (notably silk). Such a long track record is not only rare, but it also avoids many of the pitfalls and of back-tested portfolios used in academic research. Figure 1 on the next page provides an overview of the evolution of the DJCI.

Figure 1
Timeline of the Dow Jones Commodity Index



The DJCI was a spot price index. As such, the change of the index does not represent a rate of return. In order to study the investment returns of the constituent commodities, Bhardwaj *et al*. (2021) calculate the rolling futures returns on the DJCI commodity set in a similar fashion as modern rolling futures indices such as the S&P GSCI Commodity Index (SPGSCI) or Bloomberg Commodity Index (BCOM).

Findings

The rolling futures-based Dow Jones Commodity Index has higher average returns compared to the spot-based DJCI. The futures index earned an average return of 8.5% per year (including collateral return in T-Bills) compared to 3.7% for the spot index. Risk premiums are total returns in excess of the risk-free T-Bill rate, which averages about 4% between 1933 and 1998. The commodity futures premium of 4.5% sits between the equity premium (9.1%) and the bond premium (1.6%). Table 1 on the next page presents a summary of the performance statistics.

Certain commodities experienced trading disruptions (such as WWII) or failures. The DJCI became "underinvested" during these periods. Bhardwaj *et al*. (2021) find that after correcting for underinvestment, the risk premium of the futures-based DJCI is 5.4%, exceeding its underinvested counterpart by 0.9% per annum. This figure offers an estimate of the impact of conditioning on contract survival and tradability for the measurement of the risk premium.

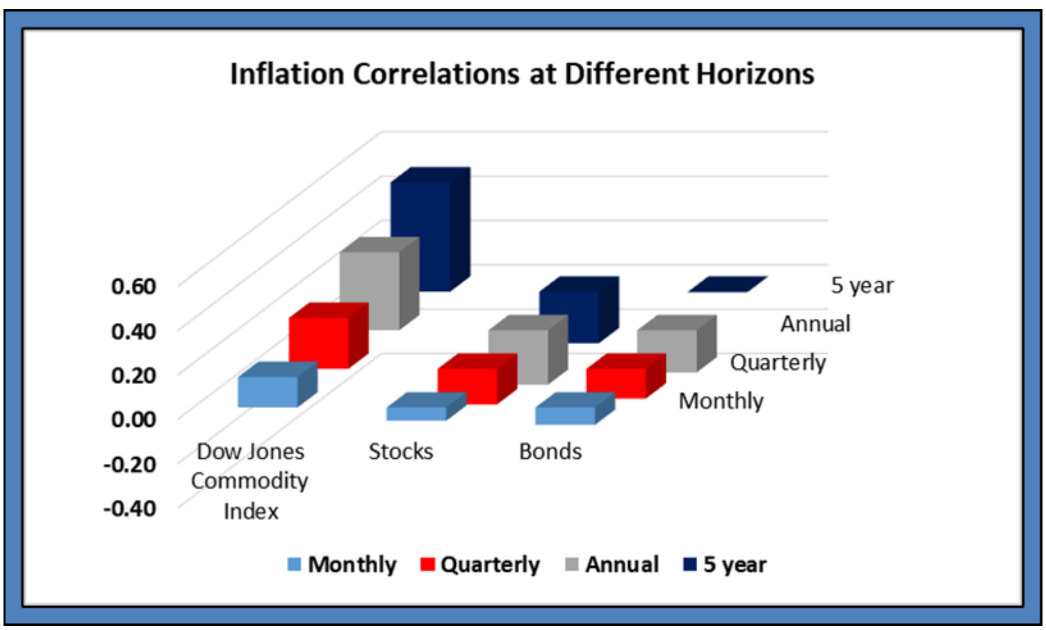
Table 1
Performance Statistics

	Dow Jones Commodity Index	Dow Jones Index Futures TR	Stocks	Bonds
Total Returns	3.7%	8.5%	13.1%	5.6%
Volatility	12.4%	13.0%	15.9%	7.9%
Sharpe Ratio		0.34	0.57	0.20
Risk Premium		4.5%	9.1%	1.6%
Max Drawdown		-44%	-50%	-21%
Skewness		0.66	-0.46	0.88

The estimate of the commodity futures risk premium using the DJCI is very much in line with Gorton and Rouwenhorst (2006) as well as with the longer-term studies of Levine *et al.* (2018) and Bhardwaj *et al.* (2019). It strengthens the overall evidence in support of a positive risk premium in commodity futures.

The study also includes a discussion on the portfolio properties for commodities. From October 1933 to November 1998, the Dow Jones Commodity Index proved to be a useful inflation hedge. On an annual basis, the correlation of inflation and DJCI is 0.35, compared to -0.25 for stocks and -0.19 for bonds. Bhardwaj *et al*. (2021) also find that the DJCI is essentially uncorrelated with stocks and bonds, posting a pairwise correlation of -0.04 with both stocks and bonds over the full sample. Correlations at different horizons are shown in Figure 2. These properties echo existing findings using back-test portfolios (*inter alia*, Gorton and Rouwenhorst, 2006).

Figure 2
Inflation Correlations for Different Assets and Horizons



Summary

Existing work examining risk premia in commodity markets may overstate the true risk premia because back-tested portfolios often do not account for contract failures or trading disruptions. To overcome potential issues associated with back tests, Bhardwaj *et al*. (2021) use a novel data set free from survivorship bias. The Dow Jones Commodity Index was an index calculated in real time based on prevailing market conditions. Critically, this index does not, and could not, include any information from the future in its construction.

Bhardwaj *et al*. (2021) document a positive risk premium for the DJCI, providing corroboration of a positive risk premium in commodity futures. In particular, the authors conclude two important findings. First, a positive commodity risk premium is present over a long time frame not covered in most commodity databases. Second, the commodity risk premium is positive after adjusting for survivorship bias. The paper also documents diversification and inflation-protection properties that commodities as an asset class provides.

Endnote

1 French (2010).

References

Bessembinder, H., 1992, "Systematic Risk, Hedging Pressure, and Risk Premiums in Futures Markets," *Review of Financial Studies*, Vol. 5, No. 4, October, pp. 637-667.

Bhardwaj, G., Janardanan, R. and K. Rouwenhorst, 2019, "The Commodity Futures Risk Premium: 1871-2018," *Available at SSRN 3452255*: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3452255.

Bhardwaj, G., Janardanan, R. and K. Rouwenhorst, 2021, "The First Commodity Futures Index of 1933," *Journal of Commodity Markets*, Vol. 23, September, 100157.

Erb, C. and C. Harvey, 2006, "The Strategic and Tactical Value of Commodity Futures," *Financial Analysts Journal*, Vol. 62, No. 2, March-April, pp. 69-97.

French, K., 2010, "Q&A: What Role for Commodities?", Fama/French Forum Hosted by Dimensional, November 1. Accessed via website: https://famafrench.dimensional.com/questions-answers/qa-what-role-for-commodities.aspx on December 3, 2022.

Gorton, G. and K. Rouwenhorst, 2006, "Facts and Fantasies about Commodity Futures," *Financial Analysts Journal*, Vol. 62, No. 2, March-April, pp. 47-68.

Gray, R. and D. Rutledge, 1971, "The Economics of Commodity Futures Markets: A Survey," *Review of Marketing and Agricultural Economics*, Vol. 39, No. 4, pp. 57-108.

Harvey, C., Liu, Y. and H. Zhu, 2016, "… and the Cross-Section of Expected Returns," *Review of Financial Studies*, Vol. 29, No. 1, January, pp. 5-68.

Kaldor, N., 1939, "Speculation and Economic Stability," *Review of Economic Studies*, Vol. 7, No. 1, October, pp. 1-27.

Keynes, J. M., 1930, A Treatise on Money, Vol. 2., London: Macmillan.

Levine, A., Ooi, Y., Richardson, M., and C. Sasseville, 2018, "Commodities for the Long Run," *Financial Analysts Journal*, Vol. 74, No. 2, Second Quarter, pp. 55-68.

Lo, A. and A. MacKinlay, 1990, "Data-Snooping Biases in Tests of Financial Asset Pricing Models," *Review of Financial Studies*, Vol. 3, No. 3, July, pp. 431-467.

McLean, R. and J. Pontiff, 2016, "Does Academic Research Destroy Stock Return Predictability?" *Journal of Finance*, Vol. 71, No. 1, February, pp. 5-32.

Working, H., 1933, "Price Relations Between July and September Wheat Futures at Chicago Since 1885," *Wheat Studies*, Vol. 9, No. 6, March, pp. 187-240.

Author Biography

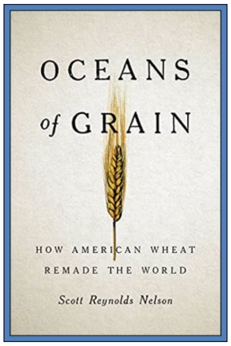
RAJKUMAR JANARDANAN
SummerHaven Investment Management

Rajkumar Janardanan is a portfolio manager and a member of the research team at SummerHaven Investment Management in Stamford, CT. At SummerHaven he has been involved in collecting the largest history of commodity price data from futures exchanges going back to 1870s. He has also published articles in the *Journal of Commodity Markets*, *Journal of Futures Markets*, and *Journal of Indexes*. Rajkumar has a Bachelor's degree from the Indian Institute of Technology, Madras and an M.B.A. from Yale School of Management.

Rajkumar Janardanan's previous research was featured in the *GCARD* article, "On Commodity Price Limits."

Oceans of Grain

Scott Reynolds Nelson, Ph.D.
Professor, Georgia Athletic Association Professor, University of Georgia



When we think about tensions between Russia and the United States we think about spying, election interference, nuclear weapons, the space race, or even the Cold War. But we should really be thinking about grain, because the U.S. and Russia both expanded rapidly into grain regions between 1770 and 1914, becoming what I call physiocratic empires. They seized grasslands from nomadic empires like the Mongols and the Delaware Indians, and encouraged grain farmers to emigrate there. These superpowers grabbed flat plains, promised tax incentives, modernized ports for export, then sold the grain to feed cities around the world. Their competition to feed grain to the world long predated the Cold War.

Historians and economists mostly think about large wheat farms as something that frees workers to do non-food production, which allows industrialization. Well, wheat as a commodity is more than that. It's the source of our fables, the building block of empires, a spur to technology, the cornerstone of finance, the intestines of armies and navies, and the weak point in any plan for world conquest.

To understand grain, we need to look back to the origins of human civilization. Modern genetic analysis suggests that trade in grain was actually prehistoric. A prehistoric plague called *yersinia pestis* spread rapidly along these trade routes around 2800 BC moving from Ukraine outward to Ireland and Manchuria, Finland and Sudan. Millions died, and ancient empires emerged in their wake. Would-be emperors absorbed portions of those pathways, seeking to seal off its edges, and so created kingdoms, then fiefs, and finally states. Heroic nation-building stories notwithstanding, empires did not build themselves, they could only reach along ancient grain traders' pathways and lay claim to food trade networks that long preceded them. And then around the time of the American Civil War, a ten-thousand-year-old world system of traded grain became unhinged when the price of grain began to plummet.

The pressure to produce food every day for survival is a task as old as the Book of Genesis: when God banished Adam he cursed the ground beneath him, condemning him to work for his daily bread. Thousands of years later, the parson Thomas Malthus famously argued that the capacity to produce food might improve but it could never match the geometric growth of human populations. After Malthus, the "dismal science" of economics became a matter of choosing between policy options that only delayed famine and economic catastrophe. Charles Darwin furthered the argument, positing that his theory of evolution derived from "the doctrine of Malthus applied … to the whole animal and vegetable kingdoms." In this sense the disciplines of modern economics and modern biology both flow from the observation of the fundamental pressure of the availability of food on the shape of human populations.

____
All views expressed in the *GCARD* are those of the individual authors and not of the JPMCC, its sponsors, or donors.

The military mobilization of American society during the Civil War diminished the Malthusian imperative. Five competing railway corridors soon carried midwestern grain to eastern cities on the east coast. A futures market based on grain graded for the U.S. Army revolutionized long-distance trade in food, and soon stretched across the Atlantic. The pressure of food on population began to ease first in America and then, after 1865, in Europe as the percentage of income that working people needed to devote to bread fell from eighty percent to forty percent. The subtle, powerful force of these oceans of grain forced empires to change their shapes between the crisis presided over by Abraham Lincoln and the political revolution that brought Vladimir Lenin to power.

While the revolution in food prices started in America and led it to displace the Russian Empire as the world's cheap-food hinterland, that cheap commodity had a greater political impact in the empires of Eurasia. As wheat flooded from the United States across the Atlantic, grain prices fell, and so did the rent that landlords could charge in agricultural empires. By the early 1870s Europeans flocked to what I call gullet cities, in part because bread was suddenly cheaper there than in the countryside. By the 1880s European workers rode back to the U.S. in the very ships that carried American grain to Europe. The "steerage" section, which carried grain east carried European workers west. European landlords in Germany, France, and Italy lost their influence and wealth while newly federated states of Germany and Italy drew their income from a carefully calibrated tax on the imported grain that fed workers in its cities.

But the grip of old empires – as food delivery engines – began to break down. Cheap American wheat soon helped to fracture, and finally destabilize, the Ottoman, Austro-Hungarian, and Qing Empires. Indeed, the term "Imperialist" first emerged in the 1870s to describe the latter-day European states that scrambled to kick out the last foundations of the Ottoman and Chinese empires while expanding English, French, and German influence over them. Imperialism came to mean mineral expeditions, wars in Africa, mile-long port facilities, and elaborate coronations. Dreadnoughts, funded by the tax on workers' bread, gave European states greater reach. But even these European empires were endangered.

Indeed, conflict over grain routes helps explain the origins of World War I as Russia fearing Germany's growing influence on the Black Sea provoked Germany into war. Grain routes help explain why the British failure at the vital chokepoint at Gallipoli was so important, and how a few dozen Bolsheviks with access to Russian grain stores on the Baltic could revolutionize St. Petersburg and Moscow in 1917.

After World War I we are inclined to see the influence of a new commodity as most important: oil. But oil is not everything. Insiders in the Soviet cabinet argue that the crucial event that ended the Soviet experiment was Russia's decision after 1960 to buy grain with oil. That worked in the 1970s but failed spectacularly in the middle of the 1980s when oil prices dropped and grain prices rose again. An international balance of payments crisis followed.

When Russia reentered the world economy after the Soviet Union collapsed in 1991, it tried to drop a new Russian oligarchy into place along the edge of the Black Sea and sell grain again to the world. Ukraine's separation from Russia, and its resistance to Russian influence, have severely weakened Russia as a world power. This story is beyond the scope of my latest book, Oceans of Grain. How some of these empires saw their end in revolutions during World War I, and how this was prefigured in America's Civil War, is the story I tell in my new book.

Part of this story is about new technologies – including dynamite, the futures contract, the grain elevator, and the screw steamer – that let loose grain across the world's oceans, with profound economic and political consequences. Surrounded as we are by cheap food it is difficult to imagine how important these changes were, and how vital and essential the hunt for food had been for the grandparents of our grandparents. The dependence on the sweat of one's brow in their time became a dependence on international food trade in ours. The change was dramatic, yet it appeared almost invisible to millions who lived through it.

But for those who meditated on the shifting lines that bound empires and nations together, who saw its powerful currents and its fatal points of weakness, a new Archimedean lever had opened up, a lever that could move the world. And so the cheap wheat produced by the American Civil War helped bring the world to the brink of famine, world war, and international revolution. Modern conflict between Russia and Ukraine over those same grain corridors in the modern city of Odessa may be the defining event of the twenty-first century.

Endnotes

This article is excerpted from Dr. Reynold's newly published (and very timely) book, Oceans of Grain: How American Wheat Remade the World.

Dr. Reynold's previous insightful work was cited in the *GCARD* article: "Looking into a Distant Mirror: the 1870s."

Author Biography

SCOTT REYNOLDS NELSON, Ph.D.
Professor, Georgia Athletic Association Professor, University of Georgia

Professor Nelson writes about 19th-century US history including the history of slavery, international finance, the history of science, and global commodities.

His most recent book is *Oceans of Grain: How American Wheat Remade the World* about the U.S. and the Russian Empires' competition to feed Europe between 1789 and 1919.

His other books include *Steel Drivin' Man* (2007), about the life of Black folklore legend John Henry, which won four national awards including the National Award for Arts Writing and the Merle Curti Prize for best book in U.S. social history. A young-adult book he co-wrote with Marc Aronson, *Ain't Nothing But a Man* (2007), describes how historians do research. With Carol Sheriff he wrote *A People at War: Civilians and Soldiers in America's Civil War* (2008). His book on the history of financial crashes, *A Nation of Deadbeats: An Uncommon History of America's Financial Disasters* (2012), was named a best business book of the year by *Business Week*.

He has been a research fellow at Harvard University, the École des Hautes études en Sciences Sociales (EHESS) in Paris, and Chicago's Newberry Library. In 2019-20 he was named a Guggenheim fellow.

He has a forthcoming chapter for UNC Press's new Ferris & Ferris imprint titled "The Bourbon South" in 2023.

In his spare time he reads science fiction and drinks too much espresso.

Interview with Colin Waugh

Editorial Advisory Board Member, *Global Commodities Applied Research Digest*

We are delighted to interview Colin Waugh who is a commodity researcher and investor. Mr. Waugh spent much of his career in the commodity investment industry, in fund management, research and trading. Formerly, he was a Partner, Portfolio Manager and Head of Research in the New York firm of Galtere Ltd, a $2.5bn commodity-based global macro fund. A regular China visitor and event speaker over the past decade, he also maintains an active interest in digital applications in banking and financial sector reform and digital solutions for developing market financial inclusion. He is also a Director of Dublin-based Vitro Software, a global medical technology company. Waugh has also worked extensively in Africa on development and migrant-related humanitarian projects and has published two non-fiction books about African political leaders. Colin is also a member of the *GCARD* Editorial Advisory Board and has contributed several articles to the digest and its newsletter.

In this issue's interview, Colin discusses his extensive career, his recent *GCARD* article, changes in the industry, African influences, digitization in developing markets, and his advice to young commodity professionals.

How did you originally become involved in commodity research and how has your career evolved?

My first job in the investment industry was in commodity sales and trading, with a newly formed Merrill Lynch subsidiary dedicated only to commodity trading clients. The Chicago Mercantile Exchange had just launched trading in Eurodollar Futures contracts, the first ever cash-settled futures trading instrument. Although physical commodities markets were depressed, in that earlier era of high interest rates and U.S. dollar strength, trading volumes in currency markets, precious metals and Treasury contracts were growing exponentially.

I built a small but active clientele around trading these booming contracts and worked with clients following a range of approaches from technical to fundamental to hedging-based strategies. While a lot of economists still relied on supply and demand analysis in decision making, technical trading was rapidly taking off, with the publication *e.g.* a few years earlier of J. Welles Wilder's '"New Concepts in Technical Trading Systems" and the incorporation of the Elliot Wave Theory into trade decision making.

My own research work was partly trying to keep up with these various new trends and indicators that clients increasingly relied on, while developing ideas of my own, particularly in volatility-based commodity options trading, a long-short premium trading technical approach which I later launched within my own CTA firm.

In the second phase of my career, I worked in a much smaller, commodity-based global macro hedge fund in New York, which drew on these early experiences and at the same time gave the opportunity to dedicate much closer attention to portfolio management and research, with much less of the day-to-day

All views expressed in the *GCARD* are those of the individual authors and not of the JPMCC, its sponsors, or donors.

client contact of my first trading assignments. Running a small trading desk at Galtere International Fund led to heading the firm's global research team, as the business grew from one million dollars managed to $2.5 billion in the years I worked there. At Galtere, there was a firm belief in top-down macro thematic investing, and research trips to Asia, Africa, and Latin America as well as London and continental Europe were an important part of my responsibilities.

After Galtere, I worked at a pure macro research firm, Lombard Street Research in London, (now TS Lombard) covering commodities for their strategy team. Interactions with clients and customers led to meetings in Asia, Australia and the U.S., as well as contributing to "Intelligent Commodity Investing" – the prescient reference work from Risk Books which brought me into collaboration with its co-editor Hilary Till – which in turn later led to involvement with the *GCARD*.

You have contributed several articles to the GCARD and its newsletter. A recent article was "Resources and Diplomacy: Commodity Signposts to a Post-War Economic Order." Can you summarize key points of this article and note any recent developments?

The article, written less than a month after the Russian invasion of Ukraine in February of 2022, focused on the commodity market – and climate change policy – implications of the conflict, on the assumption that the fighting, with or without stalemate and peace talks, would be protracted. Briefly surveying the relative vulnerabilities of major Western countries, actual as well as potential, the article speculates on the degree to which climate change goals will have to be compromised. While the base case is that major clean energy economic transformations will have to be put on hold, or severely curtailed, the article also looks at how Europe's markets got to where they are today in their dependency on Russian oil and gas. Indeed by late October, despite a government composed of a coalition including the anti-nuclear Green Party, Germany had already put on hold the closure of its remaining nuclear plants, while the U.K. parliament voted down a motion to allow wider debate and consultation before initiating controversial gas fracking operations in rural areas.

But the most difficult question to answer, and the situation likely to be the longest to evolve, concerns global, not European-centric geopolitics. How other powers with interests potentially allied as much to Russia as to the West might deploy their strategic resources – whether energy, food, mineral or military, will depend on a more complex set of factors.

Not only will it be important to keep China at worst a neutral party to the conflict and work to maintain India as a potential ally, but the poorer – and increasingly vociferous developing world may have an unexpectedly powerful role to play. For example, at the October 2022 UN Security Council vote on condemning the illegal annexation of Ukrainian provinces, India, in common with its Asian superpower rival China abstained, suggesting that there is much that could still be achieved on the diplomatic front as well as the military.

The head of the World Health Organization, Dr. Tedros A. Ghebreyesus has sharply criticized the West for its "racism" in prioritizing support for the conflict in Ukraine and ignoring suffering in Afghanistan, Yemen, Syria and his native Ethiopia. Those countries and their West African neighbors *e.g.* in the Sahel, also under severe drought-induced threat, will be more interested in negotiating to secure food rather than missiles and military alliances in the years to come.

It has already been seen how the sharp rise in the world price of wheat and other food commodities affected by the war occurred in the wake of the fighting, prompting calls for “food corridors” and a humanitarian truce – not only for war displaced, but also to save victims of hunger in North Africa and many less developed countries, whose grain supplies traditionally came from the Black Sea ports.

Overall, successful resources diplomacy will need to take account of the needs of a far wider global constituency and its complex interests, looking beyond the immediate interests of the western military alliance and the actions of its battlefield enemies.

What are some of the major changes you have experienced in the commodity industry?

In common with almost all industries, the period which my commodities career spanned was one in which the advent of the internet and digital transformation revolutionized procedures, particularly in the operations side of the business. Some of my earliest exposures to the sharp end of trading included trips to the floor of the New York and Chicago Mercantile exchange floors, where the bigger independent traders – the “locals” – could be seen occupying dominant positions at the front of the trading ring, arms outstretched, a fistful of paper waiting to be filled in either hand. Things have changed beyond recognition.

At the fund management end, technical trading was quickly overshadowed by quantitative methods which in turn gave way to AI-based decision making in a certain breed of funds. While there were headline-hitting blow-ups and brutal post-crash periods of consolidation, overall developments in the industry have ensured the development of a wider-than-ever variety of trading approaches, and undoubtedly today’s commodity fund investor is more thoroughly spoiled for choice than ever before.

On a less positive note perhaps, I would point to the looming risks of the increasing “financialization” of commodity markets which threatens to distort values rather than reflect true market forces over time. Financialization became most evident during the time of the Global Financial Crisis when crude oil’s futures price soon became totally detached from the reality of world supply and economic demand, first brushing the $150/barrel mark in 2008 and later dropping to below $10, or later still in the COVID era, briefly to less than zero for certain contracts.

More recently still, the outbreak of the Ukraine War sparked enormous speculation in grains, as well as European natural gas futures, arguably exacerbated wildly by short term financial flows and doing little to calm the nerves of the end-users of fuel and food, often already in very disadvantaged economic conditions. While certainly a result of natural human instincts to price protect as well as to profit, the appearance of excess in these developments has done little to enhance the value and reputation of world commodity markets.

You have worked extensively in Africa on development and migrant-related humanitarian projects. How has your work in Africa impacted your research and investments?

After 11 years in commodity trading, I decided it was time to do something totally different for a spell and so I took a two-month assignment as finance manager and administrator of an American Red Cross funded program in the Horn of Africa, where famine threatened (as it does again today) in the wake of a long drawn out civil war (as is the case again today). The work was intense and it certainly cleared out some metaphorical cobwebs that had accumulated over a decade of screen watching. Those two months in post-conflict assistance work turned into over seven years and brought me into contact with a wide range of societies working within (and often struggling under) a broad variety of different types of regimes.

Some were the African leftovers of the Cold War era and former Soviet-backed regimes across the continent were in the midst of transformation to more pro-market economies. It struck me how several were not only waiting to embrace entrepreneurship but at the same time were still condemned to operating within outdated structures *e.g.*, in agriculture, or confined to cottage industry scale of operation due to lack of capital availability.

Western governments and the IMF threw money at many of the countries they favored for development, but only in a few did it stick and in others it backfired, as sometimes the conditions that came with their cash deprived rural populations of a living. There surely could be a better approach, engaging the private sector in fostering growth.

Stock markets seemed like one answer, and at the end of my spell in the public sector, I took a few weeks and visited the embryonic exchanges in Abidjan, Accra, Gaborone, Lagos, Maputo and Tunis, as well as the flagship of the continent, Johannesburg, whose trading volumes, despite all the turbulence that has occurred in that country in recent decades, still dwarfs every other African Exchange.

In terms of resources, no investor could ask for a better endowed continent than Africa – but neither could one imagine a region with such an unpredictable financial landscape. Based on my own experience if I had to pick one area where I think African business more generally is being held back, I would pick contract enforcement, and all that that entails.

It is why many prefer to invest in African commodity businesses, but based on contracts tied to *e.g.*, English or New York law – and where they prefer to buy African companies and commodities on Western exchanges: for liquidity, transparency and above all – contract enforceability in the event things don't turn out as expected.

While Western-style organized markets in Africa suffer from barriers to scale, it is clear that other exciting business opportunities exist and I spent some years in partnership with local firms in a couple of countries trying to get business plans off the ground. However, even in some of the best resourced economies, progress is often hampered by bureaucracy and the least transparent business culture, making it uphill work for the inexperienced outsider. In the end I decided, as many others have, that Africa was well worth the investment, especially of time and engagement, and for the fortunate few, of money as well.

You are interested in digital applications in banking and financial sector reform and digital solutions for developing market financial inclusion. What progress has been made toward this end?

With the advent of mobile banking and hand-held transaction making, it has often been assumed that the biggest relative beneficiaries from technological advance would be in the developing world, unable as most are to compete with the traditional financial infrastructures of the advanced economies.

In the same way that the mobile phone itself made redundant the laying of tens of thousands of miles of telephone cables to install fixed lines, the digitization of transaction-making should offer potentially similar "leap-frogging" access to modern markets for rural, low-income populations in every corner of the world. Regardless of whether they can reach physical banks or open conventional financial accounts, consumers and vendors, as well as savers and investors could benefit from a levelling of the global financial playing field. So, to what extent has this happened in practice?

From my several years of work in half-a-dozen Sub-Saharan African countries my overall observation is that while broad progress has been made in cashless transacting, the opening up of the real opportunity which digitization potentially offers to the mass market can be impeded by a variety of unrelated factors in many economies. Despite technology-based breakthroughs and lower-cost access to communications and transaction making, traditional interests in government, banking and capital markets have often been as much obstacles as enablers.

The countries which already had existing capital markets such as Kenya and pro-technology governments, such as Rwanda, plus educational standards and adequate infrastructure have clearly embraced digitization the fastest and have benefited the most. Others, whether poorer in physical terms or due to uncompetitive entry conditions, national security motivations, or again where governments and established interests have opposed change, have unsurprisingly benefited less.

Again, ostracized by western ratings agencies and dealmakers as too risky or not worth the trouble, most have fought uphill battles to raise the necessary capital to join the ranks of global players and achieve the scale that would allow a break-out from local and national markets. Frustrations with the dollar and IMF-based *status quo* have even led to talk of replacing traditional currencies floating against the dollar with Bitcoin or other cryptocurrencies.

Yet Africa's middle class is growing rapidly, within a continental population that is set to reach 1.7 billion by 2030, and 2.5 billion by 2050, close to matching that of today's China and India combined.

What advice could you give to students and young professionals interested in the commodity markets?

Despite the financialization of markets which I talked about earlier, the commodity markets are one of the few areas in investment where practitioners really do have an investible universe which responds to a different range of factors and influences beyond the price of money. This offers opportunity beyond those available to so many others who set out on a career in financial market investing.

Individual stocks have their micro economic opportunities and crypto may yet become a mainstream asset class to match other global markets, but commodities will always have the allure of that unique mix of supply and demand, geo-politics, climate, freight, storage and so much more. As a young commodity practitioner, it is important to master all these factors that make our markets stand out, sometimes for good, sometimes for not so good.

Despite the enduring ubiquity of a risk-on, risk-off investment universe, commodities offer true diversification and in most cases the kind of liquidity that can match other markets. Learn the quirks, the twists, the tricks, and the traps, be prepared for frustration and disappointment, but extend your mind and in the end the rewards will come.

Biography

COLIN WAUGH
Editorial Advisory Board Member, *Global Commodities Applied Research Digest*

Colin Waugh has spent much of his career in investment management, research and trading. He was a Partner, Portfolio Manager and Head of Research in the New York firm of Galtere Ltd, a $2.5bn commodity-based global macro fund, until 2009 when he joined Lombard Street Research (LSR) as an Associate Director for Commodities Research in LSR's Global Strategy Division. He also worked in commodities at Merrill Lynch, and was Vice President, Commodities at Shearson Lehman Brothers. He joined the Editorial Advisory Board of *Global Commodities Applied Research Digest* (*GCARD*) at the J.P. Morgan Center for Commodities in 2018. He also contributed the chapter, "Collision: Investing for the New World Commodity Order," in the bestselling Risk Book (London), "Intelligent Commodity Investing" (Edited by Hilary Till and Joseph Eagleeye). In addition, he has published two non-fiction books about African political leaders: "Paul Kagame and Rwanda" (2004) and "Charles Taylor and Liberia" (2011).

Colin Waugh's previous articles for the *GCARD* are available here.

Business School
UNIVERSITY OF COLORADO **DENVER**

JP MORGAN CENTER FOR COMMODITIES + GLOBAL ENERGY MANAGEMENT

ENERGY AND COMMODITY PROFESSIONAL EDUCATION

Build skills for transitioning and expanding the future of energy. Whether you are an executive, looking to move into the energy space, or new to energy, you need the flexibility to learn quickly, and on your time.

The Center provides a variety of ways to advance your career and knowledge without requiring the large financial or time commitments of a graduate degree. Our courses target practical skills you need to thrive, including certificates and professional education in high-demand fields such as energy analytics, trading and hedging, sustainability, supply chain and fundamentals of energy and utilities.

Delivered 100% VIRTUAL

Participants from across the Globe

Industry sectors represented:
Mining, Energy, Agriculture

500+ Students completed professional education course
500+

PROFESSIONAL DEVELOPMENT OPPORTUNITIES	COURSE LENGTH
Masterclass in Trading and Hedging *NOT-FOR-CREDIT CERTIFICATE, CEU/CPE CREDITS* This four-week online certificate course is for new hires on the trading desk, risk managers, analysts & senior management. Learn how professional traders distill information into an actionable perspective on the future of price, then select the optimal strategy to express that view of the market.	4 WEEKS
Energy and Commodity Analytics for Analysts *NOT-FOR-CREDIT CERTIFICATE, CEU/CPE CREDITS* This 8-week online course for managers and new data professionals offers a broad-based, but gentle, introduction to the rapidly expanding disciplines of analytics and Big Data in the energy and commodity industries. The course focuses on developing quantitative data literacy and establishing the foundation of analytics, algorithms, and models. You will be able to comfortably discuss the issues, impacts, and tools of energy analytics.	4 WEEKS

Lifecycle of Oil and Natural Gas *NOT-FOR-CREDIT CERTIFICATE, CEU/CPE CREDITS* This two-day in-person course is designed to educate professionals within the energy industry and those on the periphery, about the complete lifecycle of oil and natural gas resources. Topics explore everything from geology to accessing land, drilling and completions, upstream marketing, and managing risk.	2 DAYS
Sustainable Commodities Production, Markets, and Supply Chain *NOT-FOR-CREDIT CERTIFICATE, CEU/CPE CREDITS* This four-week online certificate course is for individuals who want to be hands-on with sustainability policy within a company, better understand what sustainability means to their specific role within a company, grasp fundamental sustainability concepts and jargon, and learn how to add value to support your company's and career's success.	4 WEEKS

We are an all energy and markets education hub supported by leading experts and practitioners within their field, backed by the University of Colorado Denver Business School, JP Morgan Center for Commodities and the Global Energy Management Program.

GET STARTED TODAY

Questions? Contact our Global Energy Management team at gem@ucdenver.edu.

Denver | **BUSINESS** SCHOOL J.P. MORGAN CENTER FOR COMMODITIES

Denver | GLOBAL ENERGY MANAGEMENT **BUSINESS** SCHOOL

CU DENVER BUSINESS SCHOOL

More Information: 303-315-8066
1475 Lawrence St. Denver, CO 80202

EDITORIAL ADVISORY BOARD MEMBER NEWS

Editorial Advisory Board

We are happy to announce the appointment of two additional commodity experts to the *GCARD*'s Editorial Advisory Board: **Kenneth Armstead** and **Faouzi Aloulou**.

Kenneth Armstead, Founding Principal of αPlus Management, has joined the *GCARD*'s Editorial Advisory Board.

As the Founding Principal of αPlus Management, **Kenneth Armstead** advises select clients in tactical multi-asset allocation and risk management across fixed income, equities, commodities and FX, customizing and implementing proprietary algorithmic frameworks to client needs. He also serves as an industry reviewer of investment research for the *Journal of Asset Management* and has authored published research on portfolio solutions utilizing non-correlated investment processes. On the subject of commodities, for example, he co-wrote a chapter on "Commodity Returns - Implications for Active Management" for the bestselling Risk Book (London), "Intelligent Commodity Investing." That book, in turn, was co-edited by the *GCARD*'s Contributing Editor, Hilary Till, and the *GCARD*'s Associate Editor, Joseph Eagleeye.

In addition, Mr. Armstead serves on the Finance Group Advisory Board at the MIT Sloan School of Management and is a Board Strategic Advisor at Seamans Capital Management.

Faouzi Aloulou also joined the *GCARD*'s Editorial Advisory Board this fall. He is a Senior Industry Economist at the Energy Information Administration (EIA) of the U.S. Department of Energy in Washington, DC, having joined in 2001. Currently, Mr. Aloulou has been involved in addressing provisions directed at the EIA from the Bipartisan Infrastructure Investment and Jobs Act 2022, regarding carbon dioxide emissions data harmonization, and provisions from the Inflation Reduction Act 2022 regarding hydrogen production and its impact on the EIA's modeling energy consumption in the manufacturing sector.

Mr. Aloulou co-authored an article for the Winter 2022 issue of the *GCARD* on how "China['s] Natural Gas Domestic Production and Imports Reached [a] Record-High in 2021 but Declined in 2022." His previous article for the *GCARD* covered "U.S. Haynesville Shale Gas Production."

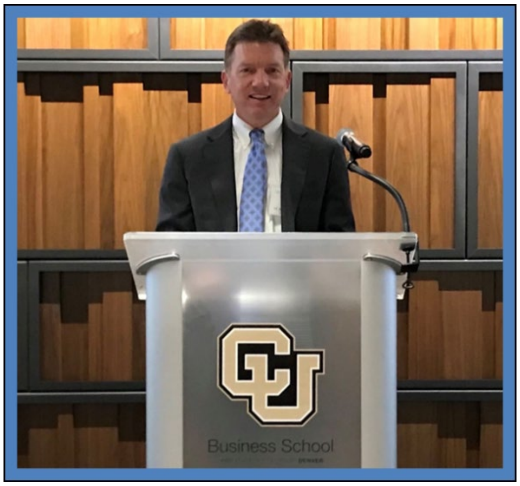
Welcome, Ken and Aloulou, to the *GCARD*'s team!

DePaul University's Driehaus College of Business

Mark Shore, Executive Director of DePaul University's Arditti Center for Risk Management, also serves as an Editorial Advisory Board member of the *GCARD*.

Kudos to **Mark Shore** for being named the Alumnus of the Year by the Finance Advisory Board at DePaul University's Driehaus College of Business on November 3, 2022. Mr. Shore is the Executive Director of DePaul University's Arditti Center for Risk Management as well as serving as an Editorial Advisory Board member of the *GCARD*.

International Journal of Mining, Reclamation and Environment



Dr. Thomas Brady presenting at the JPMCC's 5th international commodities symposium. Dr. Brady is the CoBank Executive Director of the JPMCC and a Managing Director at Capitalight Research (Canada).

Congratulations to Dr. David Hammond and **Dr. Tom Brady** for the publication of their article, "Critical Minerals for Green Energy Transition: A United States Perspective," which was published in the International *Journal of Mining, Reclamation and Environment*!

Dr. Hammond has had a longstanding affiliation with the J.P. Morgan Center for Commodities and is a Principal Mineral Economist at Hammond International Group in Colorado. Dr. Brady is the CoBank Executive Director of the University of Colorado Denver's JPMCC and is also a Managing Director at Capitalight Research (Canada). He also serves as an Editorial Advisory Board member of the *GCARD*.

Their academic "paper examines the green energy transition objectives from a U.S. viewpoint. It is highly doubtful that targets announced by politicians, climate advocates and green investors will be achieved under-desired timeframes. The lack of a coherent domestic mineral policy, exceedingly long and burdensome permitting timeframes and increasing litigation will result in continuing underinvestment domestic mineral opportunities. As a result, geopolitical risks across necessary critical mineral supply chains are anticipated to escalate as the U.S. de facto strategy will be reliance on foreign sources, both friendly and not."

The 5th JPMCC International Commodities Symposium

We were delighted that six members of the *GCARD*'s Editorial Advisory Board participated in the JPMCC's 5th International Commodities Symposium in August 2022. In alphabetical order, they were **Dr. Isabel Figuerola-Ferretti** (Universidad Pontificia Comillas, Spain); **Dr. Kartik Ghia** (Bloomberg), **Robert Greer** (Originator of the first investable commodity index); **Dr. Thomas Lee** (U.S. Energy Information Administration); **Dr. Xiao Qiao** (City University of Hong Kong); and **Lance Titus** (Uniper).

The JPMCC symposium featured an industry panel on "Investing in Commodities Today" on August 15, 2022. From left-to-right are **Robert Greer** (J.P. Morgan Center for Commodities), **Dr. Kartik Ghia** (Bloomberg), **Dr. Nicholas Sly** (Denver branch executive at the Federal Reserve Bank of Kansas City), and **Paul Pittman** (Farmland Partners, Inc.).

U.S. Energy Information Administration

Hilary Till is the JPMCC's Solich Scholar and the Contributing Editor of the *GCARD*.

The JPMCC's Solich Scholar, Hilary Till, presented at the EIA's 2022 Workshop on Financial and Physical Energy Market Linkages on November 17, 2022. Her presentation covered, "A Practitioner Perspective on When OPEC Spare Capacity has Mattered for Oil Prices." Professor James Hamilton, University of California San Diego, and Dr. Reinhard Ellwanger, Bank of Canada, also participated in the workshop, which in turn was organized by the EIA's Dr. Thomas Lee. Professor Hamilton is a Research Council member of the JPMCC; Dr. Ellwanger is a contributor to the *GCARD*, including in the current issue; and Dr. Lee is a member of the *GCARD*'s Editorial Advisory Board.

The issues and topics that were discussed at the EIA workshop included (a) the fundamental drivers of the high level of oil prices in the current environment; (b) the energy price and economic growth relationship; (c) price responses given geopolitical risk and market trading behavior; (d) implications and price reactions related to OPEC's announcement and its production capacity; and (e) new methodologies with oil futures to improve the forecasting accuracy.

Professional Risk Managers' International Association (PRMIA) Thought Leadership Webinars

This fall, both **Keith Black**, PhD, CFA, CAIA, FDP and **Jodie Gunzberg**, CFA graciously shared their expertise on the risk of cryptocurrencies and digital assets at two PRMIA Thought Leadership webinars. Black and Gunzberg are both Editorial Advisory Board members of the *GCARD*. Keith Black is an alternative investment course designer, and his past articles for the *GCARD* are available here. Jodie Gunzberg is a Managing Director at CoinDesk Indices and also serves on the Industry Advisory Council for the JPMCC.

In addition, Adila Mchich also shared her knowledge at a PRMIA Thought Leadership webinar on the "Impact of [the] Russian-Ukraine War on [the] Global Gas and LNG Market." Mchich is a Director in Research and Product Development at the CME Group. She is also an Editorial Advisory Board member of the *GCARD*. Her most recent co-authored article for the *GCARD* is here.

Adila Mchich, Director in Research and Product Development at the CME Group, also serves as an Editorial Advisory Board member of the *GCARD*.

References

Aloulou, F., 2017, "U.S. Haynesville Shale Gas Production," Industry Commentaries, *Global Commodities Applied Research Digest*, Vol. 2, No. 2, Winter, pp. 134-137. Accessed via website: https://www.jpmcc-gcard.com/wp-content/uploads/2018/01/Page-134-137_GCARD-Winter-2017-Industry-Analysis-Aloulou-010518.pdf on December 9, 2022.

Black, K., 2022, "Valuation of Cryptocurrencies and Digital Assets," Presentation, Professional Risk Managers' International Association Thought Leadership webinar, November 9.

Brannlund, J., Dunbar, G. and R. Ellwanger, 2022, "Are Temporary Oil Supply Shocks Real?", JPMCC Symposium Presentations, *Global Commodities Applied Research Digest*, Vol. 7, No. 2, Winter.

Ellwanger, R., 2022, "Futures Prices are Useful Predictors of the Spot Price of Crude Oil," U.S. EIA's 2022 Workshop on Financial and Physical Energy Market Linkages, November 17.

Figuerola-Ferretti, I., 2022, "Credit Risk and Bubble Behaviour of Credit Default Swaps in the Corporate Energy Sector," Presentation, JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/sites/default/files/attached-files/1._isabel_figuerola-ferretti.pdf on December 9, 2022.

Ghia, K., 2022, "What Do Investors Expect from Their Commodity Portfolios?", Presentation, JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15. Accessed via website: https://business.ucdenver.edu/commodities/sites/default/files/attached-files/kartik_ghia.pdf on December 9, 2022.

Gunzberg, J., 2022, "Managing Risks in Digital Assets," Presentation, Professional Risk Managers' International Association Thought Leadership webinar, December 7.

Hamilton, J., 2022, Presentation, "Energy Prices and the World Economy," U.S. EIA's 2022 Workshop on Financial and Physical Energy Market Linkages, November 17.

Hammond, D. and T. Brady, 2022, "Critical Minerals for Green Energy Transition: A United States Perspective," *International Journal of Mining, Reclamation and Environment*, Vol. 36, No. 9, Published online: October 19, 2022, pp. 624-641. Accessed via website: https://www.tandfonline.com/doi/abs/10.1080/17480930.2022.2124788?journalCode=nsme20 on December 9, 2022

Lee, T. and J. Zyren, 2019, "Revisiting Price Volatility Behavior in the Crude Oil Market," Editorial Advisory Board Contribution, *Global Commodities Applied Research Digest*, Vol. 4, No. 1, Summer, pp. 71-83.

Lee, T., 2022, Discussant Presentation on "Are Temporary Oil Supply Shocks Real?", JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 15.
Accessed via website: https://business.ucdenver.edu/commodities/content/lee-discussant-2022 on December 9, 2022.

Mchich, A. and H. Till, 2020, "Is Oil-Indexation Still Relevant for Pricing Natural Gas?", Industry Analyses, *Global Commodities Applied Research Digest*, Vol. 5, No. 2, Winter, pp. 105-110. Accessed via website: https://www.jpmcc-gcard.com/digest-uploads/2020-winter/issue-pages/Page%20105_110%20GCARD%20Winter%202020_Mchich_Till.pdf on December 9, 2022.

Mchich, A., 2022, "Impact of Russian-Ukraine War on Global Gas and LNG Market," Presentation, Professional Risk Managers' International Association Thought Leadership webinar, December 14.

Qiao, X., 2022, Discussant Presentation on "A Tale of Two Premiums Revisited," JPMCC International Commodities Symposium, University of Colorado Denver Business School, August 16.
Accessed via website: https://business.ucdenver.edu/commodities/content/qiao-discussant-2022 on December 9, 2022.

References (Continued)

Till, H., 2018, "Interview with Professor James Hamilton," Interview with a Thought Leader in Commodities, *Global Commodities Applied Research Digest*, Vol. 3, No. 1, Summer, pp. 136-139.
Accessed via website: https://www.jpmcc-gcard.com/wp-content/uploads/2018/05/GCARD_Summer_2018_Interview_Hamilton.pdf on December 9, 2022.

Till, H., 2022, Presentation, "A Practitioner Perspective on When OPEC Spare Capacity has Mattered for Oil Prices," U.S. EIA's 2022 Workshop on Financial and Physical Energy Market Linkages, November 17. Accessed via website: https://www.jpmcc-gcard.com/digest-uploads/presentations/CU%20Denver%20-%20JPMCC%20-%20Till%20-%20EIA%20111722%20%28final%29.pdf on December 9, 2022.

U.S. EIA's 2022 Workshop on Financial and Physical Energy Market Linkages, Agenda, November 17.
Accessed via website: https://www.jpmcc-gcard.com/digest-uploads/docs/Agenda_EIA22.pdf on December 9, 2022.

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, in association with Premia Education, Inc.

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. The CoBank Executive Director of the JPMCC is Dr. Thomas Brady, Ph.D.

Subscriptions to the Global Commodities Applied Research Digest, which is edited by the JPMCC's Solich Scholar, Hilary Till, are complimentary at jpmcc-gcard.com/subscribe.

Copyright © 2022 University of Colorado Denver Business School

The Winter 2022 *GCARD* cover image is cropped from the following artwork, whose complete image is above: Original vintage travel poster realized by Roger Broders in 1922, Marseille PLM - Paris Lyon Méditerranée - Marseille - La grande métropole industrielle et commerciale. Printed by : Cornille & Serre.

Accessed at: https://www.elbe.paris/en/vintage-travel-posters/2486-vintage-travel-poster-marseille-plm-france-roger-broders-1922-railways.html

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

Physical Address

J.P. Morgan Center for Commodities

University of Colorado Denver Business School

1475 Lawrence Street
Denver, CO 80202

Mailing Address

J.P. Morgan Center for Commodities

University of Colorado Denver Business School

Campus Box 165
P.O. Box 173364
Denver, CO 80217

Web

business.ucdenver.edu/commodities

Contact

Erica Hyman

Assistant Director

J.P. Morgan Center for Commodities

University of Colorado Denver Business School

erica.hyman@ucdenver.edu
1.303.315.8019

Business School
UNIVERSITY OF COLORADO DENVER