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

GLOBAL COMMODITIES

APPLIED RESEARCH DIGEST

SUMMER 2020

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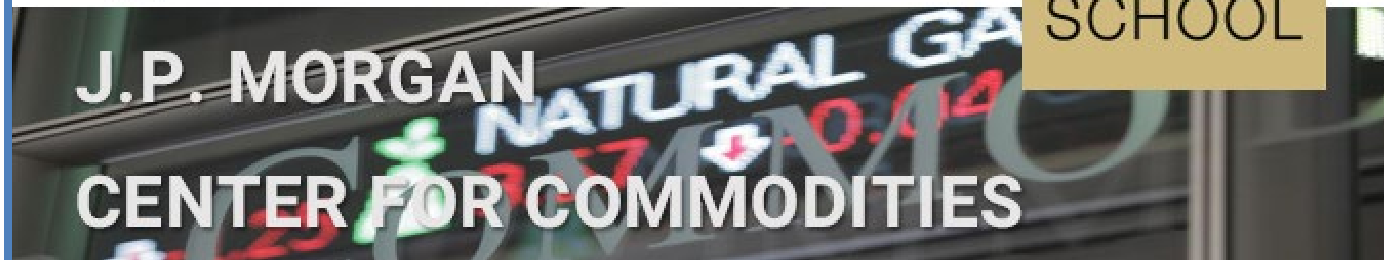
UNIVERSITY OF COLORADO **DENVER**

GLOBAL COMMODITIES APPLIED RESEARCH DIGEST

Vol. 5, No. 1: Summer 2020

Index of Articles



The JPMCC is positioned as a collaboration between business and academia across the broad agriculture, metals, and energy commodity sectors. Our focuses include Commodity Business Education, Applied Commodity Research, and Commodity-Related Public Forums & Discourse.

Undergraduate & Graduate Specializations in Commodities

Our commodity classes cover the dynamics of the physical commodity markets, supply chains, data analytics & forecasting, risk management and trading.

4 Courses – 12 Credit Hours – Evening Courses
2 Courses in Fall Term, 2 Courses in Spring Term

Professional Education Opportunities

We are offering 2, four-week online data analytics courses for commodity professionals.

June 17 – July 17, 2020 Energy & Commodity Analytics for Analysts
June 25 – July 25, 2020 Energy Analytics & Big Data for Managers

Commodity Research

In addition to the *GCARD*, the JPMCC sponsors an annual Commodities Research Symposium where global commodity thought leaders and prominent stakeholders from both academia and industry convene to discuss critical thinking and new research related to commodities.

Upcoming Webinars & Recorded Sessions

Follow us on LinkedIn and our Website for information.

Contact Enrico Leone for more information or to schedule a visit to the Business School.
Enrico.Leone@ucdenver.edu; 303-315-8026

Professional Education

Sponsored by a Collaboration of CU Denver Business School's Global Energy Management (GEM) program and the J.P. Morgan Center for Commodities (JPMCC)

Energy and Commodity Analytics for Analysts

This 4-week, online course for analysts and technical professionals will take a deep dive into energy and commodities analytics. Designed for those who want to learn best practices around commodity data analytics, visualization, and forecasting, the course offers hands-on projects and real-world data. You will learn commodity data analysis utilizing EViews, an industry-leading data management and analysis software.

Schedule and Curriculum

The next course begins June 17 (four weeks).

The curriculum for the course spans complex topics including data transformation and visualization, regression analysis, model estimation (including vector autoregression and error-correction) and forecasting across the broad commodity sector. This program is offered every Summer and Fall.

- Introduction to data analysis and EViews "bootcamp"
- Applied introduction to time-series modeling and forecasting
- Case studies and real-world applications for data analysis

About the Instructor

Daniel Jerrett, Ph.D., has more than 15 years of experience developing and implementing forecasting models, spanning both the private and public sectors. He has spent time in the investment management industry, state, and local governments as well as consulting with Fortune 500 companies.

Dr. Jerrett continues to be active in academia and teaches courses in econometrics and forecasting at the University of Colorado Denver's J.P. Morgan Commodities Center.

How to Apply

Admission is open to all applicants, with no prerequisites to register. A fundamental knowledge of business statistics and strong quantitative skills are highly recommended.

Discounts apply for professionals participating in both the Energy and Commodity Analytics for Analysts and Energy Analytics and Big Data for Managers certificates.

For any questions about registration, please contact Michele Cooper, *Associate Director of Student Success and Analytics* for the Global Energy Management Program, at michele.cooper@ucdenver.edu or 303-315-8066.

For more information visit: business.ucdenver.edu/analysts-energy-analytics

Professional Education

Sponsored by a Collaboration of CU Denver Business School's Global Energy Management (GEM) program and the J.P. Morgan Center for Commodities (JPMCC)

Energy Analytics and Big Data for Managers

This 4-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.

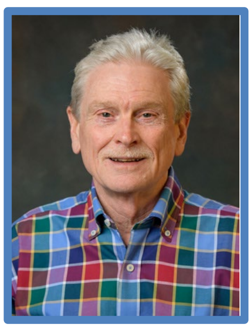
Schedule and Curriculum

The next course begins June 25 (4 weeks).

This program will offer an overview of Big Data and energy analytics, including the roles of management, and demonstrate the link to corporate performance indicators and operational efficiency. This program is offered every Summer and Fall.

Course topics include:

- Introduction to Big Data
- Data is the new currency
- Prediction and predictive analytics
- Industry case studies in energy and commodities



About the Instructor

Tim Coburn, Ph.D., has a career that intersects various aspects of the energy industry, including oil and gas, renewables, coal, transportation, electricity, infrastructure, and human factors. In addition to his extensive research in energy analytics, Dr. Coburn has worked for Phillips Petroleum, Marathon Oil Company, and the National Renewable Energy Laboratory. Dr. Coburn has held professorship roles at numerous universities and is an instructor for CU Denver's Masters in Global Energy Management.

How to Apply

Admission is open to all applicants, with no prerequisites to register. A fundamental knowledge of business statistics and strong quantitative skills are highly recommended.

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For any questions about registration, please contact Michele Cooper, *Associate Director of Student Success and Analytics* for the Global Energy Management Program, at michele.cooper@ucdenver.edu or 303-315-8066.

For more information visit: business.ucdenver.edu/managers-energy-analytics

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

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

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

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

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

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

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

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

The *GCARD* was originally conceptualized by Dr. Ajeyo Banerjee, Ph.D., CMA, Associate Professor of Finance and Risk Management, and Director of the Risk Management and Insurance Program at the University of Colorado Denver Business School.

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.

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

Interview with the Executive Director of the JPMCC

In this issue of the *GCARD*, we are delighted to interview the JPMCC's new Executive Director, Dr. Thomas Brady. Dr. Brady discusses how he became involved in the commodity markets and what his goals are for the JPMCC. Prior to joining the JPMCC, Dr. Brady was the Chief Economist at Newmont Mining.

Research Director Report

In this brief report, Dr. Jian Yang, the JPMCC's Research Director, provides updates on the JPMCC's research activities through the spring of 2020. In particular, Dr. Yang discusses the publication of an innovative study on crude oil and notes the continued impact of the 2019 symposium.

Advisory Council

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

Research Council

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

Editorial Advisory Board

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

Research Council Corner

This paper is the second in a two-part series. In part 1, which appeared in the Winter 2019 edition of the *GCARD*, the authors examined different liquidity measures and considered their relevance to the natural gas markets. In the current paper, the authors review unique features of the U.S. natural gas market and how price formation occurs for various types of natural gas products.

JPMCC Symposium Presentations

This article investigates how the size of price differentials between different grades of crude oil have changed over time. The paper shows that these price differentials have generally become smaller. In particular, the paper documents that many of them experienced a major structural break in or around 2008, after which there was a marked reduction in their means and volatilities. A growing ability of the global
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JPMCC Symposium Presentations
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Research Digest Articles

The following research digest articles were contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics, Cass Business School, City, University of London, U.K. and Member of the GCARD's Editorial Advisory Board

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Interview with Dr. Thomas Brady, Ph.D.

Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School

Dr. Thomas Brady, Ph.D., Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School.

In this issue of the *GCARD* we are very pleased to interview Dr. Thomas Brady who was named as the JPMCC's Executive Director in September 2019. Dr. Brady was previously the Chief Economist at Newmont Mining Corporation and has been a long-time supporter of the JPMCC, having served on the JPMCC's Advisory Council and Research Council as well as serving on the *GCARD*'s Editorial Advisory Board. In this interview, Dr. Brady discusses how he became involved in the commodity markets and what his goals are for the JPMCC.

Interview with Dr. Thomas Brady

Prior to becoming the Executive Director of the JPMCC, you served on the Advisory Council, Research Council and Editorial Advisory Board of the GCARD. What initially prompted your involvement with the JPMCC?

I was very intrigued by the broad commodity scope of the JPMCC when it was launched in 2012, offering education, research and public policy across the agriculture, energy, and mining-related commodity sectors. While I was employed with Newmont Mining, I very much enjoyed connecting with fellow industry Advisory and Research Council members; listening to ideas and issues shared from their particular industries or research focus and how I could potentially apply these to my job in mining. During my years in industry, I envisioned eventually getting involved with an academic institution following this part of my career. So far, being with the JPMCC has been great. In particular, I am appreciating the opportunity to understand the wider commodity space (previously I was focused on precious metals, oil and FX rates.) In addition, with the Center's two tenured business school faculty members, Jian Yang and Yosef Bonaparte, and myself from industry, we can truly move the center forward, addressing both applied and theoretical viewpoints for commodities.

How did you first get started in the commodity markets?

My first full-time position after I graduated with undergraduate degrees from Regis University was as a statistician. At that time, I enrolled in a commodity project investment class which focused on cash flow modeling, discounting and other financial valuation methods. This really opened up my eyes and I remember thinking, "… I would like to work for a company related to this sector someday …" After this, I decided to pursue a Ph.D. in Mineral Economics at the Colorado School of Mines, which I still consider one of the best career moves I have made. A few years later, as I was nearing the completion of my dissertation, I very much wanted to work for a large, global commodity-related company. Initially, I had a post-doc assignment with J.P. Morgan's commodity research team in New York. It was a tough decision to leave that opportunity. However, I ultimately accepted a full-time position in corporate development with Newmont Mining. Over 2 separate stints of employment, I stayed with the company for nearly 15 years with roles in financial risk management, strategic planning, investor relations and ultimately as the firm's chief economist. Working in commodities has and continues to be a great choice for me, every day brings new challenges, a global perspective and there is always something to learn. With the JPMCC, I want to open up these types of opportunities to our students.

You have held various roles including in financial risk management and strategic planning. How can you apply your past experiences as Executive Director of the JPMCC?

My career in industry has been centered in quantitative finance (so I am admittedly biased here.) In my opinion, anyone seeking a career in commodities (and/or overall business for that matter) needs to have a basic understanding of and be comfortable in applying quantitative methods. Analyst positions on corporate development, business planning and strategy teams, at a minimum, require strong financial modeling abilities, coupled with a good understanding of underlying financial market fundamentals. Those seeking positions with treasury and trading/risk management groups need to have a thorough understanding of financial derivative instruments, their underlying value drivers and risks as well as trading market fundamentals. I increasingly see how technology is shifting, and I recommend supplemental skills that enhance the ability to collect and work with large data sets, such as Python and/or R programming. Overall, these quantitative and technology skills have broad applicability across the broad commodity sector. With my past experience, I understand the many needs from industry and seek to align the Center towards these.

What are your goals for the JPMCC? What impact can the JPMCC have on the commodity industry?

My goals for JPMCC are three-fold concerning: undergraduate, graduate and professional commodity education; applied commodity research, and public education concerning commodities.

- For undergraduate, graduate and professional education, my goal is for students coming out of the Center to have a solid understanding of the commodity markets (from production, through supply chains and ultimately to the trading floor.) I want these folks to be very well prepared for interesting and challenging careers throughout the commodity sector. Over the coming year, I would like the Center to significantly increase enrollment and expand our course offerings. Of note, we will be offering two, four-week professional education classes in commodity data analytics. I also would like us to offer a commodity market fundamentals & trading class in 2021.

- Both the *GCARD* publication and our annual research symposium have proven effective in providing applied commodity research and bridging the gap between academia and industry professionals. While we have seen significant increases in interest in the *GCARD* and participation with the symposium, a key goal for both of these is to expand the audience. In addition, we need to secure additional sponsorship for the *GCARD* to ensure the continuation of this publication going forward.

- Commodity-related public education is an area where the Center has yet to establish a much needed and solid foundation. In my view the Center needs to provide a nonpartisan virtual and physical location where critical commodity-related issues may be presented, discussed and debated. As an example, an issue that continues to arise here in Colorado, nationally and around the globe is, "…what is a realistic energy mix for the future…?" I believe there are too many faulty expectations out there and the Center needs to bring light to these. We will be looking to sponsor in-person sessions and online webinars over the coming months.

Overall, these goals aim to provide industry with current and future employees that possess the necessary skills to hit the ground running, by adding immediate value. Bridging the gap between industry and academia, the J.P. Morgan Center for Commodities seeks to provide practical commodity-related research, addressing business needs. Public opinion and policy are critical drivers across the commodity sector and the Center strives to ensure these are informed through proper discussion and debate.

What trends do you see in the natural resources markets and how do you plan to incorporate these trends in courses offered by the JPMCC?

Commodity markets and prices are inherently volatile, resulting in boom and bust cycles for producers, through suppliers and into financial institutions. From my experience, the majority of commodity-related firms have demonstrated a lack of ability to maintain operating discipline gained through down cycles when prices improve. This leads to aggressive hiring when prices trend up and painful personnel reductions when prices decline. In my view, one way to mitigate the downside of the prevalent hiring and firing cycles is to have education across the broad energy, agricultural and mining commodity sectors, accompanied with applicable quantitative and technology skills. This offers the flexibility for individuals to gain employment in other segments and add value very quickly. Our goal with education at the Center is to enhance student's employment opportunities across all commodities.

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 future." What other initiatives are in place to carry out the research mission?

An area that I continue to find fascinating is the misalignment between academic institutions (particularly business and economic departments) and industry. In the end, this is driven by differing incentives. Over the last four years, however, it has been heartening to be involved with the JPMCC's annual commodity research symposium, with wide participation from both commodity related academics as well as industry practitioners. This conference continues to grow in reputation and participation across the commodity sector and we will be seeking to expand its influence. Likewise, the *GCARD* is fulfilling a much-needed niche in supplying relatively easy to digest, applied research across commodities for industry practitioners. During my stint as Newmont's economist, I appreciated being able to quickly read a *GCARD* article, on oil prices for example, then reflecting on the potential applicability to precious metals. Over the nearer term, I would like the Center to hold "Commodity Conversations" where we host in-person and/or virtual seminars, presentations and panel discussions to pull in both academic and industry experts to discuss key current topics and market outlooks.

Biography

THOMAS BRADY, Ph.D.
Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School

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

Dr. Brady holds a Ph.D. in Mineral Economics with research emphases in commodity markets from the Colorado School of Mines. In addition, Dr. Brady holds a Master's degree in Mathematics, also from the Colorado School of Mines.

Dr. Brady previously authored three applied research articles for the *GCARD*. He contributed to the Spring 2016 issue of the *GCARD* on "The Distribution of Economic Benefits from Mining"; the Winter 2017 issue where he discussed, "Global Gold Mine Supply"; and he also authored an article for the Winter 2019 issue on the "Practical Considerations for Commodity Investment Analysis".

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, presented his keynote speech at the 2019 "International Conference on Derivatives Market and Risk Management" in Shanghai, China. This conference was organized by Tongji University, the University of Colorado Denver/JPMCC, and the World Bank.

In this brief report, the J.P. Morgan Center for Commodities' (JPMCC's) Research Director will provide updates on the JPMCC's research activities through March 2020 and which have taken place since the August 2019 international commodities symposium. We are happy to (a) announce the publication of an innovative study on crude oil; and (b) report on the continued impact of the 2019 symposium.

Publishing the First Study Covering All Top Four Crude Oil Futures Markets

The research paper, "Return and Volatility Transmission Between China's and International Crude Oil Futures Markets: A First Look," coauthored by the JPMCC's Research Director and forthcoming in the *Journal of Futures Markets (JFM)*, is already published online and is expected to be formally published around June 2020 (Yang and Zhou, 2020). The *JFM* is a leading finance journal on futures and derivatives. Based on the preliminary results in this article, the Research Director delivered a keynote speech at the Workshop on the Chinese Oil Futures and Energy Markets at Xiamen University in June 2018. This speech, in turn, was extensively featured in Chinese by *Economic Daily* (of the State Council of China), *China National Radio*, and *Financial News* (of the People's Bank of China). In addition, some of these media articles were reposted on the official websites of China's *Ministry of Commerce, National Energy Administration*, and SINOPEC, the latter of which is China's largest state-owned oil & gas company and which also ranks as the third largest company in the world in 2018, based on the *Fortune* Global 100 list.

In July 2019, the Research Director delivered another keynote speech, also partly based on the forthcoming *JFM* paper, at the "International Conference on Derivatives Markets and Risk Management" in Shanghai, China. This symposium was co-organized by Tongji University in Shanghai; the University of Colorado Denver/JPMCC; and the World Bank. An analysis of the Research Director's coauthored paper was also featured in the English media publication, *Yicai Global*, after this international conference.

After the *JFM* paper was published online, some additional findings of the article were again featured by *Economic Daily* (of the State Council of China), *Financial News* (of the People's Bank of China) and *International Financial News* (of People's Daily Online) around the time of the two-year anniversary of China's crude oil futures market in late March 2020. As of March 2020, the number of media articles featuring the JPMCC via the Research Director had reached over 90.

The 2020 *JFM* publication may be considered "the first study" in several different contexts:

1. This paper is the first academic journal article published with a JPMCC affiliation (based on the date of publishing online) since the launch of JPMCC in 2012. Earlier, a study published in 2018 on the U.S. crude oil futures and options markets (Miao *et al.*, 2018), and also coauthored by the Research Director, was the first academic/policy research presentation with a JPMCC affiliation. The Research Director had presented this earlier study at the U.S. Energy Information Administration (EIA) in 2017, as was noted in the Winter 2018 issue of the *GCARD*'s section on the EIA's "Dynamics of Oil, Natural Gas, and Liquefied Natural Gas Markets" workshop (p. 111).

2. In addition, the forthcoming *JFM* publication is the first study examining the international linkages between major international oil futures markets and the growing crude oil futures market in China. This is the first futures market in China which allows international investor participation.

3. And lastly, this is the first study that covers all four top crude oil futures markets (WTI, Brent, INE and Oman), encompassing both light sweet and medium sour crude as underlying assets. Amongst the study's findings are that (a) "Chinese oil futures have stronger linkages with the international major futures markets than Oman futures"; (b) "[b]oth China's and Oman's oil futures markets react to deviations from their long-run equilibrium with West Texas Intermediate and Brent oil futures"; and (c) "[t]here is … new evidence for asymmetric volatilities and correlations across these oil futures markets."

The Continuing Impact of the August 2019 International Commodities Symposium

As discussed in the *GCARD*'s Research Director Report in the Winter 2019 issue, the August 2019 international commodities symposium included submissions from researchers in thirteen countries, and we were honored with the attendance of researchers from eleven major countries.

We are happy to report on the continuing positive impact of the 2019 symposium. The October 2019 issue of *China Futures* magazine published a lengthy article featuring many of the speakers at the 2019 JPMCC symposium, which followed the magazine's recognition of the 2018 JPMCC symposium in its October 2018 issue. *China Futures* magazine included the symposium amongst its news items from major global futures and options exchanges and national derivatives regulators worldwide.

In addition, the news story on the symposium by Robinson (2019) was posted on the CME Group Foundation's website. The CME Group Foundation, in turn, was the seed sponsor of the JPMCC's initial international commodities symposium.

The *Journal of Futures Markets* will publish a special issue in August 2020 that will feature four high-quality articles presented at the 2019 symposium. The selected articles are coauthored by chair professors or senior professors from MIT, University of Texas at Austin, University of Houston, and from a senior economist at the Bank of Canada. Like the special issue published in August 2019 for the 2018 symposium, the Editor's note to the special issue will again highlight JPMCC (and its Research Director as the organizer) and the University of Colorado Denver Business School.


CME GROUP FOUNDATION

NEWS

3rd Annual JPMCC International Commodities Symposium brings academic and industry leaders together

August 27, 2019

The New Directions in Commodities Research international symposium returned to the CU Denver Business School on August 12-13, 2019. Led by the J.P. Morgan Center for Commodities, the symposium brought more than 140 academic researchers and industry practitioners from around the world to discuss current challenges and advancements in commodities research. For many of those in attendance, the most valuable part of the conference was sharing research and ideas between academics and industry professionals.

Source: Excerpted from the CME Group Foundation's website.

Dr. K. Geert Rouwenhurst, Ph.D., (left) Robert B. and Candice J. Haas Professor of Corporate Finance, Yale School of Management and JPMCC Distinguished Visiting Fellow, in discussion with **Dr. Sheridan Titman**, Ph.D., (right), a past President and Fellow of the American Finance Association and Professor of Finance at the University of Texas at Austin where he holds the McAllister Centennial Chair in Financial Services at the McCombs School of Business. Professor Rouwenhurst gave a keynote address at the 2019 JPMCC symposium on "The Commodity Risk Premium: 1870-2019."

Conclusion

We are very grateful for so many of the world's renowned academics in the field of commodities linking up with our efforts, either as members of the JPMCC's Research Council or as presenters at our conferences. In addition, we would like to note that *GCARD* readers can stay informed on the JPMCC's many research activities by visiting:

https://business.ucdenver.edu/commodities/jp-morgan-center-commodities-research.

We wish everyone a healthy and safe summer!

Best Regards,

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

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

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Introduction

This paper is the second in a two-part series. In part 1, which appeared in the Winter 2019 edition of the *GCARD*, we examined different liquidity measures and considered their relevance to the natural gas markets.

In the current paper, we review unique features of the U.S. natural gas market and how price formation occurs for the various types of natural gas products traded. Natural gas demand is highly sensitive to weather conditions, and market prices can fluctuate widely from day to day and from location to location. This means that gas traders turn over a new leaf every day and have to go through the process of price discovery every morning with the previous day's prices being often of limited usefulness in the determination of prices for the current day. Price discovery on the Intercontinental Exchange (ICE) platform is instantaneous through the interaction of bids and offers posted by traders. The process of price formation is squeezed into a relatively narrow window of a few hours and has to be completed before the deadline for pipeline nominations with most of the volumes being committed by 1 p.m. Central.[1] The market has no designated central price maker with many market participants operating both as providers and consumers of liquidity, depending on market conditions and location. There is always a potential for liquidity providers to abandon the market or become liquidity consumers: this is especially true of financial companies who do not have firm supply commitments and are often opportunistic players. The use of price indexes is also an important feature of the industry as they are used to establish hub prices and price risk-management products. However, since 2003 index-priced transactions have been increasing as a portion of overall transactions reported in FERC's Form 552[2] at the same time that the share of fixed-priced transactions used to compile the indexes has been steadily declining.

We next discuss assessing liquidity in the U.S. natural gas market. Data limitations restrict the measurement of liquidity because access to intraday prices and transaction volumes is only on ICE and the Chicago Mercantile Exchange (CME). Only aggregate information is available on the trades underlying the indexes calculated by the Price Reporting Agencies (PRAs). Over-the-Counter (OTC) transactions are only reported with a delay and on an aggregated basis as well. Furthermore, the U.S. gas market is fragmented by trading venue and geography. Different trading venues coexist for the same class of assets with each having different levels of transparency, price formation and discovery processes. There is unequal access to available information for different members of the trading community and the public at large. At the same time gas markets often become fragmented during times of supply or demand shocks, which create pipeline constraints that in turn limit the geographic scope of the market. Nonetheless, ICE price data still serves as an important barometer of the U.S. natural gas market and is useful in estimating various liquidity measures.

This task of following liquidity trends in the U.S. market has become particularly important in the aftermath of the shale revolution, shifting spatial production patterns and changing market conditions at different market hubs. Market liquidity is changing as new production areas and infrastructure come online, linking the new shale natural gas plays to market hubs and new Liquefied Natural Gas (LNG) export terminals. U.S. shale production is expected to maintain considerable growth to satisfy growing LNG and Mexican exports as well as the continued increase in domestic gas-fired electric generation. Using ICE price data to estimate liquidity trends by hub will help us to assess efficiency of the U.S. natural gas market and to identify locations that may be more prone to manipulation.

U.S. Natural Gas Market Structure

Overview

The U.S. natural gas markets have many unique features that are a result of historical developments and cross pollination between the energy and financial markets. The most important features include:

- Natural gas is traded actively at many locations, referred to as market hubs, the intersections of multiple intra- and inter-state pipelines, and interfaces of the pipelines with the local distribution systems.

- Natural gas markets are based both on physical (i.e., involving physical delivery) and purely financial (cash-settled) transactions. Settlements of financial transactions are based on publicly available price benchmarks of natural gas in physical and/or other financial markets.

- In the past, physical markets were organized around monthly transactions for baseload gas, delivered at roughly equal quantities over the course of a calendar month. The prices of baseload gas at specific locations are referred to as monthly indexes. Monthly markets are still very important, but the importance of daily markets is increasing.

- The development of the natural gas industry led to the emergence of short-term markets for gas flowing over the next day. Increasingly, we can see frequent transactions for natural gas traded intraday, with pipelines offering multiple nomination cycles (up to four per day or even at hourly frequency.)

- Another unique feature of the North American natural gas market is the use of a central pricing benchmark, the natural gas futures contract with delivery at Henry Hub, Erath, Louisiana. Natural gas at other locations can be priced by adding the so-called basis to the NYMEX futures price. The basis represents the differential between the index (i.e., locational price) and the NYMEX contract price.

- The locational basis in the U.S. and Canadian natural gas markets is traded, for most locations, as a standalone contract. This creates a unique triangular relationship between three types of prices: the NYMEX futures contract price, the locational index and the basis. One can replicate an index position by entering simultaneously into a NYMEX position and a basis position. One can also enter directly into an index transaction and a NYMEX transaction, implicitly assuming a basis position.

The U.S. is becoming increasingly dependent on electricity generated from gas-fired power plants. Interactions between natural gas and electricity, as well as transactions referencing prices of these two commodities, create unique price dynamics, which favor traders present in and familiar with both markets. Different power pools are increasingly using gas indexes in their tariffs. For example, the growth of the Energy Imbalance Markets in the western United States is one area where natural gas indexes are used to set reference prices for electricity transactions. U.S. natural gas prices have also evolved into important international benchmarks with liquefied natural gas exported from the U.S. often being indexed to domestic prices. It is conceivable that Henry Hub (the delivery point for the CME futures) could become the central reference point for the integrated global gas market.

The U.S. natural gas market acquired its current form in the 1990s as a system based on related physical and financial products with unique price formation and discovery features. The critical components of this system include:

1. The natural gas NYMEX futures contract;

2. Interconnected natural gas market hubs with location-specific daily and monthly prices for physical contracts;

3. A system of financial forward, swap and option contracts that are both OTC and exchange traded; and

4. Long-term physical transactions based on different pricing schemes.

The NYMEX[3] natural gas futures contract was launched in April 1990 and became one of the most successful derivatives instruments in the history of the commodity markets. It is used as a critical benchmark for pricing natural gas related transactions in the U.S., including many OTC and exchange traded derivatives with the potential for becoming an international reference price, given its growing use for structuring long-term LNG contracts.[4] The delivery point for the contract is at Henry Hub in Erath, Louisiana, an intersection of several pipelines with vast storage capacity available in the area. This location was a logical choice in 1990 as Texas and Louisiana were the most important U.S. supply areas. The shale revolution shifted the industry's center of gravity from the South and the Southwest to the Northeast with the Marcellus in Pennsylvania being the fastest growing production region in the U.S. Some market participants expressed an opinion that the U.S. market would need either another central pricing benchmark or multiple benchmarks, given the evolution of natural gas spatial production patterns. Many industry practitioners believe that the use of multiple price benchmarks is imperative from the point of view of risk management. This is one of the critical issues for this market, and we are signaling this to the reader.

Classification of Transactions

Transactions in the U.S. physical natural gas markets can be classified using multiple criteria such as:

- Tenor;
- Mode of execution;
- Design; and
- Price formation process.

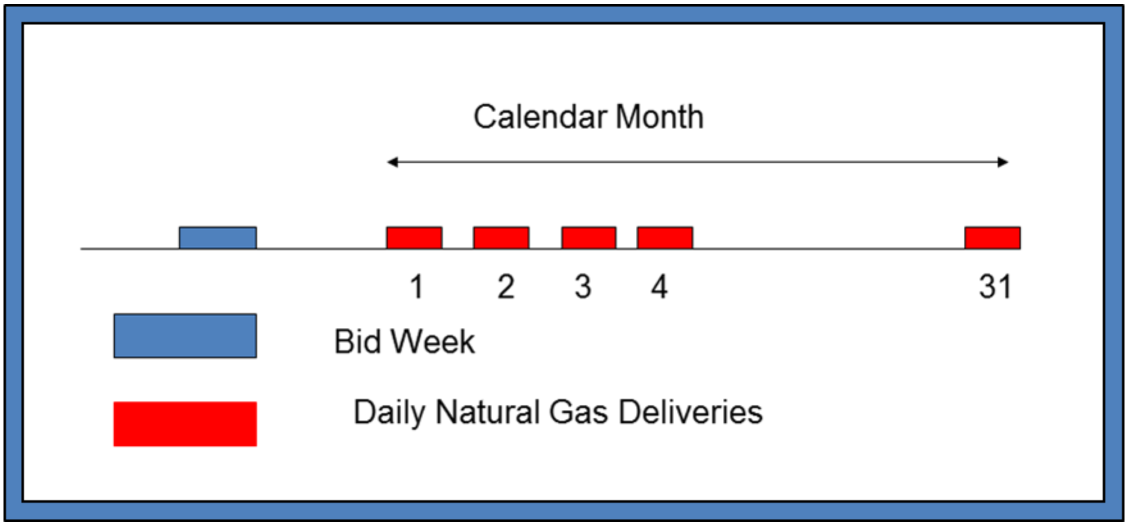
Classification of Transactions by Tenor

The tenors of physical natural gas transactions range from less than a day to many years; in some rare cases the time horizon may be as long as 20 to 30 years. Intraday transactions represent adjustment trades executed in order to address unexpected imbalances due to infrastructure outages, unexpected extreme weather events or pipeline scheduling mistakes. Day-ahead transactions, executed in the morning of a gas day, are for natural gas flowing during the next day (or on Saturday through Monday in the case of Friday trades.) The day-ahead transactions are mostly squeezed into a narrow window of time between 8:00 and 11:00 a.m. Central Prevailing Time, ahead of the pipeline nomination schedules. Some transactions may be executed later during the gas day.[5]

The natural gas markets in the U.S. were historically organized around monthly transactions for baseload gas delivered ratably over the course of a calendar month. The transactions were negotiated during a period of five days close to the end of the calendar month preceding the delivery month, known as the "Bid Week." For a long time, the volumetric adjustments over the period of the month would be accomplished by over-drawing or under-drawing natural gas from a pipeline on a daily basis as the flows were usually balanced over the monthly time period. The Local Distribution Companies (LDCs) have a strong preference for this strategy and their risk-managing decisions drive the gas market activity during the shoulder periods as they prepare to meet summer and winter demand in a cost-efficient way (particularly the latter.) Today, the volumetric adjustments happen through intramonth transactions, for the next day delivery, or for the balance of the month. Figure 1 on the next page illustrates the monthly transactions schematically. The monthly market developed around the market hubs, usually located at the intersection of multiple pipelines or at the points of interface between the pipelines and local distribution systems (the so-called city gate hubs.)

An example will help to explain the mechanics of this market. One of the most important market hubs in the U.S. natural gas industry is the Houston Ship Channel (HSC), a location with access to many intra- and interstate pipelines that supply one of the biggest clusters of chemical plants in the world and move natural gas from production areas to other parts of the U.S. Transactions for baseload natural gas at HSC and other hubs happen during the period of a few days around the NYMEX futures contract expiration dates, traditionally called Bid Week.[6] The Bid Week transactions can take place over-the-counter or on electronic trading platforms such as on the ICE platform.

Figure 1
Monthly Baseload Natural Gas Transactions



Transactions with longer tenors than one month are based on long-term contracts that range from fairly standardized agreements to highly complex structures which are a product of time-consuming negotiations involving teams of traders, structurers and lawyers.[7]

Mode of Execution

Physical natural gas transactions can be executed on an exchange or transacted bilaterally either with the assistance of brokers or directly between two counterparties who have a long term-business relationship based on mutual trust and access to the same transportation and storage infrastructure. The most important next day exchange-traded contract is hosted by the Intercontinental Exchange and is screen based. The definition of a next day contract is somewhat flexible, given intervening holiday schedules. Levitan & Associates (2018) documented the definition of a next day contract as follows:

> "The standard Next Day product is for a constant rate of delivery over its term, and the term is often longer than one day because trading is only done on non-holiday weekdays and multi-day deliveries across calendar months are split into separate sessions in order for the sum of Next Day terms within a month to be identical to its monthly product. These Next Day product definition and trading rules reduce spot market trading opportunities in any of three ways:
>
> - Regular Friday trading is for a three-day block (Saturday, Sunday, Monday) with typically higher demand on Monday than on the weekend days.
>
> - Before holidays, when the Next Day gas markets on NYMEX and ICE are closed, the Next Day product delivery term is extended for at least one more day. For example, trading on the day before Thanksgiving is for a five-day product (Thursday through Monday.)

- Whenever a multi-day delivery term would otherwise cross a calendar month boundary, the last day(s) of the current month are traded two days before the start of delivery and the first day(s) of the next month are traded on the last trading day of the current month."

Transactions executed through brokers and directly among the counterparties dominate the volume of ICE-based transactions. Unfortunately, the information about these transactions is only available in a highly aggregated form once a year from a FERC-mandated report that in turn is discussed below.

Price Discovery

Price discovery on the ICE platform is instantaneous and is arrived at through the interaction of bids and offers posted by traders representing different entities approved for trading on the platform. There is no single entity that operates as a designated market maker, and different traders can switch from operating as market makers (posting bid and/or offer prices to set the market) to behaving as passive price takers.

Currently in the U.S., information about bilateral transactions is incomplete and based on voluntary submissions of trade data to the PRAs, which in turn are referred to in the industry jargon as newsletters. PRAs collect information about the transactions, including volumes and agreed-upon prices to calculate quantity-weighted price indexes. The day-ahead price indexes are published Monday through Friday with Friday transaction prices used for gas flowing on weekends and Monday. The monthly indexes are published on the first business day of a calendar month. The difference between the index price and the settlement price of the NYMEX expiring contract for the same calendar delivery month is known as the "realized basis." Twelve specific basis numbers are calculated during the course of the year for a given location for which a published index is available. The basis may be either positive or negative, depending on the relationship between the prices of natural gas at a given place and the NYMEX contract price. As a rule of thumb, locations east and north of Henry Hub were historically associated with a positive basis, and locations to the west were associated with a negative basis.[8]

Most energy traders use price indexes calculated and published by the publication known as *Inside FERC Gas Market Report*. The price index published by this newsletter is referred to as an IFERC index.

The monthly price indexes for natural gas are calculated in two different ways using fixed price transactions or physical basis transactions. Fixed price transactions are very straightforward: for example, the buyer commits to pay $4.5 per million British Thermal Units (MMBTU) for baseload natural gas delivered over the next month at a given location. Physical basis is negotiated as a fixed difference in price, or price differential, to NYMEX before the final settlement price of the NYMEX is known; once the NYMEX price settles on the contract expiration day, the negotiated differential is added to the NYMEX price, and the total determines the price of natural gas at the specific location. In other words, after the NYMEX contract settles, the transaction mutates from floating to fixed, and the monthly price crystallizes.

Pricing

Pricing in the U.S. natural gas markets can be based on the following rules:

- Outright (flat price);
- Floating price; and
- Formulaic price.

Outright prices are used mostly in the day-ahead and month-ahead transactions and are the most straightforward. An example would be a physical transaction for delivery of 10,000 MMBTUs of natural gas at Houston Ship Channel on Wednesday, January 2, 2019. The outright prices are important because they are used by PRAs in calculation of price indexes explained below.

Floating price transactions (referred to in the industry as index deals) are based on published price indexes that the counterparties agree to accept. The published index may be adjusted by a negotiated differential, reflecting modifications of delivery conditions, variability in volumes, or other options embedded in the contract.

Formulaic prices are used in long-term transactions and typically reflect the need to protect the interest of both parties against future adverse market developments. The provisions may include indexation to prices of other commodities (for example, electricity), the use of moving window averages of historical prices as a reference, or the right to exit or renegotiate the contract under certain circumstances.

The Importance of Index Prices

The importance of the index prices for the natural gas industry is difficult to overstate. Many market participants use the monthly prices for the so-called index transactions that are effectively floating price deals with natural gas delivered over long time periods at prices determined during Bid Week and calculated by the index publishers. Such transactions are typically priced at index, adjusted by the so-called premium, a differential contained typically in the range of (-2, 2) cents. In many markets, the producers receive prices equal to an agreed percentage of a specified index. The index prices are also used in financial swaps and the so-called basis swaps, which are explained below. There are many different justifications for a premium to an index in a floating price transaction:

- The premium may be charged to cover transaction costs and the profit margin of a marketer and is equivalent to a bid / offer spread;

- The producers often want to maximize market share and are willing to sell gas at a small discount to the index in order to attract customers; and

- Sometimes natural gas is delivered not at the hub location but at a meter at some distance from the market and the premium captures the physical delivery cost differential, i.e., the extra transportations cost.

Insights into the role of price indexes in the U.S. natural gas markets can be obtained from the data collected by FERC on Form 552, “Annual Report of Natural Gas Transactions.” The submissions on this form, following FERC Order 704 (December 26, 2007), apply to market participants that sell or purchase 2.2 million MMBTU or more of natural gas annually. This is approximately the amount of gas used by a 90-MW peaker power plant running every day for 9 hours. It is obvious that this form does not capture all transactions, but it still provides a good snapshot for the bulk of trades.

Daily physical transactions take place every morning for next day delivery[9] at many trading hubs. The daily transaction prices are reported to the *Gas Daily* publication and become available on the day of the transaction when the newsletter is distributed electronically to the subscribers, usually between 5 and 6 p.m. Central Time. The publication uses fixed price transactions in calculation of the volume weighted indexes. It is important to remember that the reported prices may be identified by the transaction date or the flow date. Ignoring this obvious distinction leads in practice to many costly snafus.

Liquidity in the U.S. Natural Gas Markets

The features of the U.S. physical natural gas markets summarized above explain why measurement of its liquidity is a challenging task, irrespective of which measure discussed in part 1 of this series of articles is used.

Data Limitations

Fragmentation of the U.S. physical natural gas market limits the amount of information available to the trading community. The levels of intraday prices and transaction volumes are available only for the Intercontinental Exchange. Information about the trades underlying the indexes calculated by the PRAs is incomplete and available only in an aggregated format. The information is incomplete because transaction reporting, as described above, is voluntary. Another issue is that the number of respondents and the reported volumes have been falling over the last few years. The reported transactions are used to calculate volume weighted average prices (with additional data regarding total reported volumes, price ranges and number of transactions also made available.) This information is insufficient to identify intraday liquidity trends and draw conclusions about the distribution of transaction volumes between different trading venues. Information about prices underlying long-term transactions is generally not available and can only be approximated relying on the industry grapevine or estimated from regulatory filings. Even if the long-term transaction prices were exactly known, the value of this information would be limited. The long-term contracts contain many embedded options (such as volume and delivery location flexibility and early termination clauses) and prices are subject to modification under different market conditions. An analyst would need detailed information about all such provisions and have the intellectual firepower and input data to value all the optionality.

Market Fragmentation

Market fragmentation can be defined as the coexistence of different trading venues for the same class of assets, characterized by different levels of transparency, price formation and discovery processes, unequal access to information available to different members of the trading community and the public at large, and often preferential treatment granted to some classes of market participants. In many cases, market fragmentation may be seen as a positive development under the following conditions:

- The range of choices available to the market participants is expanded;
- No market segment offers privileged treatment to some classes of traders;
- Information about different markets (such as volumes and prices) is widely available at a reasonable cost; and
- There exist market participants who specialize in arbitraging away price differentials between different markets.

In other words, fragmentation may be beneficial if different market segments do not form completely isolated silos, dominated by a few large players, with very limited, or no information at all, available to the rest of the market.

The U.S. and European financial markets in the last two decades have become more fragmented, which is a development that is often very troubling to many market participants, regulators and academics. The U.S. energy market is no different, and fragmentation is observed both geographically (across different market hubs) and across different trading venues. Geographical fragmentation is not a fixed feature of the markets but a condition which is dependent on the state of the physical transportation and storage infrastructure, which in turn varies with weather, and is subject to demand or supply shocks. Such conditions may be temporary or may last a few years and may result either in extremely high or depressed prices.

At some locations, weather or pipeline outages may isolate a given market hub (or a group of hubs) turning it into an island with no ability to deliver more natural gas or to move excess supplies to other market locations. The best-known example of a market where temporary shortages may produce extreme price spikes is Transco Zone 6 New York during winter months and the Algonquin hub. Pipeline maintenance may result in excess volumes of natural gas "looking for a home" with prices in the temporarily isolated area falling close to zero. Sometimes geographical fragmentation of natural gas markets may become a chronic condition. New England's natural gas market is one example. As explained in Lander (2015):[10]

> "New England's natural gas problem would most accurately be termed a '50 day on-peak deliverability problem. That is, for some portion of around 50 days per year the near-simultaneous and high demands of regional heating and natural gas for electric generation loads are not being met efficiently."

The Appalachian region is an opposite example: growing production from the Marcellus and Utica basins, combined with lagging pipeline expansion, resulted in a protracted period of depressed prices and reduced liquidity at some market hubs (Dominion South and Dominion North.)

The trading venues for physical natural gas are equally fragmented. The producers and end users of natural gas have the option of selling/acquiring gas in a number of ways:

- Physical trading of natural gas on ICE;
- Natural gas futures contract traded on the CME;[11]
- Brokered bilateral transactions;
- Bilateral transactions negotiated directly and often based on long-term relationships; and
- Long-term structured transactions.

A recent trend is the direct acquisition of natural gas reserves by utilities to satisfy their long-term needs at predictable costs and with reliability guarantees.

Transparency of different trading venues for natural gas varies from reasonably good to rather unsatisfactory. Information about market activity on ICE and CME is available to the trading community and market analysts though more detailed data may be obtained at a price.

Information about direct, bilateral markets is available with a delay in a highly aggregated report, the aforementioned FERC Form 552. Partial pricing information is available in a highly compressed form through price indexes published by PRAs such as *Platts* or *Argus*. The indexes are based on transactions reported to PRAs on a voluntary basis. Many market participants engage in the so-called index (floating price transactions) which reference price indexes published by PRAs or derived from transaction prices established on ICE or CME. As reported by Leonard and Moran (2017):

> "Since 2013, the index-priced transactions have comprised an increasing fraction of overall Form 552 transactions each year while the portion of transactions that have fixed prices has steadily declined. From 2012 to 2016, index price transactions increased from approximately 72 percent to 79 percent of all Form 552 transactions."

The share of fixed (outright) price transactions that underlie index prices has been shrinking and only a subset of these transactions is reported to the PRAs.

Given limited transparency of the market segment comprising direct bilateral transactions, one can pose a question whether any statements can be made with respect to this segment's liquidity. One option is to use the Amihud Index[12] based on *Gas Daily* prices that are reported by *Platts*. (*Argus* and *Natural Gas Intelligence* (*NGI*) also publish corresponding price indexes.)

The applicability of *Gas Daily* prices to the measurement of liquidity can be validated through a correlation analysis of ICE-based liquidity measures (a more transparent market) with the *Gas Daily*-based index. Table 1 on the next page shows correlation coefficients for selected hubs.

Table 1
Correlation between Amihud Indexes: *Platts Gas Daily* vs. ICE Next Day Index

Henry Hub	0.88263
Transco Zone 6 NY	0.87525
TETCOM3	0.78054
Katy Oasis	0.70439
PGE Citygate	0.8363
Transco85	0.94762
TCO	0.76408
Dominion South	0.93334
CG Mainline	0.88027

Note: Calculations based on daily prices, November 2013 through December 2017.

The correlation coefficients reported above may be affected by differences in the definition of different market hubs between ICE and *Platts* (namely, the specific pipeline zones and meters included in the definition of a hub) and the differences in market participant characteristics between traders on ICE and entities reporting to *Platts*. In our view, the results reported above provide limited support to extending conclusions based on the analysis of ICE transaction data to other segments of the natural gas market. ICE, being the most transparent U.S. platform for physical natural gas can be used as the proverbial "canary in the mine," a proxy for overall liquidity conditions in the U.S. physical natural gas markets. Unfortunately, this gauge tends to break down under extreme market conditions when trading migrates to the opaque regions of the market and transparency and full information are most needed.

<u>Liquidity Leakage</u>

One important aspect of liquidity patterns is the transfer of liquidity between different trading venues, depending on market conditions. One of the important trends in the commodity markets was the transformation of organized exchanges (such as CME) and electronic trading platforms (such as ICE), which were historically established as conduits between producers and end users and providers of risk management instruments. Over time, this role of exchanges has been overshadowed by another important function: price discovery for market participants who choose to trade away from the exchanges either by using OTC markets or relying on direct bilateral relationships. Futures contracts traded on the exchanges are mostly cash settled, but a very small percentage of the traded contracts is settled through physical delivery. In the U.S. natural gas markets, this trend is further amplified by special considerations related to reliability concerns and access to physical infrastructure. In the case of ICE, this manifests itself as leakage of liquidity from ICE to other trading venues.

Conversation with traders provided specific examples why and how this would happen. Physical traders often observe trading activity on ICE but prefer to execute large volume transactions away from ICE by contacting potential counterparties directly with whom they have long-term relationships based on mutual trust and who have access to the transportation/storage infrastructure and logistical apparatus to make delivery. In some cases, next-day gas prices are based on the average price of trades observed on ICE during a certain time window (for example, from 8:00 to 10:00 a.m. Central time.) The traders gave a different rationale for this way of trading, emphasizing the importance of reliability and trust in operational skills of a selected counterparty. Another important factor was the objective of avoiding market impacts of a transaction. As one trader explained, ICE is a very transparent market and the price action is closely watched by the trading community. A large transaction volume is likely to move the market to a significant degree. Another important factor is the desire to transact large volumes in one step. For example, a natural gas storage capacity owner does not want to rely on a large number of small volume transactions to make decisions regarding injection or withdrawal of natural gas. Another reason to transact directly is to simplify and streamline logistical operations and avoid overwhelming the back office with a large number of confirmations and invoices, and make physical operations and accounting more straightforward.

Liquidity leakage from ICE to direct bilateral transactions markets is most pronounced during periods of market stress, exactly when transparency becomes most important to market participants. The recent episodes of Polar Vortexes provide the best illustrations of such trends.

In the natural gas and electricity trading community, a polar vortex[13] is associated with periods of extreme market stress caused by abnormally cold winter temperatures in the Northeast and Midcontinent areas of the U.S. The demand shock results in extreme price spikes, potential shortages and elevated trading losses (or profits) for energy traders.

The cold weather spell of January 2018 and associated demand shock affected trading of natural gas on ICE, particularly at the locations where extreme weather conditions coincided with infrastructure constraints. One example comes from Transco Zone 6 (New York) on January 2, 2018 where trading was fairly typical for this time of the year with some symptoms of stress. The bid-offer spreads were initially posted at levels approaching $40 and stabilized around $1, once active trading started. On Wednesday, January 3, 2018, quoted bid-offer spreads continued at punitive levels, but some transactions were evidently executed within the bid-offer spreads. On Friday, January 5, 2018, only one transaction took place on ICE (for 7,500 MMBTUs.) The *Platts Gas Daily* index for the period Saturday – Monday, January 6 – 8, 2018, printed at $48.89/MMBTU, with 10 transactions and a volume of 17,000 MMBTUs, according to *Gas Daily* (2018). Such a small transaction size may be due to the need to obtain a price print by marketers who operate under long-term contracts, which reference ICE or *Gas Daily* prices. As the temperatures in New York City continued to decrease through the week, trading on Monday, January 8, 2018 came to a grinding halt.

When trading on ICE during the periods of extreme weather conditions comes to a halt, the exchange ceases to function as both a price discovery platform and as a link in the supply chain. Pipeline congestion makes it impossible to react to developing market shortages and market participants without access to physical infrastructure (such as transportation contracts and storage contracts) withdraw from the market. Market participants who have available supplies choose to hoard them as it is difficult to predict how long extreme conditions will last. The transactions that take place often happen at extreme prices when the pipelines announce Operational Flow Orders[14] under which imbalances are settled at punitive prices. Economic rationality leads market participants to trade up to the penalty level.

The liquidity leakage described above happens intraday and may become significant on certain days, especially during periods of extreme weather. More troubling is the liquidity leakage from active markets to passive transactions based on floating prices. As explained above, the so-called index deals are medium- and long-term transactions referencing an agreed-upon monthly or daily price index (as reported by *Platts*, *Argus* or *NGI*), adjusted by a negotiated differential. Migration to index deals happens at the expense of flat (outright) price transactions. This means that price discovery is impaired as fewer market participants collect and process information required to support active trading and a portion of supply and demand is removed from the public view. There are several factors explaining growing industry preference for index transactions: the common denominator is the U.S. shale revolution and its consequences.

On the buy side, the growing supply of natural gas suppressed prices and price volatility, which in turn reduced the appetite of end users for hedging transactions. Many local distribution companies were criticized for hedging their future supplies at elevated prices and passing the costs to the ratepayers. Buying natural gas in the forward markets under conditions of a contango[15] in the oversupplied market with chronically depressed spot prices is a prescription for incurring significant losses. Buying natural gas at floating prices through index transactions is a safe policy, shielding management from criticism by regulators and complaints by ratepayers.

On the sell side, the producers see index transactions as a way to reduce royalty payments to the lease holders.[16] Index prices are used to calculate the value of produced natural gas (as these are the prices received by producers), but if production flows are hedged in the forward markets the benefits from financial trading are not passed to the lessor. This treatment of hedging profits in calculating royalties is supported by the Federal courts (Sartain, 2013). As Cimarex Corporation argued in a commercial dispute case:

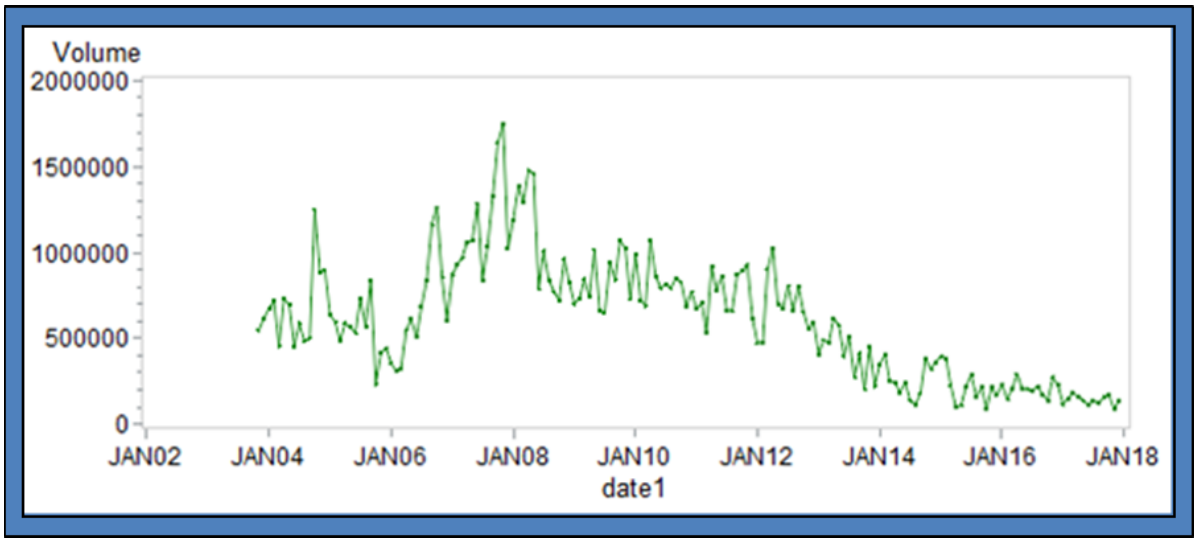
> "Louisiana law […] is equally clear that royalties are due on the market value of the natural gas or crude oil at the well, lease, or field, where it is produced. As a matter of Louisiana law, royalties are a share of the production itself, which entitle the lessor to a share of oil or gas where it is produced, free of the expense of drilling and production." (United States District Court, Western District of Louisiana, Lafayette Division, 2012)

The plaintiff in this case argued that he was entitled to profits from the separate hedging activity by the Cimarex. The court sided with the producer.

Market Liquidity Trends

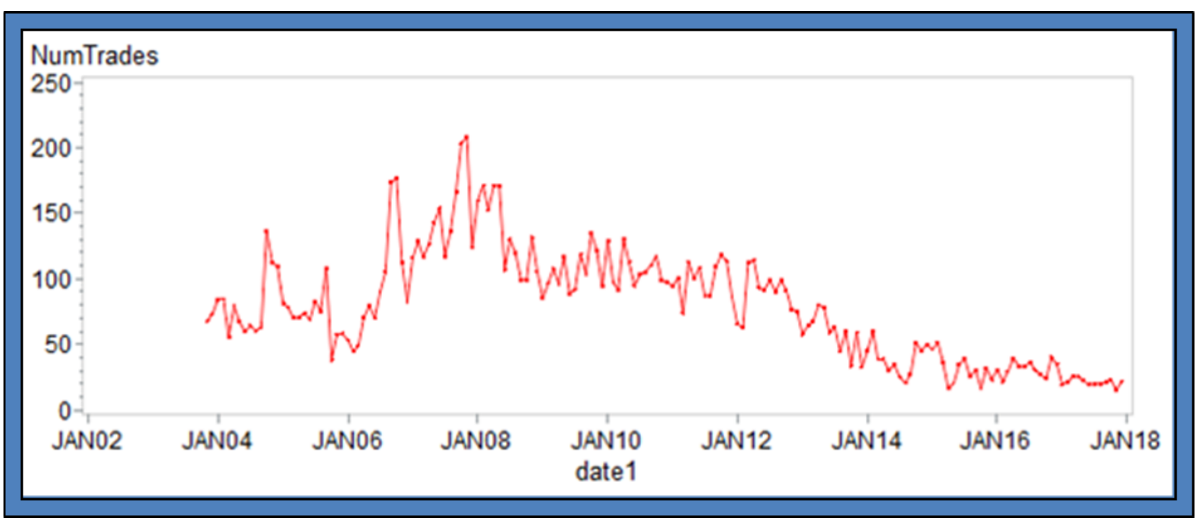
The factors discussed above have reduced the liquidity of the U.S. natural gas markets over the last few years. One example is a decreasing level of trading activity on ICE for spot natural gas at Henry Hub, once the most active market hub in the U.S. Figures 2 through 4 on the following two pages show the evolution of average daily transaction volume, average daily number of transactions, average daily number of market participants (by month in all cases.) The trends at other market hubs are similar though one can see improvements of liquidity at some hubs. The improved hubs are those where trading has been adversely affected through recent alleviations of pipeline constraints due to new construction (for example, Dominion South, a pricing point for natural gas produced in the Marcellus Basin.)

Figure 2
Average Daily Transaction Volume (MMBTU) by Month, Henry Hub



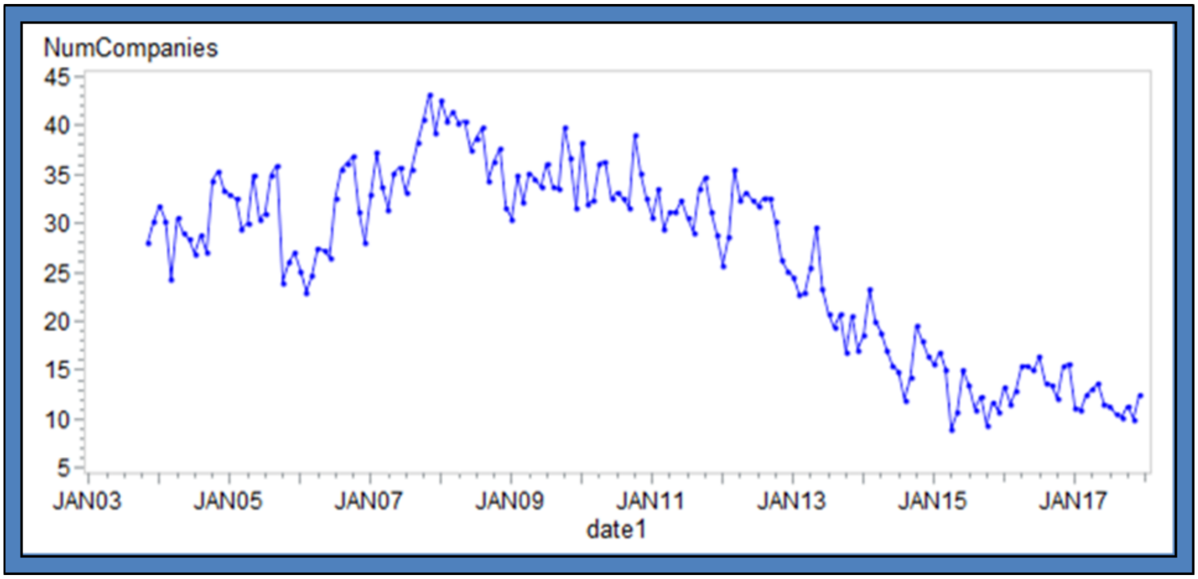
Source: U.S. Energy Information Administration

Figure 3
Average Daily Number of Transactions by Month, Henry Hub



Source: U.S. Energy Information Administration

Figure 4
Average Daily Number of Market Participants by Month, Henry Hub



Source: U.S. Energy Information Administration

Conclusions

Adequate liquidity is an important aspect of a well-functioning, efficient natural gas market. It is generally associated with a low bid-ask spread, and the ability to transact large volumes on short notice without significant price impact. The ability to buy and sell natural gas quickly helps to lower transaction costs and facilitates effective responses to market developments, including emergencies such as outages of pipelines or gas-fired power plants, and unanticipated weather changes.

Enhancing natural gas market liquidity is an important objective of the Federal Energy Regulatory Commission. It is a component of a wider policy designed to promote the goal of integrating the U.S. natural gas market, insuring greater price uniformity across trading hubs at a given point in time. Moreover, greater liquidity reduces the price impact of a trade, improves price discovery processes and helps both producers and consumers manage price and volume risk. It allows market participants to optimize the portfolios of physical and financial products to meet the needs of consumers of natural gas at a lower cost. Greater liquidity increases the confidence of industry participants in the efficiency of the market mechanism and increases their ability to warehouse risks associated with highly volatile prices, fluctuating demand and evolving daily load profiles in both natural gas and electricity industries. It allows producers and distributors of natural gas to be adequately compensated for important services they provide to the rest of the national economy. It also accelerates the transition to a more environmentally friendly future through greater use of natural gas, particularly the move toward greater use of gas-fired generation.

Market liquidity is critical to the ability of power generators to take full advantage of the intraday nomination opportunities created through FERC Order No. 809, which provided an additional intraday pipeline nomination cycle to meet unexpected changes in supply or demand in order to stay in balance and maintain reliable electricity service. Enhanced liquidity also helps to promote coordination between the gas and electricity markets, an important concern of industry regulators, given the differences in the markets' designs (namely, the differences between definitions of Gas Day and Electricity Day across the ISO electricity markets and regional gas markets.) Greater liquidity can also help to facilitate entry in electricity generation and natural gas supply by helping to accommodate greater depth of forward trading.

Identifying illiquid hubs helps regulators know where market manipulation is more likely and also where to look to enhance market efficiency. Natural gas market liquidity at key supply hubs has changed over time as the traditional sources of supply declined and new regional sources emerged. Liquidity at market center hubs has also changed as new sources of demand emerged, driven by growth in gas-fired generation and changes in the regional generation mix. It is important to assess hubs where there are significant changes in liquidity over time as these changes can impact price formation and signal major market realignments. The challenge any market analyst faces is capturing many different aspects of market liquidity in a few indexes that can enable meaningful comparisons across space (different market hubs) and time (evolution of liquidity at the same location and across different regions.)

Endnotes

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

1 FERC Order 809 changed the nationwide Timely Nomination Cycle nomination deadline for scheduling natural gas transportation from 11:30 a.m. Central Clock Time (CCT) to 1:00 p.m. CCT.

2 FERC Form No. 552 is used to collect transactional information from natural gas market participants, which is further explained in https://www.ferc.gov/resources/faqs/form-552.asp.

3 NYMEX was acquired by CME in 2008.

4 For example, many Cheniere LNG contracts are indexed to 115% of the Henry Hub first available futures contract price.

5 A typical set of circumstances leading to a late day-ahead transaction is a power generator with surplus gas supply due to an outage or not being dispatched by the power pool operator (or a reverse situation.) More frequent pipeline nomination cycles (down to hourly nominations) may in the future increase the importance of day-ahead transactions and distribute them more evenly over the gas day. The FERC issued Order No. 809 in April 2015 that in part provided for an additional intraday nomination cycle later during the gas day to help better coordinate the wholesale natural gas and electricity markets (Apr 16, 2015 - 18 CFR Part 284). [Docket No. RM14-2-000; Order No. 809].

6 The name survives though most market activity is now often squeezed into a period of a few hours in the NYMEX contract expiration day.

7 Examples of a long-term contract are the so-called volumetric production payments and municipal prepay transactions (involving issuance of tax-advantaged bonds by local governments buying natural gas.) See Kaminski (2013).

8 Growing natural gas production from the shale formations (especially from the prolific Marcellus formation) and construction of new pipelines changed these historical patterns, which now tend to evolve much faster than in the past. Traders and risk managers have to monitor production statistics and pipeline expansion plans to avoid costly surprises.

9 Transactions executed on Fridays are for Saturday, Sunday and Monday delivery.

10 As observed in Lander (2015), "pipelines ... are an extremely uneconomic way to meet demand spikes, like the system-wide peak demand each winter. This is so because any pipeline capacity needed for such short time periods must be built (to have a big enough pipeline) and then purchased (as the result of pipeline regulation and economics) on a 365-days-a-year basis. As a result, a significant percentage of the capacity within any pipeline built to handle such peak demand spikes will only be used for a few days each year."

11 Only a very small percentage of futures transactions leads to physical delivery of natural gas.

12 As covered in part 1 of this series of articles, "the logic behind Amihud's index of liquidity is very simple, and this explains its popularity in applied financial economics. The value of the index increases with greater absolute return, i.e., greater market impact, for a given level of volume (turnover.) A higher value for Amihud's index means that the market becomes more illiquid: the price reaction measured by the price return is stronger for a given transaction volume."

13 The term "polar vortex," introduced by scientists studying the earth's atmosphere in 1853, denotes "a large-scale region of air that is contained by a strong west-to-east jet stream that circles the polar region. This jet stream is usually referred to as the polar night jet," noted Berwyn (2017).

14 An Operational Flow Order (OFO) is a system of operational procedures to protect the integrity of pipeline operations when capacity usage exceeds or falls short of safety limits.

15 In a contango market, spot short-term forward prices are below long-term forward prices. The forward price curve for natural gas displays pronounced seasonality with prices fluctuating around an upwardly sloping trend line.

16 A royalty is a payment to the owner of mineral rights for the right to produce natural gas or oil. The level of royalties (typically calculated as a percentage of the value of the volumetric production flow) is determined through negotiations, and the agreed rates are part of a lease agreement.

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

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

Closer to One Great Pool? Evidence from Structural Breaks in Oil Price Differentials

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The Federal Research Bank of Dallas Working Paper, from which this article is summarized, is available at:
https://www.dallasfed.org/-/media/documents/research/papers/2019/wp1901.pdf

Our research investigates how the size of price differentials between different grades of crude oil have changed over time. We show that these price differentials have generally become smaller. We document, in particular, that many of them experienced a major structural break in or around 2008, after which there was a marked reduction in their means and volatilities. A growing ability of the global refinery sector to process lower-quality crude oil and the U.S. shale boom, which has unexpectedly boosted the supply of high-quality crude oil, are two factors consistent with these changes.

Introduction

The physical characteristics of different crude oils can vary significantly, making them imperfect substitutes for one another in the refining process and creating price differentials between the various grades of crude oil.

These price differentials are important to many oil market participants. For refiners, they can affect profitability and influence investment decisions about specific equipment, such as cokers, that could improve the profitability of processing lower grades of crude. Oil producers and fiscal authorities are concerned about these differentials because of their effect on revenues earned from producing or taxing certain types of oil. Finally, for analysts, academics and others interested in understanding the upstream and downstream oil markets, these differentials provide important signals about how supply and demand conditions change for one type of crude relative to others.

This paper investigates how the size of these quality-driven price differentials has changed over time. More specifically, we consider if these differentials have experienced permanent shifts, or structural breaks, in their average values. The research was motivated by a simple observation: in the data, many differentials between high- and low-quality crude oils appear to have significantly narrowed and become less volatile since 2008.

Data and Econometric Results

Our price data extends from 1997 to 2018 and includes 14 crude oils. The data covers a variety of geographical areas including the U.S. Gulf Coast, northwest Europe, the Middle East and Asia. A wide range of quality is considered, as our data set contains prices for high-, medium- and low-quality crude oils.

Dr. Michael Plante, Ph.D., Senior Research Economist at the Federal Reserve Bank of Dallas, presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

The data is used to construct percent differentials between various pairs of prices. Our main set of results considers 27 differentials where the pairs of crude are of different qualities. These differentials are based mainly on daily price data. Some further results, based on monthly price data covering additional crudes, are presented in the appendix of the comprehensive paper and cover 42 differentials.

A structural break test, Bai (1997), is used to formally document when the mean of a price differential has changed. Our most interesting finding is that a large number of quality-related oil price differentials experienced a major structural break around the time of the Great Recession: specifically, 25 out of 27 possible differentials in our daily price data, and 38 out of 42 cases when using monthly data.

We also use the test to investigate whether oil price differentials between crudes of the same quality experienced a similar set of breaks around 2008. If so, that would suggest a broader change in the oil market not necessarily connected to crude quality. Overall, we do not find any evidence for such breaks, although we do find evidence that these differentials have experienced breaks at other times. One group of breaks occurs after the start of the U.S. shale oil boom and affects many differentials involving U.S. based, light, sweet crude oils.[1]

Visual inspection of the price differentials between various types of crude point to a marked reduction in their means and volatilities after the breaks that occur around 2008. A table in the comprehensive paper compares the pre- and post-break values for those statistics, where the pre-break sample goes from 1997 until the end of 2008 and the post-break sample runs from 2009 to the end of 2018. The average size post-break is often half that of the pre-break sample, and post-break volatilities are usually half to three-quarters the size of those before 2009.

Putting a Story to the Breaks

The econometric test does not provide a story for why a structural break occurs, let alone why we find a cluster of breaks around the time of the Great Recession. Part of our research investigates changes in the oil market that would be consistent with the emergence of smaller oil price differentials between higher- and lower-quality crude oil. This included looking at longer-term market changes, as well as potentially important events around the time of the breaks.

Given the complexity of the upstream and downstream oil sector, knowing where to look for clues was initially daunting. To guide our work, we researched how the refining process works and the role of crude quality. This turned out to be very fruitful, leading us to a handful of potentially important factors meriting further investigation.

Crude Quality and the Refining Process

While crude oil has a number of characteristics important to refiners, the two receiving the most attention are density and sulfur content. Density is formally measured by a crude oil's American Petroleum Institute gravity, hereafter API gravity. It is typically a number between 10 and 70—the lower the value, the denser the oil. Sulfur content is often measured as a percent of crude weight and can range from near 0 percent to more than 3.5 percent.

The industry has found it convenient to lump crude oils into several groups based on these properties. It is common to label oils as light, medium or heavy depending upon their API gravity and sweet or sour depending upon whether they have low or high sulfur content.

There is a price hierarchy of quality in terms of density, with light at the top and heavy at the bottom, and in terms of sulfur content, with sweet crudes preferred to sour ones. In terms of prices, light, sweet crudes usually command a premium relative to other grades, while heavy, sour crude oils usually sell at a discount.

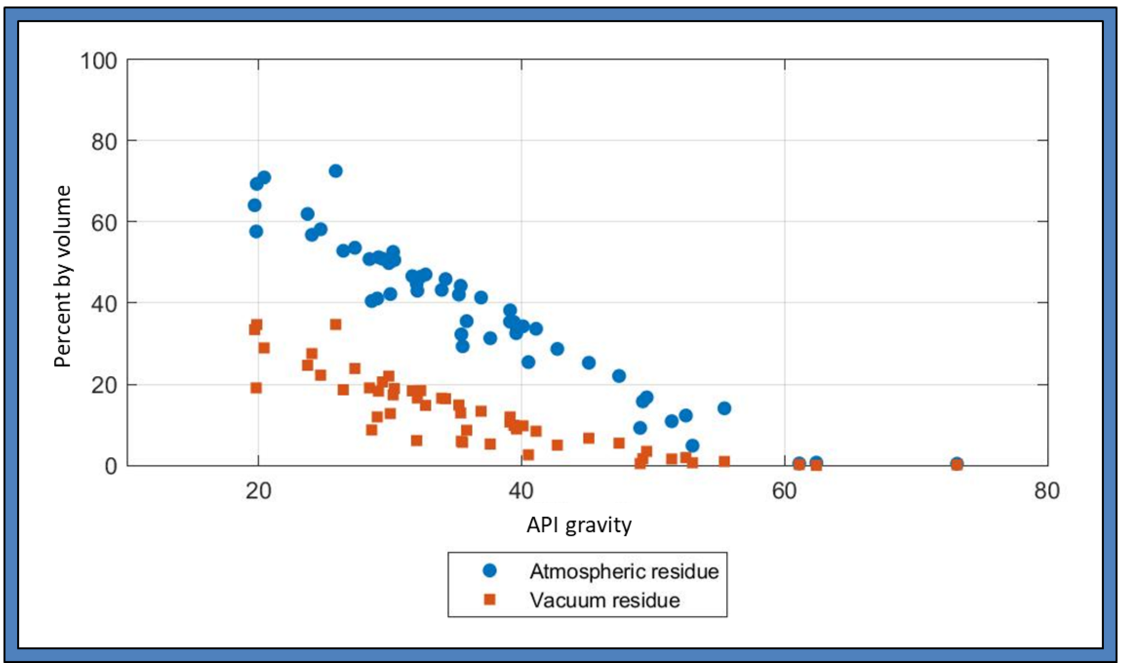
Why a Price Hierarchy?

Sulfur is a pollutant and also prevents the use of sophisticated emissions control technologies in vehicles. As a result, many countries' environmental regulations require gasoline and diesel to meet strict specifications limiting sulfur content. Removing the sulfur requires refiners to invest in costly desulfurization units, also known as hydrotreaters. This creates a premium for sweet crude oil, as it generally requires less processing than sour crude oil. While these rules only target sulfur content, they disproportionately impact lower-quality crude oil because those crudes often have higher sulfur content than do light crude streams.

Regarding density, it turns out the API gravity of a crude is related to the proportion of the different products found within a specific type of crude oil. Light crudes, i.e., those with a high API gravity, tend to have greater proportions of gasoline and diesel than residual products, while medium and heavy crude oils usually contain greater amounts of residual products. These proportions determine how much of each product is available after the first step of refining: distillation.

The residual from the first stage distillation, literally the bottom of the barrel, is often referred to as atmospheric residue. The circles in Figure 1 show the relationship between API gravity and the amount of atmospheric residue present for 54 crude oils.[2] It is possible to further distill the atmospheric residue into a product known as vacuum gas oil and vacuum residue, which is essentially residual fuel oil. The squares in the figure show the residual fuel oil content for the 54 crude oils.

Figure 1
Heavy Crude Oil Contains More Residual Content, Less Gasoline and Diesel



Note: This chart shows the amount of residual content by volume for 54 different crude oils. The x-axis is a crude oil's API gravity, a measure of its density, while the y-axis is the percent by volume of either atmospheric residue (circles) or vacuum residue (squares).

Refiners can Arbitrage across Crude Quality

Unlike gasoline or diesel, the physical properties of residual fuel oil make it impractical to use as a fuel in a wide range of settings. As a result, it sells at a much lower price than gasoline or diesel. This inherently makes medium and heavy crude less valuable than light crude.

It is here that complex refineries step into the picture. These refineries try to take advantage of the price differential between light crude and lower quality crude oil by using equipment to transform the residual content into higher-valued petroleum products. Collectively, this capital is often referred to as upgrading capacity or conversion capacity.

The most complex refineries can transform almost all of the residual fuel oil into other products. This is done using an expensive piece of equipment known as a coker. As the residual content is highest in heavy crude oil, refiners specializing in that type of crude most often use cokers. The equipment can also be used to upgrade medium crude oils.

Long Term Shifts in Refining, Crude Quality

Based on our research into the refining process and crude quality, we decided to investigate how four specific factors evolved over our sample period. The factors are: (1) environmental regulations governing sulfur content in petroleum products; (2) demand for residual fuel oil relative to lighter petroleum products; (3) the relative supplies of various types of crude oil; and (4) global refining capacity to process low-quality crude oil. Each of these could theoretically influence the long-run values of price differentials between high- and low-quality crude oil.

For each factor, we collected as much relevant data as possible and used those data to inform our understanding of oil market developments over the sample period. We find that changes in the relative supplies of different types of crude and changes in the refining sector are consistent with smaller oil price differentials, while changes in environmental regulation and in the relative demand for different fuels are not.

More specifically, the data show that the supply of light crude relative to heavy crude has increased dramatically and somewhat unexpectedly over the past 10 years due to the U.S. shale boom. At the same time, the global refining sector has become more complex due to greater upgrading capacity.

On the other hand, we find that environmental regulations on sulfur have become more stringent and cover a growing proportion of consumption of the affected fuels, which should lower the relative demand for low-quality crude oil. Likewise, consumption data show a clear negative trend in the use of residual fuel oil and significant growth in consumption of other, lighter petroleum products.

What Happened Around 2008?

Since we found a cluster of structural breaks around the start of the Great Recession, it seemed natural to take a closer look at events around that time. Consumption data show the Great Recession played a role by unexpectedly and significantly reducing global petroleum product demand in 2008 and 2009, particularly for lighter products such as gasoline and diesel. In fact, those two years are the only period when the demand of such products relative to residual fuel oil declined. At the same time, additions to global upgrading capacity begun before the downturn continued uninterrupted—the result of the long lead times for refiner expansions. Both of these outcomes would contribute to lower price differentials.

The fact that price differentials have remained smaller and less volatile since then suggests that global refining capacity additions after the Great Recession have been sufficient, in light of the other trends affecting the market, to meet growing demand for gasoline and diesel, without leading to an oversupply of residual fuel oil.

Endnotes

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

For further coverage of the crude oil markets, one can read past *GCARD* articles on these markets.

1 The literature has previously documented and discussed the importance of some of those breaks. See, for example, Buyuksahin *et al*. (2013), Borenstein and Kellogg (2014), Scheitrum *et al*. (2018), and Agerton and Upton (2019).

2 This data comes from Exxon's crude oil assay library and can be accessed at https://corporate.exxonmobil.com/Crude-oils/Crude-trading/Assays-available-for-download.

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Monopoly Power in the Oil Market and the Macroeconomy

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This paper studies the macroeconomic consequences of oil price shocks caused by innovations in the monopoly power in the oil market. Monopoly power is interpreted as oil producers' ability to charge a markup over marginal costs. We propose a novel way to identify markup shocks based on meetings of OPEC and show the organization's unique macroeconomic consequences compared to supply and demand shocks. In particular, global real economic activity expands when oil producers' monopoly power rises. A general equilibrium model suggests that higher monopoly profits attract investments in oil producing capital, which drive down marginal costs and stimulate economic growth.

Introduction

It is well known that the oil price is driven by supply and demand shocks that have first-order implications for the world economy. In perfectly competitive markets, the forces of supply and demand result in an equilibrium price that is equal to the marginal cost of production. Recent evidence for the oil market suggests that producers charge a markup over their marginal costs (e.g., De Loecker and Eeckhout, 2017; Asker *et al*., 2019), which is in line with the notion that oil producers possess some degree of monopoly power. This markup is positive and time-varying. Shocks to the markup charged by oil producers may therefore represent another important determinant of the oil price and potentially have different macroeconomic effects than supply and demand shocks. Identifying and understanding the responses of the macroeconomy to markup shocks is the goal of our paper.

Empirical Evidence

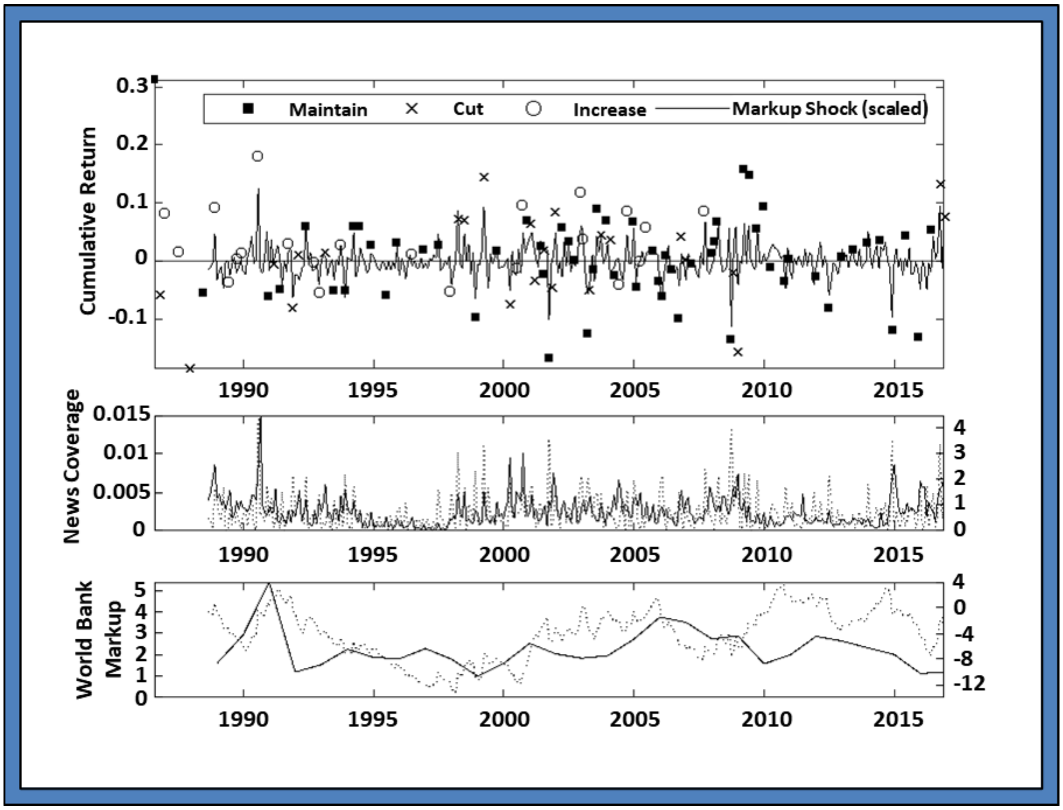
In order to identify the macroeconomic effects of unanticipated markup shocks in the global oil market, we develop a novel strategy that does not involve estimation of the markup itself, since this is hampered by data limitations. Rather, we exploit the fact that the oil market is dominated by the Organization of the Petroleum Exporting Countries (OPEC). OPEC regularly holds conferences to agree on future oil production quotas and publicly announces its decisions at the end of each meeting. Economically speaking, OPEC expresses its competitive policy at these meetings and exerts power in the global oil market by optimally choosing supply to maximize profits. The oil price reacts to such announcements. Oil price movements, i.e., cumulative returns, over event windows surrounding the announcements are often large in magnitude and reflect changes of the markup and marginal costs. We want to isolate the *unanticipated* changes of the monopoly power of *all* oil producers. For this reason, we measure cumulative returns and marginal cost changes such that they come as a surprise to agents. Changes of the markup, i.e., the residual, are then fully unexpected, too. Moreover, we measure cumulative returns and marginal cost changes at the aggregate market level, which means that we capture changes of the common markup that all oil producers can charge.

Mr. René Marian Flacke, Chair of Derivatives and Financial Engineering at the Finance Center, University of Münster, Germany, responds to a question during the "Commodities Matter Everywhere" session at the J.P. Morgan Center for Commodities' 3rd Annual International Commodities Symposium in August 2019. To Flacke's right are Dr. Xiaoqing Zhou, Ph.D., Economist, Federal Reserve Bank of Dallas and Dr. Lutz Kilian, Senior Economic Policy Advisor, Federal Reserve Bank of Dallas, and the chair of the "Commodities Matter Everywhere" session. Dr. Kilian is also a member of the JPMCC's Research Council.

Our goal is to study how markup shocks affect the macroeconomy. For this purpose, we augment the workhorse structural vector autoregressive model of Kilian (2009). Our model includes global oil production, global real economic activity, the real price of oil, and cumulative returns around OPEC announcements as endogenous variables, recursively ordered. Our identification strategy can be motivated as follows. First, it is important to note that the original model of Kilian (2009) does not include any forward-looking variable and thereby assumes that agents in the economy act on present and past information only. This assumption is likely to be violated in our case because we introduce the financial market's reactions to announcements of OPEC's quota decisions as a new variable. The new production quotas are typically effective only in the future, such that the information set of agents involves some expectations that need to be accounted for. For this reason, we use the futures price when computing cumulative returns. We consider the 3-month futures traded on NYMEX because it is liquidly traded and expires after the effective dates of new production quotas. Price movements of futures over short event windows are a nearly pure measure of unanticipated shocks (Kuttner, 2001). We construct event windows of 11 trading days symmetrically surrounding OPEC announcements. We therefore capture any information leakages prior to the announcements and any comments on the meetings' outcomes and atmosphere by OPEC members after the announcements. In other words, the event windows are long enough to allow the shocks to unfold fully. However, they span almost half a month and open up the possibility for other shocks to distort the measurement. In particular, it is possible that the cumulative returns not only reflect changes in oil producers' markup but also changes in marginal costs. We address this issue by ordering cumulative returns in our model last. We therefore correct the cumulative returns and separate out contemporaneous marginal cost changes arising from supply and demand shocks.

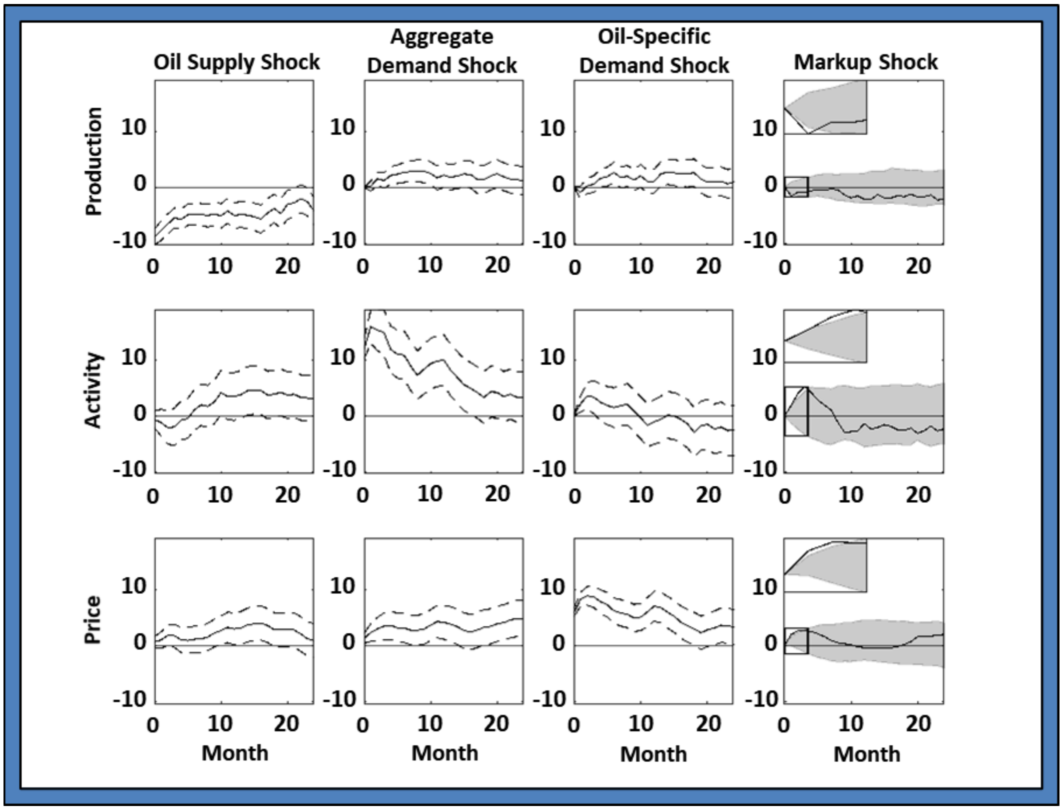
We calculate cumulative returns around 104 OPEC announcements within the sample period from August 5, 1986 to November 30, 2016. We construct a continuous monthly time series by setting cumulative returns in months in which OPEC did not meet to zero. The scope of our measure is therefore limited. It is possible that oil producers' monopoly power also changes when OPEC is not meeting. Our approach overlooks those cases. On the upside, however, focusing on OPEC announcements allows us to pin down the underlying cause of the oil price movement and lets us identify the macroeconomic effects of markup shocks in a narrow, concrete, and conservative manner. In particular, our event study approach greatly limits the role of other events that take place in the same month and also move the oil futures price, but are not properly accounted for in the model, e.g., monetary policy shocks around Federal Open Market Committee (FOMC) meetings.

Figure 1
Markup Shocks



We estimate the model with ordinary least squares (OLS) and orthogonalize shocks using the Cholesky decomposition. Figure 1 plots the obtained time series of markup shocks as a solid line in the first panel. It shows that the futures price reacts to OPEC announcements over the entire sample period, even after controlling for contemporaneous changes in marginal costs. To check the plausibility of this time series, we examine two alternative measures that look at oil producers' importance and power from different perspectives. OPEC's news coverage, which is defined as the number of newspaper articles written about OPEC relative to the total number of articles (Plante, 2019), is plotted in the second panel of Figure 1 along with the absolute of markup shocks (dotted line, right axis). In line with intuition, we observe that media attention spikes when oil producers experience significant losses or gains of power, while little attention is paid when the monopoly power remains relatively constant. In the third panel of Figure 1, we compare a yearly estimate of the level of the markup in the global oil market provided by the World Bank with a cumulated version of markup shocks (dotted line, right axis). We find a positive relation between the two time series as expected. However, while our markup shocks are based on forward-looking information and are fully unanticipated, the estimated markup level of the World Bank only incorporates backward-looking information and reacts to anticipated shocks, too. Taken together, the two plausibility checks of the time series of markup shocks corroborate the view that our measure captures unanticipated innovations in the monopoly power of oil producers. We provide further evidence based on narrative records in the full version of our paper.

Figure 2
Structural Impulse Responses



Responses of global oil production, global real economic activity, and the real price of oil to one-standard deviation structural shocks are plotted as solid lines in Figure 2. The macroeconomic consequences of supply and demand shocks (first three columns) confirm previous studies (e.g., Kilian, 2009; Baumeister and Hamilton, 2019). In comparison to supply and demand shocks, markup shocks (fourth column) affect the macroeconomy in a unique way, although all shocks raise the real price of oil. Oil production sharply drops in the first month after a positive markup shock. This reaction is statistically significant at the 5% level, since it lies outside the 95% confidence interval obtained through bootstrapping pseudo event dates (shaded area). Markup shocks do not have any considerable effect on oil production afterwards. Besides, markup shocks are associated with increases in real economic activity within the first 3 months following the initial shock. This impact is at least statistically significant at the 10% level. Consequently and perhaps surprisingly, real economic activity in the world *expands* when oil producers' monopoly power rises. Furthermore, markup shocks drive up the real price of oil within the first 2 months. This effect is statistically significant at the 5% level, but starts to fade away afterwards. Thus, oil producers are indeed able to charge a higher price for some time if the monopoly power in the oil market increases – as indicated by our measure of markup shocks.

The presented empirical results are robust to using different futures contracts (1-, 2-, 4-, 6-month futures), extending the event window (21, 31, 41 trading days), and employing different proxies for real economic activity (Hamilton, 2019), as shown in the full version of our paper. Moreover, when replacing

OPEC announcements with other major events (reflecting other oil-, inventory-, stock market-, monetary policy-, or general policy-related news), we arrive at macroeconomic responses that are very different, suggesting that OPEC announcements provide unique information to agents.

Theoretical Framework

In order to understand the mechanisms that are at work when the economy is hit by a markup shock, we propose a tractable general equilibrium model that is able to replicate the empirical findings. The key ingredient of our model is the oil sector, which is modeled as being in monopolistic competition, such that oil producers can set the price in accordance with their monopoly power and charge a markup over their marginal costs. The markup is specified to be highly persistent and matches the empirical estimate of De Loecker and Eeckhout (2017). We introduce time variation in the markup in order to study the macroeconomic implications of changes in the competitive structure of the oil market. Oil producers employ oil producing capital (e.g., oil wells and rigs) in their production and sell their output to the final good sector. The final good sector produces the consumption good and cannot perfectly substitute oil with other inputs. Two additional, auxiliary sectors, the sector for patented goods and the research and development (R&D) sector, are introduced to generate sustained endogenous growth as in Kung and Schmid (2015).

We expose the economy to supply, demand, and, most importantly, markup shocks. The model confirms our empirical finding that markup shocks have distinctly different macroeconomic implications than supply and demand shocks. A positive markup shock, first and foremost, exogenously raises the price of oil. Oil as an input becomes more expensive such that the demand for and, in equilibrium, the production of oil decline. Due to the final good sector's limited ability to substitute inputs, final good production initially declines, too. As a result, economic growth decelerates for the moment. However, as a persistently heightened markup suggests higher present and prospective monopoly profits, the oil sector increases investment in oil producing capital in order to reap these profits. In the long run, a higher stock of oil producing capital implies lower marginal costs. Despite a lastingly increased markup, lower marginal costs eventually drive down the oil price below its pre-shock level. In turn, oil as an input becomes less expensive, triggering final good and oil production. Reversing and overcompensating its immediate negative effects, a markup shock eventually fuels long-term economic growth. Comparing the model-implied responses to those implied by the data, we observe that our model can replicate the sharp downturn in oil production and the surge in the price of oil following a markup shock. The reaction of economic growth is positive – as in the data – but the timing is somewhat different. While the model's response is positive only in the long run, the data shows an immediate positive effect on real economic activity.

Conclusion

Our paper makes the point that changes in the markup charged by oil producers represent another important source of oil price shocks. In the empirical part, we propose a novel way to identify markup shocks in a structural vector autoregression based on oil futures price movements around meetings of OPEC. We show that markup shocks have unique macroeconomic consequences compared to supply and demand shocks. A positive markup shock raises the real price of oil and results in a sharp decline of global oil production in the first month after the initial shock. Most surprisingly, global real economic activity expands for a couple of months when oil producers' monopoly power rises. We explain these findings in a general equilibrium model. The model suggests that a higher markup signals higher prospective monopoly profits and triggers investment in oil producing capital. In the long run, an elevated stock of oil producing capital drives down marginal costs of oil production. Despite a lastingly heightened markup, the oil price therefore drops below its pre-shock level. This, in turn, stimulates long-term growth in the economy and explains our empirical finding of an expansion of global real economic activity.

Endnotes

Mr. Flacke presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Commodities Matter Everywhere" session on August 13, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

For further coverage of the crude oil markets, one can read past *GCARD* articles on these markets.

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The Effect of Oil-Price Shocks on Asset Markets: Evidence from Oil Inventory News

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https://www.bankofcanada.ca/wp-content/uploads/2020/03/swp2020-8.pdf

This paper quantifies the reaction of U.S. equity, bond futures, and foreign exchange returns to oil-price shocks. Using instrumental variables methods based on U.S. oil-inventory announcements, the authors find that equity prices decrease in response to higher oil prices before the 2007/08 crisis but increase after it. The U.S. dollar tends to depreciate against a basket of currencies in response to positive oil-price shocks, and this effect is larger after the financial crisis. By contrast, oil-price shocks have a modest effect on bond futures returns. The authors argue that changes in risk premia help to explain the time-varying effect of oil-price shocks on U.S. equity returns.

Introduction

Oil-price fluctuations have important implications for the terms-of-trade, investment, output, and other macroeconomic aggregates of both oil-importing and oil-exporting economies. Even before oil-price shocks are fully transmitted to the real economy, the prices of financial assets adjust to reflect market expectations about the response of macroeconomic fundamentals to such shocks. Recent empirical research has related oil-price fluctuations to variation in equity market returns (Kilian and Park, 2009; Ready, 2017), exchange rates (Chen *et al*., 2010), and interest rates (Datta *et al*., 2018; Kilian and Zhou, 2019).

However, because oil-prices and asset prices move for a variety of reasons -- for example, oil prices and asset prices mutually influence each other and respond jointly to macroeconomic developments -- identifying the effects of oil price fluctuations on asset prices remains a significant challenge. The authors address this challenge by using the information contained in weekly U.S. oil inventory news to investigate and quantify the effect of oil-price shocks on the returns of different financial assets and the shifts in expectations that the changes in returns reflect.

Changes in oil inventories are a fundamental feature of oil markets and play a central role in the intertemporal relationship between current and future supply and demand conditions (Alquist and Kilian, 2010; Kilian and Murphy, 2014). As such, higher-than-expected (lower-than-expected) U.S. oil inventories lead to systematic decreases (increases) in oil prices in the minutes following the announcement. By combining variation in oil prices and a comprehensive, high-frequency data set of the returns of different financial assets, including stocks, bonds, and exchange rates, the authors study how information about oil-market fundamentals is transmitted to asset prices and the broader economy.

Dr. Reinhard Ellwanger, Ph.D., Senior Economist, Bank of Canada, presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

Data

The data for commercial U.S. inventories of crude oil, gasoline, and distillate inventories are from the U.S. Energy Information Administration's (EIA's) *Weekly Petroleum Status Report*, which is typically released on Wednesday at 10:30 am Eastern Time. Ahead of each release, Bloomberg collects market participants' expectations about crude oil, gasoline, and distillate inventories. This set of expectations permits the authors to measure the news component of the change in each type of inventory by subtracting the expected change in inventories from the actual change of inventories reported in the release.

The financial asset data are the intraday price series of the S&P 500 Exchange-Traded Fund (ETF) and eight sector-level ETFs, U.S. Treasury bond futures, and selected foreign exchange rates, including those of both commodity-exporting and importing countries. The sample period for the equity and bond returns is 2003M10 to 2017M10, while the exchange rate data start from 2006 or later.

Methodology

The empirical approach is based on instrumental variables (IV) estimation methods that use the three types of inventory news as instruments for nearby WTI futures returns during a narrow window of 15 minutes around the announcement. The predicted values of the oil futures returns are then used as the principal explanatory variables for the various asset returns during the announcement window.[1] Because the inventory news is determined before the EIA release, they are uncorrelated with other macroeconomic news during the announcement. Hence, the IV estimates identify the response of asset returns to oil-market-specific news. Moreover, if their principal effect on the returns of other assets works through the price of oil, the IV strategy identifies the causal effect of oil-price shocks on asset returns. As the authors show, the inventory news explains a significant share of the variation in oil futures prices around the announcement, which is a necessary condition for the IV approach to be valid.

The regressions are estimated using the weekly data from October 2003 to October 2017. Existing evidence suggests that the relation between oil-price fluctuations and asset returns shifted around the time that the financial crisis began. This shift has been documented in reduced-form correlations at a variety of different frequencies (see, e.g., Lombardi and Ravazzolo, 2016; Ait-Sahalia and Xiu, 2016), as well as in the context of structural oil market models (Foroni, *et al*., 2017; Datta *et al*., 2018). The authors' empirical specification includes an interaction term with a time dummy that takes on the value of 1 after September 2008. This specification permits the authors to compute different effects for the pre-crisis and post-crisis period and use conventional t-statistics to test for a structural break around this date.

Results

The empirical results support existing evidence of a structural break in the relation between oil-price shocks and asset returns around September 2008. The authors document that before the 2007/08 crisis, higher oil prices are associated with lower equity market returns, while after the crisis, higher oil prices are associated with higher equity market returns. Both effects are economically significant: a 10% increase in oil prices is associated with a 0.8% decline (1.1% increase) in the aggregate stock market in the pre-crisis (post-crisis) period. Interestingly, the pattern observed in aggregate equity market returns is pervasive across different sectors, including those with limited direct exposure to energy prices, such as health care. The authors also find that the sector ETF that is the most responsive to oil-price fluctuations is the consumer discretionary fund. This result is consistent with the idea that oil-price shocks affect the U.S. economy through their effect on the discretionary income of consumers (Baumeister and Kilian, 2016).

The estimates for bond returns follow the reverse pattern. Bond futures returns tend to increase with higher oil prices pre-crisis and to decrease with higher oil prices after the crisis. While these results suggest that nominal interest rates became increasingly aligned with oil-price fluctuations, the estimates are economically small and indicate that the effects of oil price changes on nominal interest rates are limited. Finally, higher oil prices are associated with a depreciation of the U.S. dollar against a broad range of currencies. This depreciation is particularly strong against currencies of oil exporters (such as the Canadian dollar) and those of other commodity-exporting countries (the Australian dollar). Interestingly, however, the U.S. dollar also depreciates relative to the currencies of other oil-importing economies, the Euro and the British Pound.

Further, the paper provides evidence for different interpretations of its findings, particularly the time-varying response of U.S. stock market returns to oil-price shocks. For example, oil inventory news might reflect different structural oil-price shocks in the post-crisis period. The authors investigate whether the informational content of U.S. oil inventories about global oil supply or demand conditions changed over time but find little evidence for this claim.

A different interpretation has highlighted the usefulness of investigating the response of stock market returns through their three primitive drivers: expected interest rates, dividends, and risk premia (Boyd *et al*., 2005). The response of interest rates to oil prices, in combination with the time-varying effect of oil prices on equity returns, suggests that oil prices may have become increasingly related to equity risk premia in the post-crisis period. More generally, the results show that oil-price changes associated with inventory news have, on average, a more negative effect on U.S. stock returns than other types of news, highlighting the importance of this transmission mechanism for oil market-specific news.

Conclusion

The authors study the transmission of news from oil markets to financial assets. They find that equity and exchange rate returns react strongly to oil-price shocks, but that bond futures do not. Interestingly, they find equity prices, both in the aggregate and across most sectors, respond differently to oil-price shocks before and after the financial crisis. They attribute this difference to the time-varying equity risk premia across different stages of the business cycle.

Endnotes

Dr. Ellwanger presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Issues on Mineral and Oil Markets" session, which took place on August 13, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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1 In practice, the IV estimations are implemented using a 2SLS procedure, which accounts for estimation uncertainty in the 2nd stage regression.

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On Real Options in Ethanol: Producers, Blenders, Valuation and Empirics

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Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3307105

This paper explores the existence and relevance of real options in the ethanol industry. It focuses on the behavior of ethanol producers and blenders in response to government mandates and economic incentives. Through a realistic yet stylized model the authors derive closed form expressions for the ethanol price and industry physical output in terms of gasoline and corn prices. In addition, the value of an ethanol producer is expressed as that of a portfolio of real options on a gasoline-corn spread. These predictions are tested empirically on market and output data for the 2000-2017 period, and by comparison with the market value of the largest ethanol producer in the U.S. Support is found for several implications of the model. The authors conclude that real options are relevant for a quantitative understanding of the ethanol industry.

Introduction

Increased concern about energy security and the environment led to the adoption of the Renewable Fuel Standard (RFS) in 2005 and, two years later, the Energy Independence and Security Act. A very large increase in the demand for ethanol followed, which in turn caused strong growth in ethanol production capacity and physical output. Between 2005 and 2017 the number of ethanol plants in the U.S. roughly tripled and the ethanol blend rate, or proportion of gasoline fuel provided by ethanol, reached 10.0%. According to the Renewable Fuels Association (2017), roughly 30% of U.S. corn output has been recently used as an input by ethanol producers, who sell their output to ethanol blenders for its final use as fuel. The large size of the ethanol market makes it economically significant in the energy landscape. It also has implications for the price of food, for geopolitical and environmental concerns, and for the transportation industry.

In this paper the authors study, through theory and empirical analysis, optimal operation in the ethanol industry and its consequences for ethanol market dynamics. The authors make realistic assumptions for the dynamics of corn and gasoline prices that drive the price of ethanol and take into account the incentives faced by competitive ethanol producers and gasoline blenders under realistic government mandates and capacity constraints. The theoretical model implies explicit formulas for the ethanol price and aggregate physical output, and for the value of an ethanol producer. Predictions are set in terms of the exogenous dynamics of gasoline and corn by focusing on the possible substitution of gasoline by ethanol. The paper also includes empirical testing for the model using aggregate and microeconomic data. Hence, some empirical support is found for a nonlinear pricing mechanism and production rule for ethanol. Then, focusing on firm level data, the share price of a major ethanol producer is found to reflect some essential elements of the model. The paper builds on Ghoddusi (2017) who observed that ethanol may function either as a substitute or a complement for gasoline depending on their relative prices. However, this paper focuses on the substitution effect between ethanol and gasoline in a general setting, derives testable implications and brings them to the data.

Dr. Nicolás Merener, Ph.D., Dean, School of Business, Universidad Torcuato Di Tella, Argentina, presenting at the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019.

Among the research agendas close to this paper, three stand out. First, there is a large literature devoted to understanding the prices of ethanol, energy sources and corn. Some examples are Mallory *et al*. (2012) on pricing ethanol in terms of futures prices of natural gas and corn, McPhail and Babcock (2012) on the RFS and ethanol prices, and Abbott (2014) on the contributions of ethanol capacity constraints versus ethanol mandates. These mechanisms are also behind our model. Trujillo-Barrera *et al*. (2012) and Serra and Zilberman (2013) studied and reviewed transmission mechanisms between corn and energy markets. Second, it is important to understand the determinants of investment and ethanol physical output. The value of the real option in ethanol production under optimal operation was studied in Kirby and Davison (2010), Schmit *et al*. (2011), Maxwell and Davison (2014) and Ghoddusi (2017) among others. Finally, the optimal operation of commodity firms has been subject of study as well.

The Model

The agents in the model, in the spirit of Ghoddusi (2017) but avoiding certain assumptions therein, are ethanol producers and ethanol blenders operating in a competitive environment. Producers have the real option to turn production on or off depending on the profitability of their operation. This is determined by the market price of ethanol and its cost of production driven by corn. Engineering parameters are as in Irwin (2016). Blenders face a floor on the amount of ethanol they must purchase, set by the government mandate. However, blenders can increase the proportion of ethanol mixed with pure gasoline if it is economically convenient to do so. Hence, the amount of ethanol demanded depends on the relative pricing of gasoline and ethanol. In equilibrium the model holds that:

1) The price of ethanol is a nonlinear function of the prices of corn and gasoline. Specifically, it is the maximum of two affine functions, one in each of these variables. Hence, when gasoline is relatively expensive, ethanol is priced as fuel. When the corn prices are high, ethanol is priced as its cost of production.

2) Industry output is set jointly with prices. When the price of gasoline is relatively high, ethanol demand is strong and the capacity utilization ratio reaches 1. On the other hand, low gasoline prices decrease the appetite for ethanol which is then produced solely to satisfy the government mandate. The capacity utilization ratio reflects this through the relative size of the mandate and installed capacity.

3) The profit of an ethanol producer is determined by the spread between gasoline and corn. Hence, the producer can be understood as holding a collection of real call options on such a spread. Closed form solutions for the value of an ethanol producer are derived under the additional assumption of a stochastic process for the spread.

The Data

The paper uses monthly data on gasoline, ethanol and corn spot prices, ethanol production, installed capacity and additional parameters such as extra costs and credits. These are taken from the USDA. Mallory *et al*. (2012) proposed a model for ethanol in terms of futures prices of natural gas and corn. We also work with CME corn futures (4th contract) and ICE NY RBOB gasoline futures (6th contract), which correspond to expiration roughly between 6 and 9 months away from spot. Each year the Renewable Fuel Association publishes a list of ethanol producers. Green Plains satisfied the joint condition of being publicly traded and focused almost exclusively on ethanol, hence a good candidate for testing the predictions of the model regarding the valuation of ethanol producers. As of 2017 Green Plains had an approximate production capacity of 1.5 billion gallons per year, close to 10% of U.S. ethanol production. Yearly data for Green Plains on outstanding number of shares, ethanol production capacity and outstanding debt were obtained from the 10K reports to the U.S. Securities and Exchange Commission.

Empirical Results

Under the model proposed in this paper, the price of ethanol is a nonlinear function of the prices of gasoline and corn. In a direct test of this statement, the formula was implemented empirically on historical prices of gasoline and corn between 2000 and 2017, and then compared with historical ethanol prices. Fitting errors, of the order of 30 cents per gallon of ethanol are shown to be not larger for the theoretical model than for the best-fit linear models with more degrees of freedom. Hence, the nonlinear mechanism proposed in the model seems relevant to explain its performance in reproducing the dynamics of historical ethanol prices to some extent.

The model predicts that the capacity utilization ratio should be an increasing function of the gasoline corn spread. It is then found empirically that between 2008 and 2017 such a relationship was present in the data. For months with a large gasoline corn spread, theoretical and historical utilization ratios were close to 1, while for instances with a small spread, theoretical and historical utilization ratios were close to 0.90.

Finally, according to the model in this paper, the value of an ethanol producer should be that of a portfolio of real call options on the gasoline corn spread. Regardless of the choice of dynamical model for the spread, the producer's value should be increasing on the spread and it should exhibit some positive convexity. These notions were tested on monthly data for Green Plains, a major ethanol producer in the U.S., between 2012 and 2017. Time series regressions were run after controlling for variations in the general level of equity markets and adjusting for installed capacity, outstanding debt and number of shares. The authors find strong statistical and economic significance for the gasoline corn spread in explaining fluctuations in the share price of Green Plains and in its first order sensitivity. Moreover, unrestricted regressions of Green Plains share price against gasoline and corn prices rediscover weightings in line with those predicted by the theoretical model from first principles.

Conclusions

This paper developed, implemented and tested a real option model for the ethanol market. Optionality arises from the interaction between producers and blenders, who respond to incentives. The cost of ethanol production, driven by corn, and the value of ethanol as fuel, driven by the price of gasoline, are the fundamental inputs to the model, which also incorporates engineering settings, industry capacity, government incentives and mandates as external parameters. The model makes precise predictions for the price of ethanol as a nonlinear function of the prices of gasoline and corn, for the magnitude of ethanol physical output in terms of the relative pricing of gasoline and corn, and for the value of an ethanol producer as that of a call option on the spread between gasoline and corn. Empirical tests for each of these predictions found support for the model. However, certain features of the ethanol industry were left outside of the model. In particular, heterogeneity among producers, exit, and entry, seem relevant questions for future research as the story of the ethanol market in the last fifteen years has had firm entry as a main feature. The possibility of ethanol storage is also likely to have an impact on the decision process faced by producers and blenders. This, too, should be explored in the future.

Endnote

Dr. Merener presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the "Agricultural Commodity and Freight Markets" session on August 13, 2019. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

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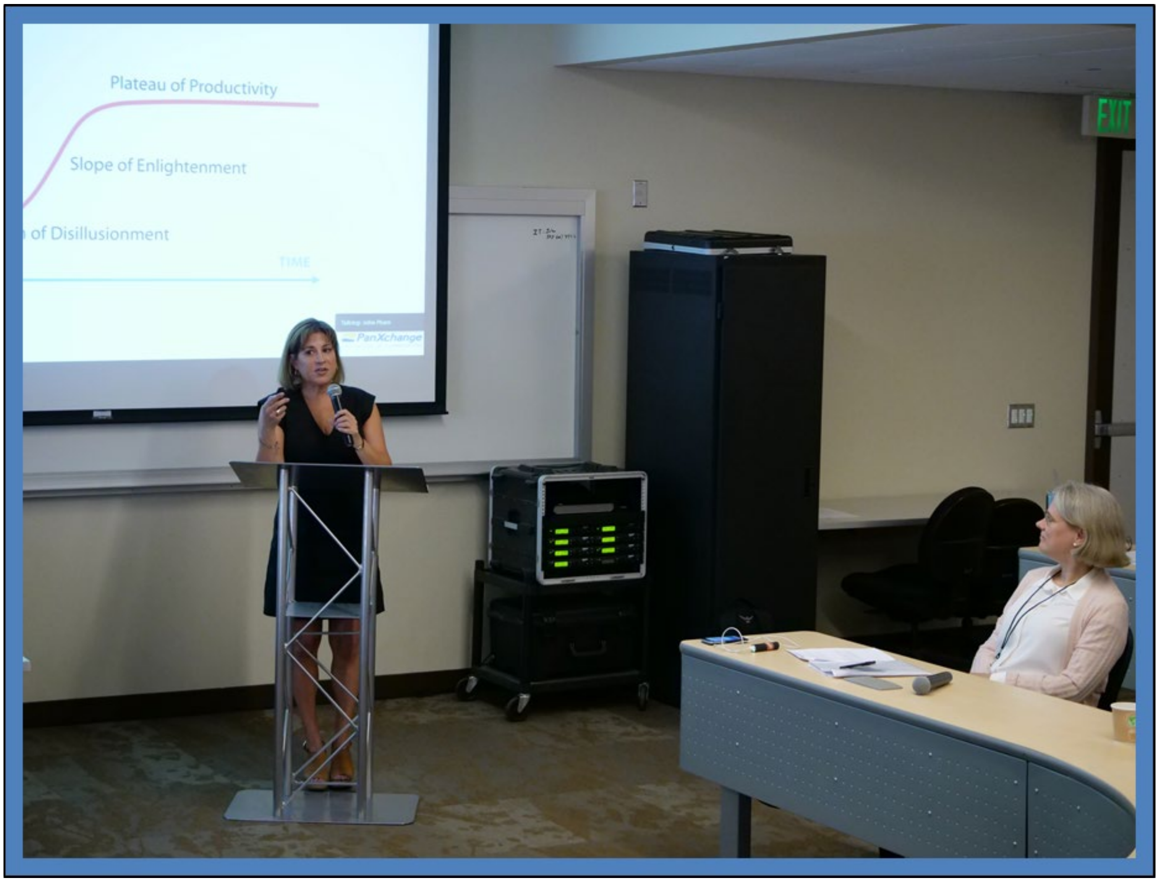
The Seven Stages of Commodity Market Evolution

Julie Lerner
Chief Executive Officer, PanXchange



Ms. Julie Lerner, Chief Executive Officer, PanXchange, participated in the commodity industry panel during the JPMCC's 3rd Annual International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2019. The panel was moderated by the *GCARD*'s Contributing Editor, Hilary Till, who is in the right-hand-side of this photo.

Introduction

2019 will be remembered as a watershed year for physical commodities. The 120 million-ton U.S. proppant market felt the sting of oversupply, the nascent hemp industry opened up following its 2018 legalization and, in an unprecedented move, the "Big Six" agribusinesses formed a partnership to digitize the highly manual international grain trade. Despite these various commodity sectors cycling at different rates, there remains a common thread to the evolution of these - and all - physical markets.

Equities Take the Lead

Physical commodity markets, whether they be energy, metals, grains, hemp or others, are unified in one significant way: they lag behind their capital markets counterparts when it comes to technology. Commodity trading, especially in agricultural sectors, is still highly manual and almost totally reliant on paper processes for contracting, invoicing and payments. To give the reader an idea of the scope of the issue and the need for modernization and harmonization in the sector, a *Reuters* report revealed that 275 million emails are sent by commodity traders each year in order to process 11,000 ocean-bound shipments of grain (Plume, 2018).

On the flipside, the capital markets have embraced technology far more speedily. Nasdaq launched in February 1971, becoming the first electronic share market. From its beginnings as an electronic bulletin board, it is now the world's second-largest stock exchange by market capitalization of shares traded behind the New York Stock Exchange. In 1987 work began on the nascent Globex Trading System, which was developed by the Chicago Mercantile Exchange (CME). The first electronic future began trading on the system in 1992, making it the first international electronic trading system to allow off-hours trading in exchange contracts.

1991 saw the launch of online trading pioneer E*Trade. By 1994, its revenues had climbed to $11 million, becoming at the time the fastest-growing private company in the United States, and allowing anyone with access to a computer to trade stocks (Encyclopedia.com, 2019). Over the course of the next decade, investment firms began to spend on electronic trading technology, and traditional floor trading waned. Since the inception of Nasdaq, computer-based high frequency trading (HFT) has risen, as have the speeds with which trades can take place. At the beginning of the 2000s, HFT accounted for less than 10% of equity orders, but according to the NYSE this volume grew by around 164% between 2005 and 2009.

Physical Markets Playing Catch Up

For the commodities industry, modernization has occurred at a much more languid pace. It was not until 2015 that the CME announced plans to close the majority of its futures trading pits in New York and Chicago – the same year that open outcry futures trading fell to just one percent of the company's total futures volume (CME Group, 2015).

Even as late as the mid-2010s, oil traders were still using Yahoo Messenger as their main communication tool, something which had been an industry standard since the 1990s. The ultimate closure of the benchmark-compliant version in 2016 sent physical traders into a tailspin, and even today industry participants are still fishing in the dark for deal flow (Gloystein, 2016). Whether by phone, WhatsApp or text, they're still using suboptimal technology for price discovery.

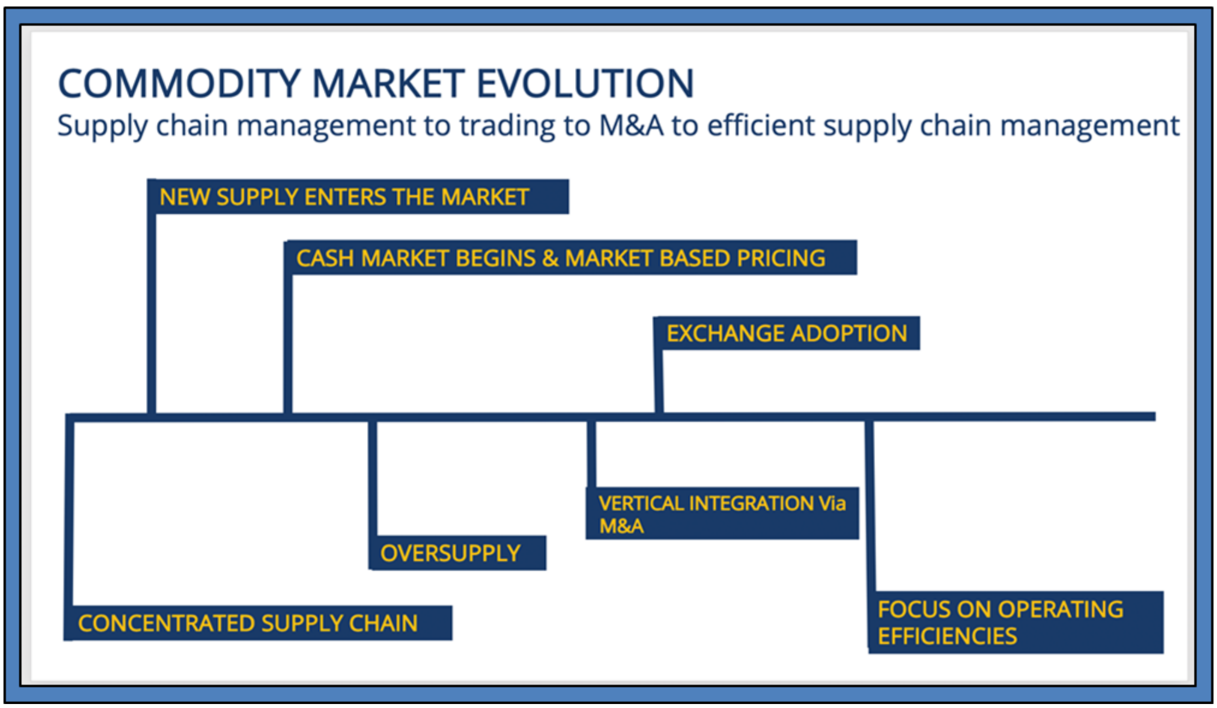
Adding to this issue is the lack of an agreed upon, satisfactory solution for end users who need to move physical supplies around the globe. Of great concern to many industry participants is the fact that the status quo process, in which a dozen different documents are stuffed into manila envelopes each time a vessel of grain is traded, is extremely challenging to move onto burgeoning technologies like blockchain.

And yet, more than a decade after its introduction to cryptocurrency markets, blockchain has yet to be fully adopted by any financial industry, which is arguably simpler for mass adoption than physical supply chains.

The Evolution of Nascent Markets

Another commonality of food, metals and energy markets is that in order for a physical item to go from being simple raw material to a full-fledged commodity, it must traverse seven key steps; see Figure 1. PanXchange's experience with nascent markets - both frac sand and hemp - illustrates the challenges of opacity and fragmentation as commodity markets mature.

Figure 1
Commodity Market Evolution



At the beginning of the cycle, when the supply chain is concentrated (step one), surety of that supply is the absolute biggest concern. Because of this, pricing initially tends to be dominated by a few players who are tied up in long-term contracts, but by the second stage of evolution, when new supply enters the market with the promise of healthy sales margins, new entrants are able to gain market share by offering competitive pricing and execution.

The current state of the industrial hemp sector is a good example of this transition.

The passage of the 2018 Farm Bill allowed for the entry of new suppliers marked by being geographically or technologically more competitive than the incumbents. This has resulted in supply pressures easing and conversations about price taking centerstage. This sector has also seen the rise of the cash market, as well as market-based pricing which has allowed newer players to undercut more established players on price (stage three).

Why Benchmarks and Exchanges

As the pricing competition heats up, the creation of benchmarks often occurs to enable more efficient price hedging and allow for transparency and price discovery -- something which is also being seen in the nascent hemp sector. It is here that oversupply of the commodity (stage four of the cycle) becomes a very real possibility. Recent changes in the frac sand sector provide one example of this.

PanXchange launched its frac sand benchmarks[1] in Q4 2017, but two years later, the sector is now in the throes of oversupply (unlike other commodities, sand does not erode over time). The threat of oversupply is also becoming evident in the burgeoning hemp[2] market, as growers rushed into this market with promises of massive profits per acre. Unfortunately, these estimates seem to have been wildly overstated, based on retail prices of consumer-packaged goods of Cannabidiol (CBD) products which contain only a few milligrams of extracted hemp product. Despite these challenges, it is important to remember that the current state of both the hemp and frac sand markets remains a natural part of market evolution. Figure 2 offers a template of how trading in other commodity markets has evolved.

Figure 2

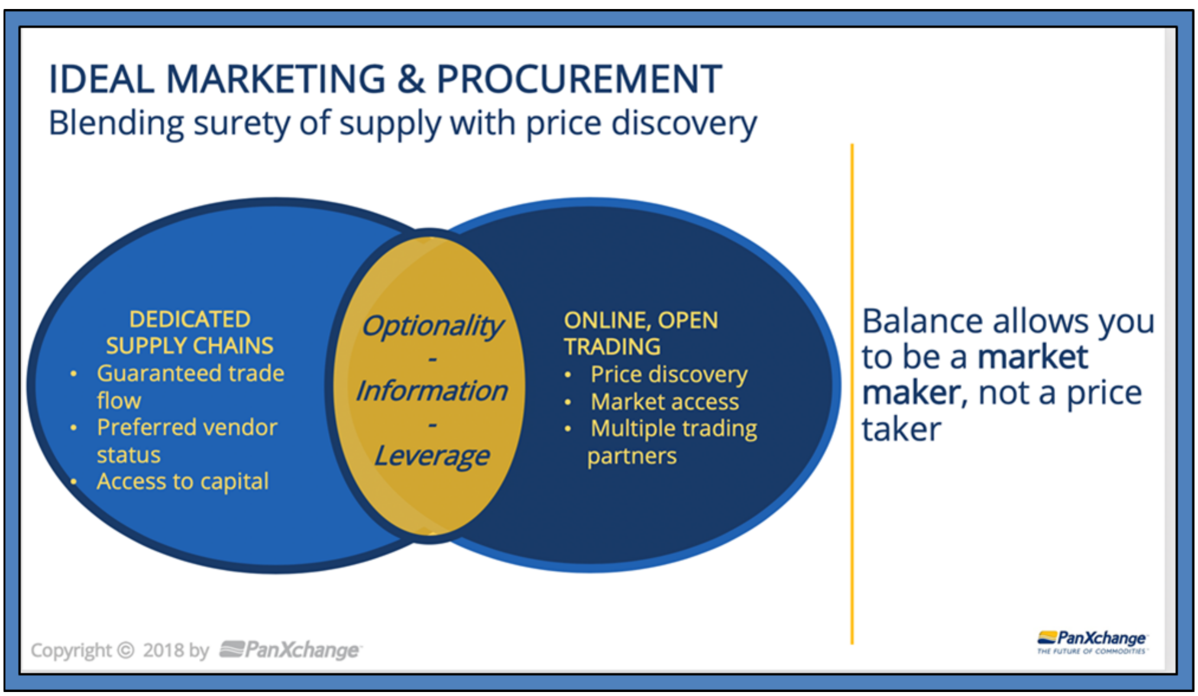
The fifth stage in commodity market evolution - and one that is being experienced in the frac sand sector - is the rise of vertical integration, often via M&A. It is here where larger players seek new profit opportunities by scooping up smaller players challenged by oversupply (as in frac sand) or long-term market fluctuations, as will be covered below on "Profit Building in Mature Markets."

As commodity markets evolve, they reach the sixth stage: exchange adoption, something often seen as a "nirvana" for industry players, where they can finally price hedge their deal flow and outside investors can enter the market. What exchanges offer is a constantly available facility for buying and selling commodities, as well as a financial inventory holding. This is a key component of the maturation of commodity markets.

PanXchange was originally designed to seek a more efficient process for locating physical sugar supply and simultaneous demand opportunities, as the old system of relying on phone calls, texts and emails became antiquated. The market needed more negotiable deals, as well as a system that was easy and efficient for traders, anonymous and without clearing. Now, PanXchange aggregates the negotiation and trade of all types of physical commodities into one web-based platform, offering instant price discovery and market access for increased operating efficiency and profit opportunities. Note that physical commodity traders use PanXchange for the actual movement of commodity from origin to destination yet use the financial derivative as listed on a regulated exchange to hedge the price of that transaction.

However, expecting all commodities players to conduct all their trading activities solely on one cash market platform is unrealistic. A good trader will always have a healthy balance between the reliability of direct relationships and the opportunities and fluidity of the cash market, as seen in Figure 3.

Figure 3
Ideal Marketing and Procurement

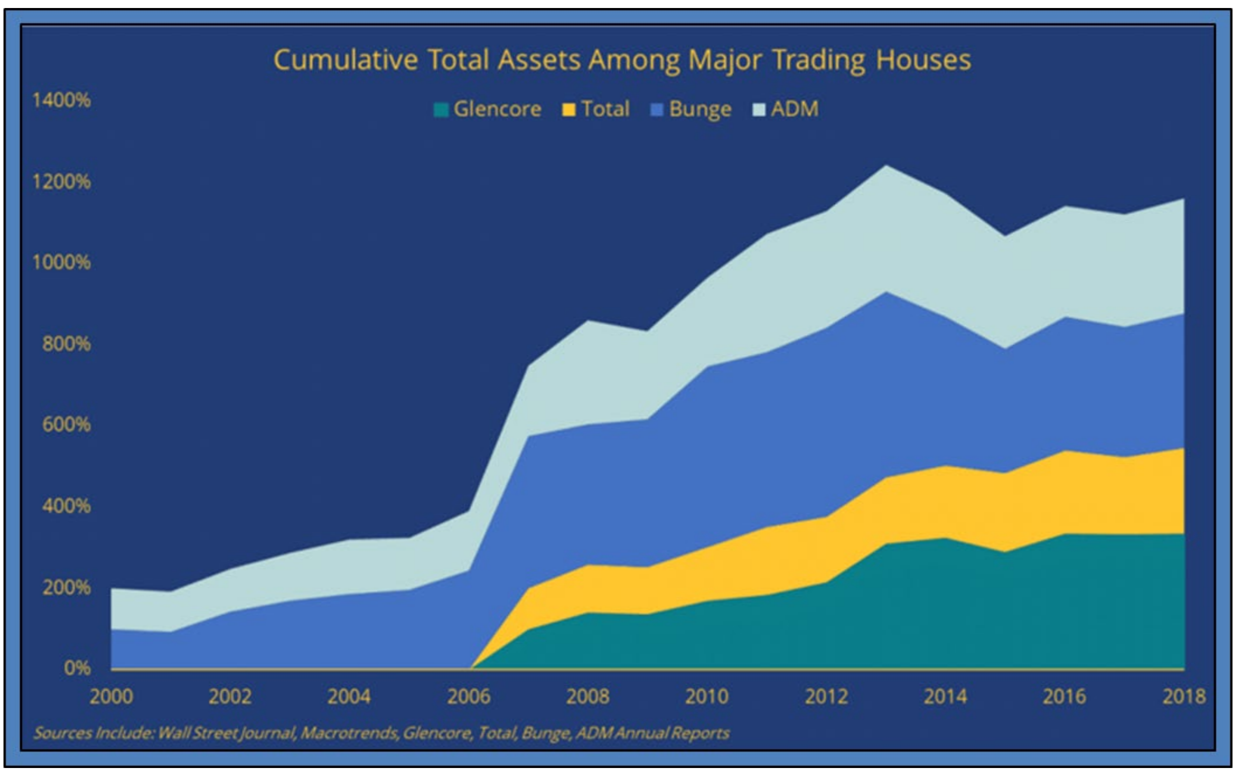


Profit Building in Mature Markets

More established physical commodity markets, like grain, have made their way through the six steps outlined above, and have also moved into the seventh and final stage: a focus on operating efficiencies. In the 2000s there was an unprecedented amount of vertical integration by the big commodity houses; however, as they made their way up and down the supply chain, they were struck by the question: where is there to go to increase profit margins?

Historical examples of vertical integration include moves made by American agribusiness company Bunge Limited. Bunge acquired Argentinian company La Plata Cereal in 2001, becoming dominant in that market. The company created Bunge Asia in 2002, acquired an Indian edible oils business in 2003 and Chinese offices in 2005.[3] Elsewhere, Archer Daniels Midland Company (ADM) bought a stake in Australian grain handler Graincorp in 2012 but sold its interest in 2016 after failing in its bid to wholly acquire the company (Plume, 2016). In 2013, Swiss commodities trader Glencore Agriculture completed its $66 billion deal for mining giant Xstrata, and that same year oil trading house Vitol announced its expansion into grain trading (Scott, 2013). Figure 3 shows the industry trend toward vertical integration and then subsequently, some divestitures.

Figure 3
Cumulative Total Assets Among Major Trading Houses



But since 2013, the global trading companies have faced new headwinds, with Dreyfus in 2016 opting to focus processing as profits fell to a 10-year low (Hume, 2016) and Bunge's chief saying in 2017 that there was "nothing off-limits" in its cost-cutting drive. By 2018, the big trading houses were looking towards digitization as a way to shore up sliding margins - in mature markets, this is really the only solution. PanXchange believes that physical trade has to move in the direction of electronic adoption for both the negotiation of the trade and the (arguably more difficult) post-trade deal execution, as this is seemingly the only solution to increased profit margins today.

The Need for Modernization

In October 2018, (Cargill, 2018a) the world's four largest agribusinesses - ADM, Bunge, Cargill Incorporated and Dreyfus - announced that they were working together to standardize and digitize international grain trades. In December, China's largest food and agriculture company, COFCO International, joined the group (Cargill, 2018b), followed by Glencore in September 2019 (Glencore, 2019).

The group wants to replace the current system, which is so reliant on paper contracts and invoices as well as manual payments and replace this with an automated electronic system - one which it plans to launch in the second half of 2020, pending regulatory approval. It is also launching a pilot that will cover international bulk shipments of soybeans from Brazil to China.

In a statement issued in 2019, the group said it was "initially looking at new technologies - such as blockchain and artificial intelligence - to create digital solutions to automate grain and oilseed post-trade execution processes, reducing costs needed to move agricultural and food products around the globe." (Glencore, 2019).

While these companies are to be commended for endeavoring to support the physical commodity sector's modernization efforts, blockchain is in and of itself not a panacea for the many issues associated with the harmonization of post-trade deal flow, and while pilots are nice, they are not a proof of concept.

Conclusion

We at PanXchange strongly believe that hemp and frac sand will continue to follow the seven-step maturation process. In mature markets such as the grain markets, operating efficiencies are clearly needed to increase profit margins. It's encouraging to see the major trade houses banding together to address the topic, but unfortunately, blockchain isn't the only answer. Before the successful rollout of distributed ledger technology, the industry must first take measured and meaningful steps to harmonize post-trade procedures and create interoperability of all back-office systems.

Endnotes

Ms. Lerner presented on this topic at the JPMCC's 3rd Annual International Commodities Symposium during the commodity industry panel on August 13, 2019, which was moderated by the *GCARD*'s Contributing Editor, Hilary Till. The symposium, in turn, was organized by Professor Jian Yang, Ph.D., CFA, the J.P. Morgan Endowed Chair and JPMCC Research Director at the University of Colorado Denver Business School.

1 https://panxchange.com/frac-sand/

2 https://panxchange.com/hemp-benchmarks/

3 See Bunge.com for history: https://www.bunge.com/who-we-are/our-history

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Ms. Julie Lerner is the CEO and founder of PanXchange, Inc., a web-based trading and price discovery platform for physical commodities. PanXchange has the leading trading and benchmark pricing data in both the U.S. hemp market and the 120 million-ton specialty sand market for U.S. oil and gas extraction. Ms. Lerner has deep experience in regional and international agricultural and energy markets. She has worked for Cargill International, XL Financial and Sempra Energy Trading (electricity). Geographically, her area of expertise covers the U.S., Europe, Latin America and East Africa.

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Fear of Hazards in Commodity Markets

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This paper examines the predictive content of active attention to hazards or "hazard fear" which is proxied by changes in the volume of internet search queries (or active attention) by 149 weather, disease, geopolitical or economic terms. A long-short portfolio strategy that sorts the cross-section of commodity futures by a hazard fear signal -- inferred from the co-movement of past excess returns with the active attention -- is able to capture an economically and statistically significant premium. A time-series analysis suggests that this hazard fear premium partially reflects compensation for known risks such as those formalized as hedging pressure, momentum, illiquidity and skewness factors, but is not subsumed by them. Exposure to hazard-fear is strongly priced in the cross-section of individual commodity futures and commodity portfolios over and above known risk factors. The hazard fear premium is significantly greater in periods of higher financial investor pessimism which reveals a channel for the transmission of sentiment to commodity futures markets.

Introduction

Commodity hazard fear is broadly defined as the economic agents' apprehension or anxiety about potential weather, agricultural disease, geopolitical and economic threats that may shift the commodity supply or demand curves. Building on economic psychology, the empirical investigation conducted by the authors builds on the assumption that economic agents' fear about threats induces them actively to search for information (Lemieux and Peterson, 2011). This active information demand is referred to as "attention" in the recent asset pricing literature (Da *et al.*, 2011, 2015; Han *et al.*, 2017a, 2017b; Vozlyublennaia, 2014). The authors hypothesize that fear of rare and extreme events contains predictive content for commodity futures returns and influences the pricing of commodity futures contracts over and beyond the fundamental backwardation and contango cycle. Fear of hazards induces expectations of a sharp rise/decline in spot prices. These expectations, in turn, can influence the hedging decisions of commodity market participants and the compensation demanded by speculators to absorb changes in net hedging. For instance, when there is fear about a threat inducing a dramatic drop in supply and thus, when the spot price is expected to sharply rise, speculators may demand a higher premium for taking short positions (than in the absence of such fear) which implies higher current futures prices; thus, the

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

decrease in the futures price as maturity approaches is the overall premium captured by short speculators which incorporates a fundamental and a hazard-fear component.

Economic agents' fear can arise from many reasons. In our paper, building on the aforementioned literature on the pricing content of "attention" we are agnostic as to whether the internet searches by the hazard terms are induced by news releases about impending hazards or simply by a phenomenon akin to the "representativeness" heuristic – for instance, a coffee producer may be anxious about extreme weather pre-harvest because her crops were thus adversely affected in the past or because she is mindful of extreme weather phenomena that had dramatically shifted inward the supply of other commodities.

The paper provides three contributions to the literature. Using the internet search volume by 149 commodity hazard-related keywords as a proxy for hazard-fear, the authors adapt the framework of Da *et al*. (2015) to obtain a commodity-specific hazard fear characteristic (hereafter CFEAR) that reflects the co-movement between the commodity futures returns and the hazard-fear. Second, they construct a CFEAR-sorted portfolio of commodities to formally assess the out-of-sample predictive content of the CFEAR characteristic for commodity futures returns (the fear premium) and deploy time-series spanning tests to examine whether the fear premium is subsumed by well-known commodity risk factors. Third, the paper contributes to the commodity pricing literature by providing cross-sectional tests for commodity portfolios (sorted on characteristics and sectors) and individual commodities to investigate whether the CFEAR factor captures priced risk over and above known commodity risk factors.

Relevance of the Research Question

The analysis conducted in this paper fills a void in the futures markets literature by investigating whether fear of (and attention to) hazards conveys expectations about subsequent futures prices. By demonstrating that a long-short portfolio strategy based on a fear signal is able to capture a significant premium and that this premium is not subsumed by fundamental premia such as term structure, hedging pressure or momentum (inter alia) the paper provides novel evidence that hazard fear can also influence commodity futures prices over and above the fundamentals. Filling a void in the literature, the authors show that "animal spirits" (paraphrasing the British economist John Maynard Keynes) in the form of adverse moods or pessimism (i.e., sentiment) in the broad financial markets, as proxied by VIX levels, can be channeled into commodity futures markets by exacerbating the hazard fear.

Data, CFEAR Signal and Portfolio Construction

Inspired by the extant literature that uses Google search volume as a proxy for investor attention (or information demand) in financial markets, this paper introduces a commodity hazard-fear characteristic that is constructed from internet search volume data from *Google Trends* using an array of 149 hazards as query terms. The Google searches are sampled at a weekly frequency (as daily searches are likely to be noisier) with each observation capturing the search queries from Monday 00:00:00 to Sunday 23:59:59. Thus, the portfolio rebalancing is carried out at the start of each Monday to exploit the previous-week searches. As in Da *et al*. (2015), the measure of interest is the weekly log change in the Google search volume or attention to hazard *j* defined as $\Delta S_{j,t} \equiv \log(s_{j,t}/s_{j,t-1})$, $j = 1, \ldots, J$, so that sharp increases in the attention to hazards can be taken to signal a surge in hazard-specific fear. Following Da *et al*. (2015), in order to make the attention series comparable across the $j = 1, \ldots, 149$ keywords we standardize each as $\Delta S^*_{j,t} \equiv \Delta S_{j,t}/\sigma^{\Delta S}_{j,t}$ where $\sigma^{\Delta S}_{j,t}$ is the standard deviation of the series $\Delta S_{j,t}$ using data from week 1 to *t*. As in Da *et al*. (2015), we run backward-looking regressions to measure the strength of the historical contemporaneous relationship between searches and commodity futures returns:

$$r_{i,t-l} = \alpha + \beta^{CFEAR}_{i,j,t-l} \cdot \Delta S^*_{j,t-l} + \varepsilon_{t-l}, \quad l = 0, \ldots, L-1 \tag{1}$$

for each of the $j = 1, \ldots, 149$ keywords in the sample. We estimate Equation (1) by OLS and, for commodity i we construct the CFEAR characteristic as follows:

$$CFEAR_{i,t} \equiv \sum_{j=1}^{J} \hat{\beta}^{CFEAR}_{i,j,t-l} \tag{2}$$

by aggregating the corresponding sensitivity measures for the $J = 149$ keywords. The long-short CFEAR portfolio takes long positions on the commodities with the most negative ($CFEAR_{i,t} < 0$) signal, and short positions on those with the most positive ($CFEAR_{i,t} > 0$) signal. To avoid a look-ahead bias, the analysis is conducted out-of-sample; namely, the buy or sell decisions at each week *t* hinge on past data.

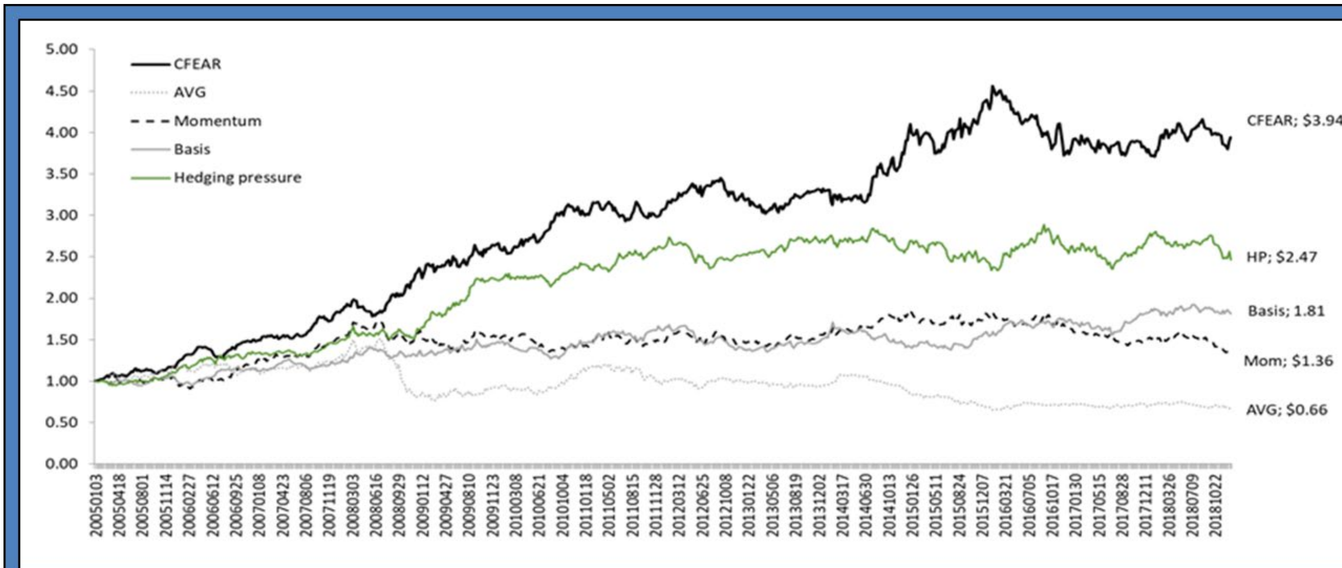
The authors deploy the long-short portfolios on a cross-section of 28 commodity futures contracts comprising 17 agricultural (4 cereal grains, 4 oilseeds, 4 meats, 5 miscellaneous other softs), 6 energy, and 5 metals (1 base, 4 precious). The observation period is from January 1, 2004 (as dictated by the availability of weekly *Google Trends* search data) until December 31, 2018.

Results

The fully-collateralized long-short CFEAR portfolio captures an economically and statistically significant premium of 9.28% p.a. ($t = 3.35$) which stands well relative to traditional premia as shown in Figure 1 on the next page. In addition, the CFEAR portfolio has an appealing risk profile, that materializes in a Sharpe ratio of 0.9012 versus 0.3387 (term structure portfolio), 0.5926 (hedging pressure) and 0.1296 (momentum). Further, the CFEAR portfolio presents relatively favorable tail (crash) risk characteristics as borne out, for instance, by a 99% VaR and maximum drawdown of 0.0341 and -0.1881, respectively, while the corresponding risk measures for aforementioned long-short traditional portfolios lie in the ranges [0.0356, 0.0421] and [-0.2872, -0.1828], respectively.

Figure 1 shows the evolution of $1 invested in the long-only equally weighted portfolio of the 28 commodities (AVG), and the long-short basis, momentum, hedging pressure and CFEAR portfolios.

Figure 1
Future Value of $1 Invested in Commodity Portfolios



Examining the excess returns of the long versus short legs of the portfolio reveals that the CFEAR premium is mostly driven by the short positions. This finding is consistent with the inherent asymmetry of inventories which can be built up to dampen commodity price falls but their natural zero lower bound makes them likely to be perceived by agents as an ineffective lever to stifle upswings in commodity prices.

Next the authors estimate time-series regressions of the returns of the long-short CFEAR portfolio on the term structure, hedging pressure and momentum factors – and other factors suggested in the literature such as basis-momentum, convexity, illiquidity and skewness inter alia (Gu *et al*., 2019; Boons and Prado, 2019; Fernandez-Perez *et al*., 2018; Szymanowska *et al*., 2014). The results reveal exposure to some of these factors but the regression intercept (or alpha) remains economically and statistically significant. Therefore compensation for exposure to fundamentals risks does not tell the whole story.

Cross-sectional asset pricing tests deployed both for individual commodities and commodity portfolios as test assets reveal that exposure to the CFEAR factor is consistently priced, and that the CFEAR factor is able to improve the explanatory power (reduce the pricing error) of extant commodity pricing models.

The mean excess return and alpha of the CFEAR portfolio are found to be greater when VIX levels are high; i.e., when risk-aversion is high or when sentiment is adverse. A rationale is that speculators may demand a higher premium in high VIX periods because their risk-bearing ability has been then impaired (due either to funding liquidity constraints or to their reluctance to take risks in bad times) or because their investment decisions are contaminated by adverse sentiment (pessimism). Given that risk aversion and sentiment are likely to co-vary over time, it is challenging to tell the two explanations apart. However, an identical analysis conducted for the fundamental term structure, hedging pressure and momentum premia reveals that they are, in sharp contrast, unrelated to the VIX; this suggests that broad financial market sentiment can be channeled into commodity futures pricing through hazard fear. The intuition is that when investors are out of their comfort zone because of turmoil in financial markets, as signaled by a high VIX, they are more vulnerable to emotions such as (hazard) fear.

A battery of robustness tests are not able to challenge the above findings. These tests include alternative portfolio formation approaches (e.g., monthly rebalanced), and CFEAR signal extraction methods. Among the latter, the authors measure the CFEAR signal in a manner that controls for the impact of media coverage defined, as in Fang and Peress (2009) and others, as the number of news articles published about each commodity per week to proxy for its overall media exposure (or information supply).

Seeking to rule out concerns that the finding of a significant hazard-fear premia in commodity futures markets is an artefact of the methodology employed, the authors carry out an intuitive "placebo" test (focusing on the 123 keywords in the weather and crop disease categories) that consists of deploying the same long-short portfolio strategy for 4 cross-sections of commodity, equity, currency and fixed income futures contracts, respectively. The fear premium remains sizeable and statistically significant in commodity futures markets at 8.17% p.a. (t=3.06) but is merely 1.83% p.a. (t=1.62) in equity index futures markets, 0.19% p.a. (t=0.25) in fixed income futures markets and 1.16% p.a. (t=1.50) in currency futures markets. This suggests that the CFEAR premium in commodity futures is unlikely to be spurious.

Conclusions

Does the human emotion known as fear influence commodities futures pricing? This paper addresses this question by focusing on weather, agricultural pests, geopolitical or economic threats to the commodity supply or demand. Fear is proxied by surges in the active search for information or attention.

A long-short CFEAR portfolio is able to earn a sizeable premium in commodity futures markets. Using time-series spanning tests, it is shown that this premium cannot be fully rationalized as compensation for exposure to known risk factors. Through asset pricing tests the paper further demonstrates that exposure to hazard-fear is a key determinant of the cross-sectional variation in the excess returns of both individual commodities and commodity portfolios beyond known fundamental pricing factors. The results are robust to trading costs and to alternative CFEAR signal measurement and portfolio construction methods. The CFEAR premium magnifies in periods of pessimism as proxied by the VIX revealing a channel for overall financial investor sentiment to transmit into commodity futures markets. A key takeaway is that fear about potential hazards contains predictive information about commodity futures prices.

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Keywords

Commodity supply, commodity demand, hazards, fear, attention, search activity, sentiment, long-short portfolios.

Investable Commodity Premia in China

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This paper discusses how investable Chinese commodity risk premia might be, amid the recent acceleration of the market opening process in China. The findings suggest that strategies based on conventional contract rolling and portfolio weighting schemes are not investable due to limited capacity induced by policy-induced liquidity dynamics. It is further shown that the capacity can be substantially increased by dynamic rolling and strategic portfolio weights, and that style integration can notably enhance the investor's opportunity set. The investable premia documented survive execution delay, stop-loss, seasonality, sub-periods, illiquidity and transaction cost tests, and provide portfolio diversification benefits. Finally, the analysis reveals that investable commodity premia in China exhibit a strong ability to predict global real economic growth.

Introduction

The investment management industry has embraced the rising opportunities in China as a result of the government's recent effort to internationalize its financial markets. As of 2020, many of the world's largest hedge funds – BlackRock, Bridgewater Associates, Invesco, Man Group, UBS and Winton Capital inter alia – have established subsidiaries in China.

Meanwhile, as one of the most popular investment styles in recent decades, a growing number of studies have confirmed the profitability of momentum and trend-following strategies in Chinese commodity futures markets (Li *et al*., 2017; Ham *et al*., 2019). Fan and Zhang (2020) conduct a study that confirms the existence of carry and momentum premia in these markets after controlling for an exhaustive list of long-short factors that have been documented in the U.S. market. However, the extant literature has largely neglected the effects of retail-dominance, barriers-to-entry, time-varying margins and strict position limits.

This paper investigates how investable various risk premia are in Chinese commodity futures markets. These premia include the momentum, carry and recently proposed basis-momentum factors that have been documented in the U.S. futures markets. Using a wide range of portfolio construction methods, the authors assess how investable these factors are in Chinese futures markets from three angles: capacity, enhancement, and implementation. The specific research questions addressed by this study in the context of the above styles in commodity futures markets are as follows: (1) Are those risk premia

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investable? (2) How can investment in those premia be effectively increased? (3) Do such premia have predictive implications for the global economy?

Why the Paper's Research Questions are Important

The literature on commodity factor investing has gained popularity because of its implications to the investment management industry. While the literature to date focused on developed futures markets in the U.S., U.K., and Japan, the emerging commodity market in China offers a natural laboratory to conduct experiments on existing factors. Despite its importance to global commodity trading and increased attention from investors, the Chinese commodity futures market is still poorly understood due to the unique institutional settings. Largely deviating from the real-world setting, naïve assumptions imposed by existing studies cast doubt on the validity and practicality of previously documented results. To fill the gap, this paper explores investing in risk premia by examining the investment capacity, implementation challenges and the implications for the global economy. The findings are of imminent interest to global institutional investors. This study also contributes to the growing debate on the replicability of risk factors (Harvey *et al*., 2016; Hou *et al*., 2018).

Data Description

Data for 44 commodities covering grains, oilseeds, industrials, metals and energy sectors, traded on the Dalian (DCE), Shanghai (SHFE) and Zhengzhou (ZCE) exchanges, respectively, are obtained from Datastream International. The cross-section of the raw dataset spans 4,500 individual contracts and maturities from 1993 to 2018. Thinly traded products are dynamically excluded. As macroeconomic variables, the authors employ inflation and industrial production data from China, the U.S. and world, the Keqiang, Kilian and Baltic Dry indices, and the Chinese versions of the Economic Policy Uncertainty (EPU) Index, the Geopolitical Risk (GPR) Index, the term spread and the TED spread. As financial variables, the authors consider broad stock, bond and currency indices for China, U.S., and Europe.

Methodology

The authors investigate how investable factors such as carry are (Koijen *et al*., 2018), as well as momentum (Miffre and Rallis, 2007) and basis-momentum (Boons and Prado, 2019), in Chinese commodity futures markets. To measure the threshold capacity (Vangelisti, 2006), the authors compute the position ceilings set by regulators for each commodity covered in the sample. Accordingly, they estimate the maximum investment capacity of carry, momentum and basis-momentum factors using the conventional rolling method and equal portfolio weights. The conventional roll holds the m^{th} (where m = 1, 2, 3, 4) nearest contracts until the last trading day of the month prior to expiration of the front contract.

In an effort to improve capacity, two alternative roll-over methods are employed: the Gradual roll expands the rollover process evenly over the last five trading days (de Groot *et al*., 2014), and the Dynamic roll changes positions whenever the open interest of the holding contract is surpassed by another contract for three consecutive days (Asness *et al*., 2013). In addition to equal weights, four strategic portfolio weighting techniques are exploited including rank (Koijen *et al*., 2018), strength (Fan *et al*., 2020), volatility (Moskowitz *et al*., 2012) and trade weights. Each long-short portfolio consists of the entire cross-section and is rebalanced monthly. For risk adjustments, the authors employ commodity market factors (Bakshi, *et al.*, 2019), common risk factors (Fan *et al.*, 2020), as well as a geopolitical risk measure (Caldara and Iacoviello, 2019; GPR) and Chinese economic policy uncertainty measure constructed à la Baker, Bloom and Davies (2016; EPU).

Key Results

Momentum, carry and basis-momentum premia are robust under conventional contract rolling and equal portfolio weights, but are not investable due to limited capacity (approx. one million Chinese Renminbi (RMB) or U.S. $142,000). However, dynamic rolling and strategic portfolio weights significantly boost the capacity of the above strategies to billions of RMB, without compromising the statistical or economic significance of the risk premia.

Second, the observed investable risk premia can be enhanced through a simple style integration framework (Fernandez-Perez *et al.*, 2019), while maintaining a high level of investment capacity. These integrated strategies report an average annualized Sharpe ratio of 0.81 and a median capacity of 932 million RMB. However, only the combination of momentum and basis-momentum under rank, strength and trade weights can deliver "alpha" when the standalone risk premia are used as benchmarks.

Third, the investable risk premia are robust to several implementation concerns, such as execution delay, stop-loss and liquidity considerations. A 10% stop-loss improves the risk-return profile for the carry strategy but not for momentum and basis-momentum. Moreover, a correlation analysis reveals that investable premia in Chinese commodity futures can provide diversification benefits for both Chinese and international risk exposures on traditional assets.

Fourth, the paper finds no evidence of a significant relationship between investable commodity premia in China and macroeconomic, liquidity, volatility and economic policy/geopolitical risks. However, investable carry premia persistently predict real global economic activity for up to one year ahead. This highlights the important role that Chinese commodity markets play in the global economy. Lastly, the robustness of investable premia is reassured in seasonality and sub-period tests and the premia remain when subjected to transaction costs.

Conclusion

This article examines investing in commodity risk premia in China. Conventional momentum, carry and basis-momentum premia are not investable given the minuscule capacity on the front end of the commodity futures curve. To harvest the premia, dynamic contract rolling and strategic portfolio weights play an indispensable role. Such investable premia survive a variety of implementation tests and can convey important information about the future growth of the global economy. Moreover, the paper shows that style integration can be a very useful tool to enhance the investable risk premia. Overall, the paper highlights the importance of taking into consideration how investable and replicable factor risk premia are across asset classes and regions.

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Keywords

China, commodity futures, momentum, carry, capacity.

The Price of Shelter – Downside Risk Reduction with Precious Metals

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This article examines the potential to reduce downside risk by adding precious metals to a portfolio consisting of traditional assets. It shows that gold, silver and platinum contribute to downside risk reduction at short horizons, but diversification into silver and platinum may result in increased long horizon portfolio risk. The price of sheltering an equity portfolio from downside risk using precious metals is a relative reduction in portfolio risk-adjusted returns. The key message is that gold is an effective but costly hedge against negative portfolio returns while silver and platinum provide only short-run relief against downside risk.

Introduction

Fearing losses from declines in asset prices, investors may allocate a proportion of their wealth to alternative assets, in the hope of limiting portfolio exposures during bear markets. In the context of traditional assets, especially equity portfolios, gold is frequently proposed as a hedge (due to its low correlation with them) and safe-haven (negative correlation during downturns); see e.g. Bredin *et al*. (2015), Baur and Lucey (2010), and Baur and McDermott (2010). The allure of gold as an investment asset also relates to its potential as a hedge against inflation (Conlon *et al*., 2018b; Gorton and Rouwenhorst, 2006) and as a currency safe-haven (Reboredo, 2013). Little is known, however, about the price an investor must pay to diversify a traditional portfolio using gold. The authors investigate the latter question and measure the downside risk protection offered not only by gold but also silver and platinum.

To quantify hedge and safe-haven properties, the authors gauge the extent to which S&P 500 downside risk at various investment horizons can be reduced by allocating a proportion of total capital to precious metals. Downside risk, the maximum expected loss for a portfolio over a given horizon, is measured through the Cornish-Fisher expansion. To measure the costs of hedging, the authors estimate the change in risk-adjusted returns (Sharpe ratio) resulting from the allocation to precious metals.

The paper contributes to the literature in several ways. This is among the first papers to examine the downside risk reduction properties of silver and platinum. The analysis provides an accurate assessment

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of portfolio downside risk by incorporating higher-order distributional moments. A central theme of the paper is the importance of the investor's horizon in estimating downside risk benefits of precious metals. Finally, the paper investigates the tradeoff between downside risk benefits from diversifying the S&P 500 portfolio with precious metals and expected portfolio returns, which are eroded by the costs of hedging.

Relevance of the Research Question

Aversion to acute losses may motivate investors to seek a risk premium for bearing downside risk (Bali *et al*., 2009) and can impact their optimal allocation strategy (Jarrow and Zhao, 2006). This dislike for extreme negative outcomes may lead investors to seek out asset classes which provide diversification benefits during downturns. Gold has long been considered a store of value, a unit of exchange and an investment asset. The late 2000s global financial crisis renewed gold's role as an investment asset.

This paper aims to provide a new perspective on precious metals as a safe-haven asset. By investigating the performance of silver and platinum as downside risk diversifiers, the paper assesses alternatives to gold. As well documented in the literature, important financial characteristic such as risk and correlation are heavily dependent upon the horizon at which they are estimated (Conlon *et al*., 2018a). This, in turn, impacts the hedging effectiveness which can be achieved at different horizons, especially for gold (Bredin *et al*., 2015). This paper seeks to identify the specific range of horizons at which precious metals act to reduce downside risk for equity investors. Finally, while diversification has been proclaimed as the only "free lunch" in finance, we determine whether this holds for investment into precious metals. Can equity investors reduce their downside risk exposures in a costless manner using any of gold, silver or platinum?

Data and Downside Risk Estimation

The paper gathers daily data on gold and silver (London Bullion Market Association) and platinum (London Platinum Free Market) in addition to closing prices on the S&P 500 index from 1980 through 2014. All data is obtained from Thomson Reuters Datastream. Logarithmic returns are calculated at a daily level and aggregated for longer horizons of up to 60 days. Downside risk is estimated as follows:

$$MVaR_p(1-\alpha,\tau) = \mu - \sigma\hat{Z}(\alpha,S,K),$$

where $MVaR_p$ denotes the modified four-moment value-at-risk (VaR) of the portfolio, α is the quantile of interest set to 99% in this study. $\hat{Z}(\alpha,S,K)$ is the quantile obtained through the Cornish-Fisher expansion, with S and K the skewness and excess kurtosis of the distribution of returns, respectively.

Relative risk reduction is estimated using the proportion of equity portfolio VaR that remains after diversifying with precious metals and is given by:

$$RR_{VaR} = \frac{MVaR_p(1-\alpha,\tau)}{MVaR_e(1-\alpha,\tau)},$$

where $MVaR_e$ is the modified VaR associated with an equities-only portfolio and $MVaR_p$ is the modified VaR of the diversified portfolio. The price of shelter is estimated with the relative Sharpe ratio (RSR) as:

$$RSR = \frac{SR_P}{SR_e},$$

that measures the Sharpe ratio of an equity portfolio diversified with precious metals relative to the Sharpe ratio of the equities-only portfolio. Accordingly, an $RSR < 1$ implies that diversification with precious metals is costly as borne out by a reduction in risk-adjusted returns.

Results

The main empirical findings are highlighted in Table 1 for a 10% allocation to precious metals. Concentrating on a 1-day interval, the analysis reveals that gold, silver, and platinum each provide downside risk reduction benefits. Silver provides the strongest short-run benefits, with a 10% allocation resulting in a 20% reduction in downside risk. This reduction comes with a cost, however, with a reduction in the Sharpe ratio of 0.77 relative to holding a portfolio containing only the S&P 500. The implication is that using silver, an investor must sacrifice 23% of the risk-adjusted returns associated with investing in the S&P 500 in order to secure a 20% reduction in downside risk.

Table 1
Downside Risk Reduction (RR) and Relative Sharpe Ratio (RSR) for a Portfolio with a 10% Allocation to Precious Metals over the Period, 1980-2014

	Gold		Silver		Platinum	
Horizon	**RR**	**RSR**	**RR**	**RSR**	**RR**	**RSR**
1	0.85	0.91	0.80	0.77	0.86	0.98
5	0.87	0.90	0.88	0.74	0.89	0.96
10	0.89	0.89	0.91	0.73	0.91	0.96
30	0.91	0.88	0.97	0.71	1.00	0.95
60	0.91	0.89	0.99	0.71	1.03	0.94

Gold provides a somewhat smaller downside risk-reduction at a 1-day horizon, by about 15%, but the price paid is lower than for silver, with a Sharpe ratio equal to 0.91 times that of the equity-only portfolio. The results suggest that at increasing horizons, the risk reduction potential of the three precious metals decrease. Specifically, while a 10% allocation to gold removes 15% of downside risk at a 1-day horizon, at a 60-day horizon the reduction is only 9%. Considering the cost of hedging downside risk with gold, the relative Sharpe ratio decreases by a modest amount from 0.91 to 0.89 as the investment horizon increases from 1 day to 60 days.

The long-horizon risk reduction available to an investor employing silver or platinum to hedge equity portfolio downside risk is much weaker. While both reduce risk at a 1-day horizon, any benefits are largely expunged at a 60-day horizon. In fact, for platinum, an investor with a horizon of 60 days will experience an increase in downside risk. The cost of including either silver or platinum in the portfolio is substantial, particularly at long horizons. For the longest horizon examined, an investor with a 10% allocation to gold only reduces downside risk by 1% but surrenders 29% of the equity-only risk adjusted returns. The analogous results for platinum suggest an increase in downside risk and a decrease in Sharpe ratio.

The paper considers alternative proportional allocations and shows that they provide analogous findings. Time variation in risk-reduction benefits is notable, with the cost of diversification proving especially high during the 1980s, perhaps relating to an increased interest in gold as an investment asset during this period of high inflationary pressures. Furthermore, precious metal-specific exchange-traded funds and futures contracts are shown to provide an interesting and viable diversification alternative to physical metals. The risk reduction benefits found in the paper are attributed to the variance and kurtosis characteristics of precious metals.

Conclusions

This paper examines the downside risk reduction benefits of investing in precious metals. The empirical findings indicate that gold provides the most consistent risk reduction benefits across all horizons, but that investors must surrender a proportion of their risk-adjusted returns to obtain these benefits. The investment case for silver and platinum is weaker, with limited long-horizon risk reduction and higher costs, as borne out by lower risk-adjusted portfolio returns. While previous research has advocated gold as a costless way to reduce risk, the finding of a reduced Sharpe ratio highlights that investors may have to forego performance to diversify away downside risk. Further research is warranted to identify the downside risk benefits of precious metals across an optimized portfolio containing a larger investment opportunity set.

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Keywords

Precious metals, gold, downside risk, risk-adjusted returns.

Futures Trading and the Excess Co-movement of Commodity Prices

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The authors empirically reinvestigate the issue of the excess co-movement of commodity prices initially raised in Pindyck and Rotemberg (1990). Excess co-movement appears when commodity prices remain correlated even after adjusting for the impact of fundamentals. The authors use recent developments in large approximate factor models to consider a richer information set and adequately model these fundamentals. They consider a set of eight unrelated commodities along with 184 real and nominal macroeconomic variables, from developed and emerging economies, from which nine factors are extracted over the 1993–2013 period. Their estimates provide evidence of time-varying excess co-movement which is particularly high after 2007. They further show that speculative intensity is a driver of the estimated excess co-movement, as speculative trading is both correlated across the commodity futures markets and correlated with the futures prices. Their results can be taken as direct evidence of the significant impact of financialization on commodity-price correlations.

Introduction

This paper revisits the issue of the excess co-movement of commodity prices in the context of a growing financial influence in commodity markets for the past two decades. Pindyck and Rotemberg (1990) (PR hereafter) define excess co-movement as commodity prices remaining correlated after adjusting for common macroeconomic variables representing aggregate demand and supply.

In this context, one major issue is the selection of the common macroeconomic variables to filter commodity returns. A first contribution of the paper is to use the large factor approximate modelling approach of Stock and Watson (2002a, 2002b) to extract significant indicators from a set of 184 macroeconomic variables of developed and emerging countries. The authors find that commodity returns are explained by the first extracted factor, that is highly correlated with the real variables of emerging countries, and by the second factor, that is correlated with the nominal variables. These findings highlight the role played by these emerging countries in shaping commodity prices in the recent years. The authors further investigate the behavior of excess co-movement through time.

A second contribution of the paper is to study the empirical relationship between excess co-movement and speculative activity in commodity futures markets. Using data from the U.S. Commodity Futures Trading Commission (CFTC), the authors find empirical evidence that an indicator of speculative trading is able to explain this excess co-movement. These results give support to Barberis and Shleifer (2003)'s contention that investors view commodities as a single "commodity style" asset and lends indirect support

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

to the theoretical model of Basak and Pavlova (2016) which predicts that the correlation between commodity returns can be explained by the positions of institutional investors.

Filtering Commodity Returns with Macro Variables

The analysis is based on monthly observations from February 1993 to November 2013 for a sample of 8 commodities[1] which are representative of the main commodity classes. Arguably, according to their negligible supply and demand cross-elasticities, these commodities should be unrelated. Instead, as a first step, the authors find 15 positive and significant correlations between their commodity returns.

To explain the correlations, the authors put together a comprehensive set of 184 real and nominal macroeconomic variables for developed countries (Australia, Canada, France, Germany, Japan, the U.K., and the U.S.; 118 variables in total) and emerging countries (China, Brazil, Korea, Taiwan, Mexico inter alia; 66 variables). The real variables are country-specific measures of aggregate economic activity (e.g., industrial production index, manufacturing orders, and capacity utilization) and the nominal variables are country-specific monetary aggregates, stock indices, interest rates, price indices, and exchange rates.

The static large factor model of Stock and Watson (2002a) is used to extract key common information from the comprehensive set of macro variables. Each variable is split into a component driven by a small set of common factors and an idiosyncratic component. The factors obtained by the principal components method are ordered according to their explanatory power from largest to smallest. The authors focus on the first 9 factors that explain around 37% of the total variation in the original set of 184 macroeconomic variables. As in Stock and Watson (2002b) and Ludvigson and Ng (2009), the authors consider all possible groupings of these factors to select per commodity the regression specification for returns, which minimizes the Bayesian Information Criterion. Finally, the Seemingly Unrelated Regression (SUR) approach is used to jointly estimate the 8 commodity regressions selected.

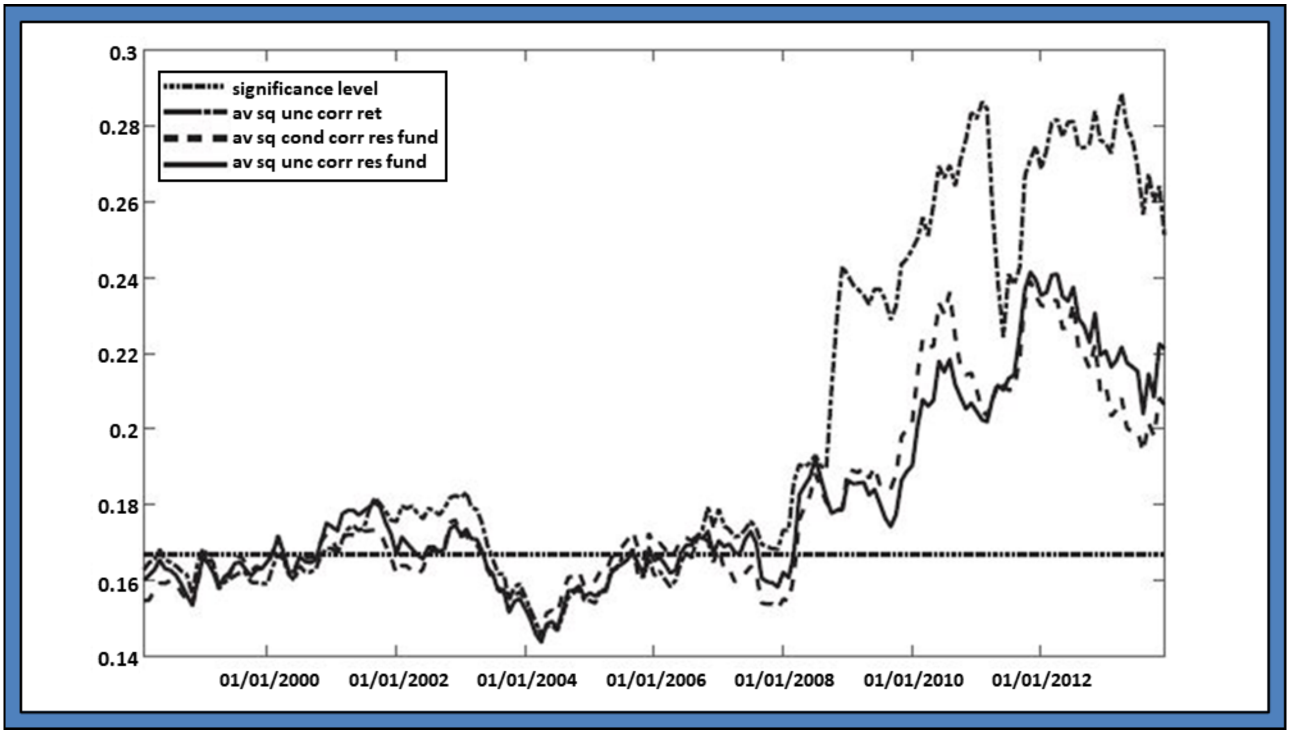
In spite of the large set of macro variables considered, the extracted factors explain only a small part of the variation in the commodity returns, except to a certain extent for copper and crude oil. The most significant factors are the first and second one. The first factor is mostly correlated with real variables from emerging countries. Its correlation with some commodity returns shows the role played by emerging countries in shaping commodity prices in recent years. The second factor is mostly correlated with nominal variables which reaffirms earlier contentions (Barsky and Kilian, 2002; Frankel and Rose, 2010) about the relationship between interest rates and commodity price movements.

Excess Co-movement of Commodity Returns

Next the authors examine the filtered commodity returns (i.e., the residuals from the SUR regressions) and observe that filtering out the common macroeconomic effects reduces only marginally the number of significant cross-correlations. At the 5% significance level, 10 out of 15 correlations are still significant, which is interpreted as evidence of excess co-movement. The authors compute a global, unbiased and time-varying indicator of excess commodity co-movement by deploying the Forbes and Rigobon (2002) unbiased estimator to compute each residual correlation recursively through 30-month rolling windows.

The indicator thus computed as the mean of the squared unbiased correlation for all commodities gives an overall picture of the pattern of excess co-movement, as shown in Figure 1.

Figure 1
Mean Excess Squared Correlation for Commodity Raw/Filtered Returns



Notes: (i) "av sq unc corr ret" is the average squared unconditional correlation for the original (or raw) returns. (ii) "av sq cond corr res fund" is the average squared correlation of filtered returns. (iii) "av sq unc corr res fund" is the average squared correlation corrected for heteroscedasticity-robust filtered returns. Significance level is the minimum value above which a squared correlation is significant at 5% level.

The excess co-movement indicator is significant at the 5% level only half of the time in the period under consideration. We thus conclude that the excess co-movement in commodity prices cannot be viewed as a general feature of commodity markets; it is instead a time-dependent phenomenon. As revealed by Figure 1, the excess co-movement provides is mostly significant during periods of financial crisis: from mid-2000 to early 2003, and from 2008 onwards. In their "convective risk flows" model, Cheng *et al.* (2015) show that financial traders (speculators) cut their net long positions in response to market distress. A coordinated drop in the long positions of financial traders may thus help explain excess co-movement. Alternatively, excess co-movement may also reflect a "flight-to-quality" phenomenon, where investors decide to partly leave the stock market and invest heavily in commodities to diversify their positions. Moreover, the period starting in 2000 also corresponds to the growing financialization of commodity futures markets, as surveyed in Cheng and Xiong (2014). As such, the excess co-movement might be induced by speculative activity in commodity futures markets, a conjecture that the authors investigate empirically in the final section of the paper.

Commodity Returns and Speculative Intensity

The Commodity Futures Trading Commission (CFTC) publishes the weekly aggregate positions of "commercial" and "non-commercial" traders in the Commitment of Traders (CoT) report released each Tuesday. The authors use these long/short futures positions data to compute the Han (2008) index of speculative activity for the eight commodities in the sample. This index is equal to the number of long non-commercial contracts minus the number of short non-commercial contracts, scaled by the total open interest in futures markets for the commodity of interest; as such this is a directional index of speculative activity in the futures market. These indices are adjusted for the effect of the business cycle.

The empirical evidence from regressions estimated by the GMM method (to control for endogeneity in the speculative indices) suggest a positive and significant impact of the Han index on the respective commodity returns for 5 commodities (wheat, soybeans, raw sugar, cotton, live cattle). Negative cross effects between crude oil return and the Han speculative index are found, for instance, in cotton. The empirical evidence suggests that the speculative indices simultaneously impact most commodity returns which provides an explanation to rationalize the strong excess co-movement in the recent decade.

Conclusions

This paper brings new insights on the issue of the excess co-movement of commodity prices. It utilizes large approximate factor models to extract the key common information contained in a large set of macroeconomic variables. The extracted factors can only explain a small part of the excess co-movement. The paper documents a time-varying overall co-movement which has notably magnified post-2008 and provides evidence to suggest that it relates to speculative futures trading activity.

Endnote

1 Wheat, copper, silver, soybeans, raw sugar, cotton, crude oil, live cattle.

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Keywords

Commodity excess co-movement, factor model, futures trading, speculative trading.

Forecasting Crude Oil and Refined Products Volatilities and Correlations: New Evidence from Fractionally-Integrated Multivariate GARCH Models

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This paper advocates the use of long-memory multivariate GARCH models to forecast spot return volatilities and correlations for crude oil and related products. The findings show from a risk management perspective that the multivariate models incorporating long-memory features outperform the short-memory counterparts in providing the most accurate Value-at-Risk measures. The paper provides useful insights to non-commercial oil traders and other energy markets agents engaged in hedging and risk management operations.

Introduction

There is a consensus in the empirical literature on the effectiveness of multivariate GARCH (MGARCH) models to forecast volatilities and correlations of crude oil and refined products returns. However, all the MGARCH model specifications used in the literature so far implicitly impose a short-memory decay rate on volatilities and correlations. This is problematic since they have been shown to display a strong degree of persistence, i.e., the impact of shocks to them decays very slowly. Several univariate long-memory models, including the fractionally integrated autoregressive (ARFIMA) model and the fractionally integrated GARCH (FIGARCH) model, have been successfully used to forecast the volatilities of crude oil and refined products returns (Block *et al*., 2015; Tong *et al*., 2013; Chang *et al*., 2010; Borenstein *et al*., 1997) but, to the best of our knowledge, no attempt has yet been made to demonstrate the advantage of incorporating the long-memory feature in multivariate models.

In practice, failure to account for this very slow decay rate in the volatility and correlation processes implies misspecification of the true data generating processes which, in turn, can potentially lead to: (i) biased conclusions about the response of refined products volatility to crude oil price shocks, (ii) inaccurate volatility forecasts and (iii) flawed risk management practices.

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This paper fills a gap in the literature by assessing whether, as regards the out-of-sample prediction of volatilities and co-movements between crude oil and refined products returns, the use of multivariate long-memory GARCH models with long-memory leads to gains in statistical accuracy as well as benefits from a risk management perspective.

The paper models the volatilities and correlations of crude oil returns (West Texas Intermediate-Cushing) and two refined products return series, conventional gasoline (New York Harbor) and heating oil (New York Harbor), by means of different MGARCH models, including the fractionally integrated dynamic conditional correlation (DCC) model. The models are rigorously compared in-sample and from an out-of-sample forecasting perspective to assess whether long-memory specifications with dynamic correlations and asymmetries outperform their short memory counterparts. The models' attractiveness in terms of risk management is assessed by forecasting the Value at Risk.

Relevance of the Research Question

Crude oil prices are central to global economic activity. Crude oil is of limited direct usage as a fuel. It is the range of products yielded by refining crude oil which are consumed either directly (e.g., gasoline and diesel for motor vehicles) or indirectly (e.g., fuel oil to generate electricity, or naphtha as petrochemical feedstock). Because of the need to transform crude oil into refined products, the interaction between upstream producers and downstream consumers is not direct. Prices for refined products can be linked back to those of crude oil through the netback mechanism. Refined product prices should theoretically be linked to the cost of acquiring crude oil (of various qualities and provenances), transporting it (via pipelines or tankers, often from abroad) to the transformation point, storing it, refining it, storing the refined products and distributing these products to a myriad of consumption points, which may be located abroad as well. Such calculations might be feasible if all the relevant information were publicly available and easily accessible. As this is not usually the case, researchers investigate the linkages empirically using models estimated with data for the most commonly traded crude oils and refined products.

The subject of the paper is important because return volatilities and correlations of crude oil and refined products are key inputs to macroeconomic models, option pricing models, investment portfolio construction, and hedging and risk management practices inter alia. These practices are of particular significance to the refining industry, which forms the nexus between crude oil production and final consumption and which is exposed to risks from the supply and demand sides of the marketplace.

Data and Models

The paper estimates 48 different MGARCH models using daily spot price returns on crude oil (CO), conventional gasoline (CG) and heating oil (HO) from 1 June 1993 to 1 June 2018 from the Energy Information Administration (EIA) of the U.S. Department of Energy. The daily return is calculated as the difference in the logarithmic closing price.

Examining the data, it is observed that the average daily returns are very small compared to the sample standard deviations. The returns display some evidence of skewness and excess kurtosis (deviation from normality). More importantly for the present purposes, the correlogram and the Ljung–Box Q statistic for serial correlation of the squared returns suggests a very strong degree of persistence in all volatility series, consistently with a long-memory decay rate. The latter is confirmed by estimating semi-parametrically for each series the long-memory parameter *d* using the local Whittle estimator of Robinson (1995) with bandwidth m = 100 and no trimming. To account for serial correlation in the data, we fit a VAR(p) model to the returns finding that a VAR(1) parameterization suffices to account for the conditional mean dynamics of the series. There is no evidence of spillover effects between the means series.

Results

In-sample results show strong evidence of GARCH-type dynamics, long-range dependence and leverage effects in the individual volatilities. In terms of the multivariate structure, the data strongly support the hypothesis of dynamic conditional correlations.

The most important finding of the paper is that the use of multivariate GARCH models with a *long-memory* significantly improves the out-of-sample forecasting accuracy of volatilities and correlations from the viewpoint of statistical loss functions and economic loss functions.

Using a fixed rolling window scheme, the authors assess the 1-, 5- and 20-day ahead out-of-sample forecasting accuracy of the models using different statistical approaches and criteria (Laurent *et al*., 2012; Hansen, 2005). Since the processes under study (volatilities) are unobservable/latent, the authors consider various matrix loss functions which are robust to the choice of the volatility proxy. Then they evaluate the models' forecasting performance in an economically meaningful way by using the model forecasts as inputs to obtain Value-at-Risk predictions.

The results suggest that models with a long-memory decay rate surpass the short-memory counterparts from a statistical as well as an economic perspective and their use can significantly improve the assessment of oil market risk. The sensitivity of the results to the sample period under study is examined by considering, in addition to the full sample, three sub-samples. The findings indicate that it is particularly important to incorporate long-memory in the multivariate models when the period to be forecasted is a turbulent (as opposed to tranquil) one. Finally, it is also shown that accounting for long-memory in the modeling tools is particularly important when the forecasting horizon is as lengthy as 21 days ahead.

Conclusions

This paper advances research on the modeling of crude oil markets and the markets of refined products by comparing the return volatility and correlation forecasts obtained from multivariate long-memory GARCH models with those obtained from the simpler short-memory models that have been used thus far in the energy markets literature. The results endorse the former and are particularly important for agents including refiners and oil trading companies who have risk exposures to both the crude and refined sides of the market. Risk managers in such companies may consider the long-memory models advocated in this paper to improve their Value-at-Risk forecasts and risk management practices.

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Keywords

Crude oil and refined products correlations, volatility forecasting, multivariate GARCH with long memory, Superior Predictive Ability test, Value-at-Risk.

Commodity Consequences of the U.S.-China Trade Disputes

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As the United States enters an election year, the on-again, off-again trade disputes with China rumble on into its third year with no definitive end in sight. The Phase One Agreement in Washington DC on January 15 of this year did mark a cooling of tensions between the parties (Donnan *et al*., 2020). However, many actors on the U.S. side reserved judgement on whether the measures pledged by China could be implemented while the U.S. administration confirmed at the time that the bulk of existing tariffs would remain at existing levels pending completion of a Phase Two deal and until at least November of this year. And as of early April, with global health issues at the fore, even this tentative timeline is beset with uncertainty.

In review, the hallmark of the entire conflict which has its origins in the steel and aluminum tariffs imposed in March of 2018 by the U.S. on various countries, including Mexico, Canada and the EU, only later focusing on Chinese exports, is that any agreement can be torn up and any commitment can be reversed at short notice. Furthermore, despite the Phase One confirmation of continuing tariffs in the short term, accelerating political pressures both internal and external, on the U.S. president and mounting economic threats facing the Chinese leadership, suggest that the potential remains for eventual compromise and resolution.

In the global clash of systems and against a backdrop of the unprecedented upheaval which commercial conflict has wrought against the Old Commodity Order, there is a risk that consequences for many established supply chains will, to a greater or lesser extent, become irreversible. Already shattered by a regime of lightning U.S. tariffs and devastating Chinese food supply destruction from disease, even with a benign outcome to negotiations, the structure and sourcing of China's commodity imports may never return to pre-2018 arrangements.

Equally, firms on both sides of the Pacific with international operations are taking evasive action, relocating facilities and diversifying marketing efforts to new regions. Corporations in sensitive sectors such as critical minerals, technology and communications may fear potential future regulatory curbs or legal sanction as an increasing cost of operations in their strategic competitor's market.

Although restrictive trade measures may be effective in protecting domestic market share in the short term, for neither side can protectionist tariffs come close to surpassing the opportunities offered by the scale and potential of access to the Chinese and U.S. economies respectively. Yet, due to the trade disputes, the commodity industry's twin pillars of economies of scale and lowest cost sourcing of product are in the process of potentially becoming irrevocably distorted as free trade is dismantled and strategic considerations eclipse economic ones as the primary drivers of supply chain construction.

While private actors in the U.S. scramble to protect their interests, hedging against the worst-case outcome and as exporters abroad seek opportunities suddenly thrown before them to exploit new market openings, the long-standing commodity trading order based on supply and demand is being turned on its head. Now, in a new order defined by trade dispute exigencies, stability, reliability, availability and increasingly, the political compatibility of sourcing are becoming Beijing's priorities with market price as the determinant of supplier choice falling away into second place.

There is a significant asymmetry in the trade skirmishes which broke out in the second quarter of 2018. On the U.S. side, the dispute has largely been about economic, and especially trade imbalances as well as intellectual property protection, while on the Chinese side retaliatory tariffs imposed by Beijing appear to have had a distinctly political flavor, often targeting sectors and states widely seen as key constituencies for the incumbent president's campaign in the forthcoming U.S. elections. We will examine the respective commercial actions taken by each side as of early 2020, and their impact, in the main part of this paper.

A Historical Context: A Predictable Phase in Global Economic Rebalancing?

When the U.S. administration targeted Chinese exports to the U.S., some observers viewed this action as one of several illogical measures from an unpredictable U.S. administration. However, economic historians might say that while the timing and dimensions of the clash initiated by the U.S. administration may have been unexpected, the broader evolution of China's rapid economic growth in relation to the West made such an outbreak of commercial hostility a likely development.

It is true that China's leaders and historians have frequently viewed the West's economic and political dominance since the mid-eighteenth century as a temporary or at best cyclical phenomenon which would run its course; meanwhile many Westerners have continued to view the post-industrial revolutionary order of first British, Western European and then American dominance as the natural state of things. However, the latter part of the twentieth century clearly evidenced an Asian resurgence with China taking the lead from Japan from the 1980s onwards. To other analysts, there was an inevitability to this and there was only discussion as to what the reactions of the different parties to the struggle for dominance would be.

The late Italian economist Giovanni Arrighi, writing in 2007, stated what he saw as the three main identifiable obstacles to continued rapid Chinese economic expansion: worsening social and regional income inequality within China leading to unrest; the mounting tendency to achieve growth following a Western energy-intensive model rather than via a more typically Asian energy-sparing growth; and thirdly but most presciently, Arrighi (2007) asserted that China cannot expect the world's most important states, in particular the U.S., not to "… attempt to disrupt its continuing economic expansion." More prophetically he wrote, "It is possible that by the time the U.S. has disentangled itself from the Iraqi quagmire, Chinese centrality in the East Asia region will be consolidated …"

This was Arrighi writing some thirteen years and four U.S. administrations ago. Earlier still, Mearsheimer (2001) voiced a similar view at the outset of the George W. Bush era, stating: "it is not too late for the United States to ... do what it can to slow the rise of China. In fact, the structural imperatives of the international system ... will probably force the United States to abandon its policy of constructive engagement ... (pp. 401-402)."

In this context, what has happened since 2018 should perhaps only surprise us by how long it took to occur, rather than any surprise that it happened. Looking further out, one might add that a deep understanding of historical Great Power conflicts can potentially help policymakers on both sides of the Pacific avoid the miscalculations of the past.

Winners and Losers from Commercial Conflict

To the economic purist, free market exchange results in a better-than-zero-sum game, with both buyers and sellers benefiting from specialization and lowest-cost sourcing in the Pareto-optimal environment. In a trade "war" scenario, however these benefits are no longer on offer and even zero-sum outcomes may be unattainable at the macro-level.

However, at the individual firm or country level, there will still be winners as well as losers from trade conflict, as producers buy raw product from second or third best sources and those higher-cost players ramp up production. Expanding output in defiance of formerly uncompetitive cost curves, these opportunist suppliers take advantage of their windfall oligopolistic market dominance and a regime of man-made supply disruptions affecting lower cost competitors.

This article will first examine the major shifts in market share for some of the most affected commodities since the inception of the trade dispute in the summer of 2018, as compared to previously. The overview begins with a survey of agriculture where price and supply swings have been among the most pronounced, followed by examples from energy and mineral commodity markets.

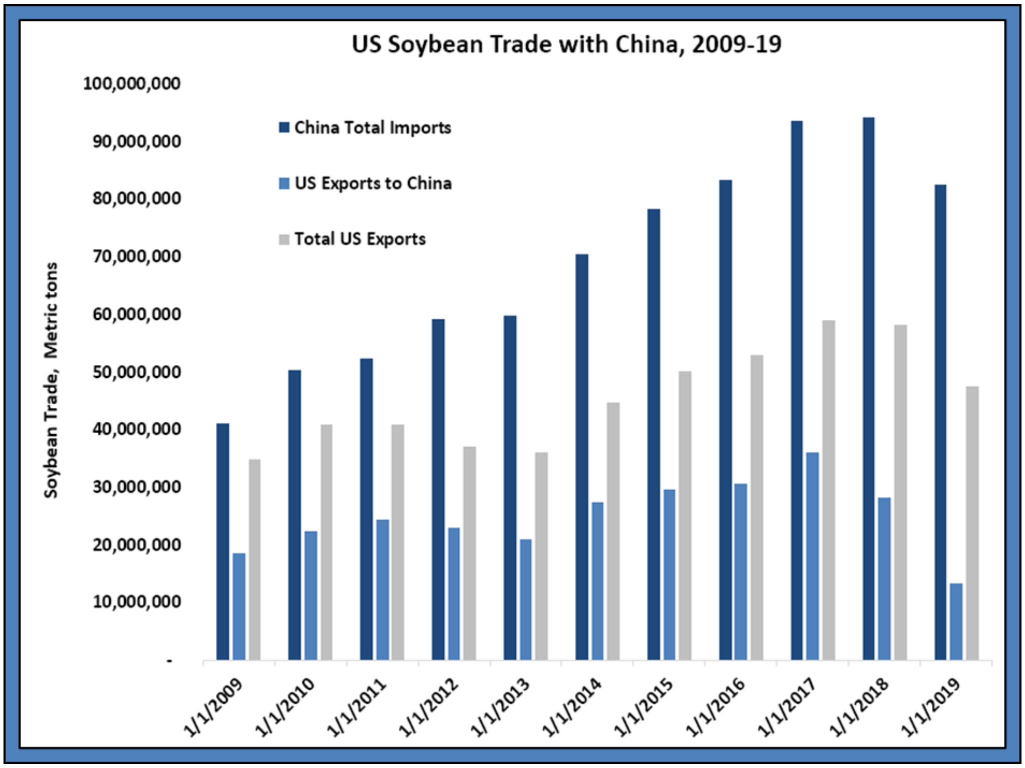
The analysis will attempt to identify who may be set to advance in the commodity supply space not only now but also in the future. Winners and losers can be gauged in terms of costs of operation, revenues and market share gained or lost. Vulnerability and increased risk in the new commodity trading environment bring its own higher cost schedules, whether through sourcing, security needs, hedging expense or insurance.

Next, the discussion will focus on the extent to which this re-channeling of supply chains is reversible, in the short as well as in the long term. In conclusion the paper looks beyond the purely economic analysis to the less quantifiable influence of domestic and geopolitical developments on the horizon, and their influence, constructive or otherwise, with an eventual return to a more stable trading equilibrium between the world's two greatest economic superpowers.

Agribusiness Impact of the Trans-Pacific Trade Dispute

The biggest immediate impact of the recent trade dispute has been a disruption to agricultural supply chains, and particularly to soybean and meat products. Brazil, Argentina and other South American countries have been the main beneficiaries, either through enhanced market share or higher export prices, or both (Fitch Solutions, 2019b). For example, due to the recent trade dispute, U.S. soybean exports to China have fallen 70% year-over-year, to only 9% of their total supply, from 36% prior to the dispute. China is purchasing the bulk of its soybean import needs from South America, but at a huge premium to the U.S. price. U.S. exporters have, to a limited degree, been able to compensate for the lost market by increasing exports to the EU and other Asian buyers.

Figure 1



Sources: Customs General Administration, PRC; USDA.

In a separate but closely related dispute, Canadian meat exports to China have also been curtailed since mid-2019 in the wake of the tit-for-tat apprehension of a senior Huawei executive on a U.S. arrest warrant and the detentions of two Canadian citizens in China, the latter of which is covered in *Reuters* (2019). In the earlier stages of the trade dispute, Canada's meat export industry had been a beneficiary as a result of the U.S. being partially shut out of Chinese pork markets, but the Huawei incident as well as a heightened war of words over Hong Kong between Prime Minister Trudeau and President Xi essentially threw that trend into reverse.

In the case of meats, the trade dispute impact is less clear, but the upheaval in pork supply chains which was already underway has resulted in a major reconfiguration of U.S.-China trade. Overall, in the mid-2018 to mid-2019 period, the U.S. in fact increased its meat exports to China, but with the pork products' share declining.

The other massive factor affecting pork is the outbreak of African Swine Fever (ASF), which has meant huge destruction of domestic supply as some 50% of the entire Chinese pig population, 25% of all pigs worldwide, had to be culled in response (Gale, 2019). According to Xiong and Zhang (2019), it is Europe, not the U.S., which has benefited the most from China's growing meat demand due to ASF.

Figure 2
China – Agriculture and Food Imports by Country (% of Total Value)

	2011	2012	2013	2014	2015	2016	2017	2018	2019 YTD
Brazil	17.3	17.1	19.5	18.3	17.9	18.3	20.4	25.7	19.1
USA	24.8	25.6	21.9	23.2	20.9	21.5	19.5	11.5	8.2
EU	3.7	3.8	5.3	5.8	7.8	9	8.2	8.6	8.3
Canada	3.3	4.8	4.8	4.5	4.5	4.9	5.4	6	6.9
Australia	4	4.3	5	4.8	4.9	3.9	4.9	5.4	6.0
New Zealand	2.8	3	4.4	5.4	3.5	3.9	4.8	5.2	6.6
Thailand	3.3	3.6	3.8	4.3	4.5	4	3.8	4.3	5.5
Vietnam	2	2.6	2.6	3	3.8	4.4	4.2	4.2	3.8
Indonesia	4.7	4.4	3.2	3.6	4	3.9	4.3	4.2	4.1
Russia	1.9	1.5	1.4	1.3	1.5	1.9	1.8	2.5	2.6
Chile	1	1	1.1	1.2	1.5	1.9	1.5	2.1	3.2
India	4.7	4.7	4.6	3.3	2.7	1.7	1.7	2.1	3.0
Malaysia	5.8	4	3.4	2.9	2.3	2.1	2	1.8	1.8
Argentina	6	4.7	4.3	3.7	4.5	3.9	3	1.6	3.6
Peru	1.5	1.2	1	1.1	1.3	1	1.5	1.3	1.7

Source: Trade Map ITC, Fitch Solutions (2019a).

Note: YTD 2019 is for average monthly imports over the period, January-May 2019.

In October 2019, the Chinese authorities released pork supplies from stockpiles ahead of the traditional National Day holiday celebrations to alleviate the shortages; at the same time longer term measures include pivoting production towards meat and poultry, as alternative protein sources.

In cotton, loss of U.S. market share versus the pre-trade dispute period has been over half, from 44% to 17% in tonnage terms but again, building on new export channels already underway to Vietnam, Pakistan and other Asian buyers has been a compensating factor.

Lastly the non-exchange traded products such as seafood where China is the largest market for U.S. produce and fruits, a booming market and where exports to China had been growing at a healthy pace, have been impacted significantly in percentage terms.

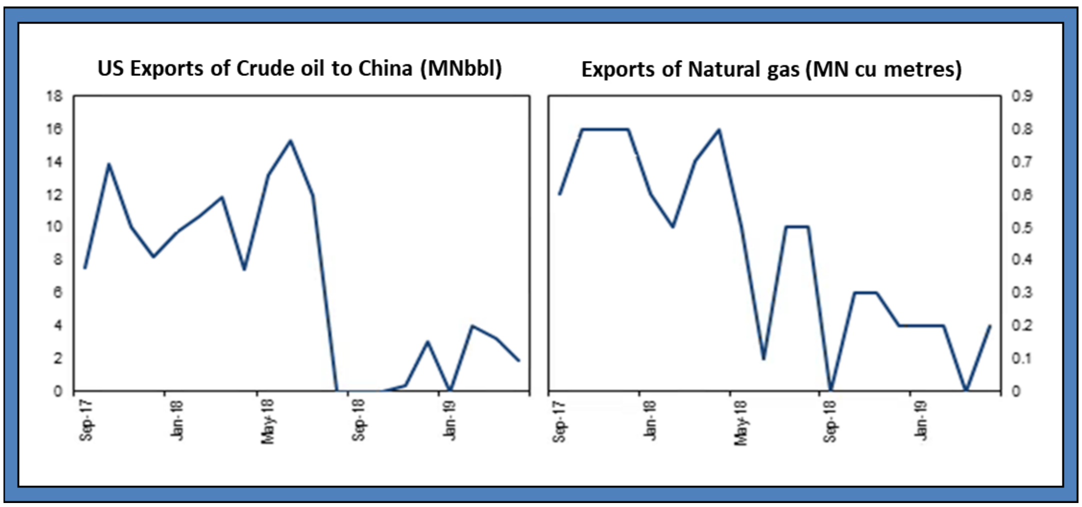
Concomitant with the impact on their produce, American farmers as a sector have been hit the hardest in terms of income loss as a result of the trade dispute. Farm debt levels soared to record highs and bankruptcies rose, aggravated by poor weather conditions across the Farm Belt in 2019. The Trump administration stepped in with $28bn of aid to offset the impact of falling incomes, which the USDA has estimated will represent one third of total farm incomes for the past calendar year (Zumbrun and DeBarros, 2020).

Moving to the energy sector, both with respect to U.S.-sourced oil and natural gas, China has been reducing its dependence and diversifying for some time.

China's imports of U.S. crude oil peaked in early 2018, but even at that time, they represented no more than 3% of the Chinese total; for the U.S. however, the picture is different: in the three years prior to the onset of the trade dispute, the U.S. rapidly increased exports as a share of its export total, to 11%. This has however already fallen back to around 3%, with South Korea, India and other Asian buyers taking up the slack in U.S. exporters' order books.

In natural gas, a similar picture emerges, with early Chinese State-Owned Enterprise stockpiling and diversification to suppliers such as Qatar, keeping dependence on the U.S. low. Again, even at its peak in 2018, the U.S. only accounted for 4% of China's import needs, while Chinese natural gas trade represented some 10% of the United States' rapidly expanding exports. U.S. sellers are now increasingly targeting Europe as an alternative market, where in the near future they face a different strategic clash: Russia's Nord Stream 2 pipeline to Germany and other buyers in the EU has already been the subject of U.S. sanctions, approved by the U.S. president late last year and challenged by the U.S.' European allies.

Figure 3



Source: U.S. Energy Information Administration.

Distortion, Contraction, Misinformation

However, while the economic news for the U.S. is not all catastrophic as a result of trade dispute developments and China's reactions are in part a reflection of its dealing with an equally devastating home-grown animal disease crisis, the international trade dispute is sending the wrong signals to markets. The starkest example is the trans-Pacific trade in soybeans, where the U.S. and Brazil have long dominated both production and exports.

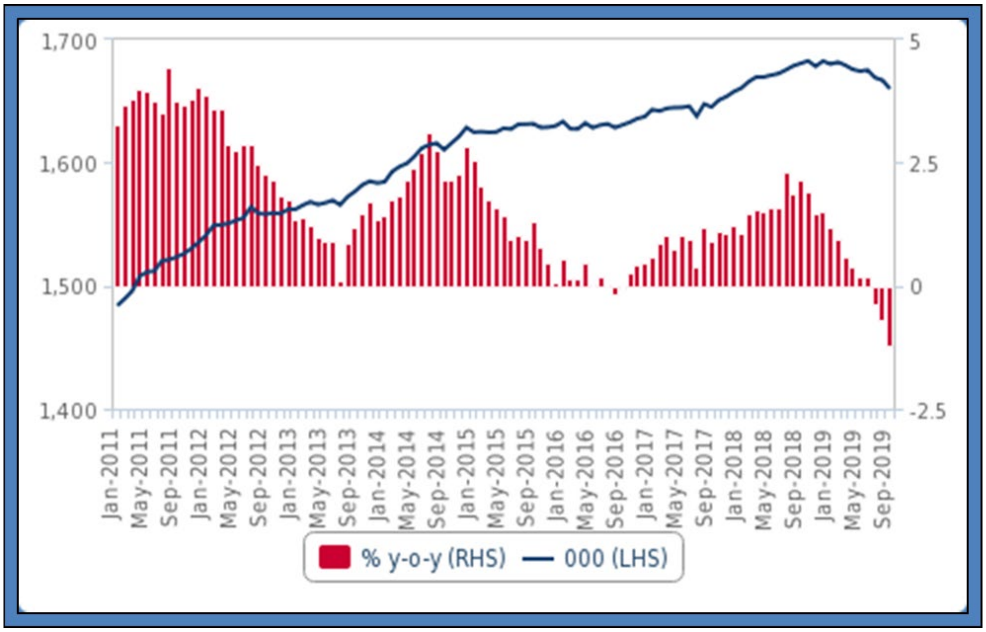
Clearly, trade dispute tariffs sharply diminish the attractiveness of U.S. soybeans to Chinese consumers and in consequence the Chinese export market is in sharp contraction. As noted by Caruso (2019), the trade dispute-distorted market is telling South America to expand production at the same time as the U.S. is holding record inventories. "If markets could operate freely, the lowest cost supplier, in this case the U.S., would see an increase in exports allowing its balance sheet to improve while pressuring South American premiums and signaling that current production is adequate, and expansion unnecessary," concludes Caruso (2019).

The concern going forward is whether supply chains have been altered forever (McGregor, 2019). And therefore, domestic producers face the decision of whether to cease, or at the very least reduce, capital investments. Such decisions being made now, with the currently available information, could have major ramifications for years to come.

This same type of scenario is playing out in several industries beyond agriculture. In manufacturing, the U.S. fared worse than China towards the end of 2019 (Lockett, 2019). The U.S. Purchasing Managers' Index (PMI) fell below the psychologically important 50 mark in Q4 after standing at 59 a year earlier and above 60 at the beginning of 2018 according to Bloomberg data; meanwhile China's Caixin PMI rose to 52 in the final months of 2019 after languishing in the upper 40s for most of the year.

Against this backdrop, the U.S. administration's public position has continued to be that "China will pay" for the trade dispute tariffs which have been imposed – omitting the impact of countermeasures on the U.S. consumer and exporter. For the U.S. president's re-election campaign, the importance of actual trends in vulnerable sectors highlights a possible need to address a potential political as well as economic vulnerability: manufacturing employment is disproportionately represented in many key states which helped him win the White House in 2016.

Figure 4
U.S. 2020 Swing States in a Downswing: Pennsylvania, Wisconsin and Michigan – Net Manufacturing Employment



Sources: U.S. Bureau of Economic Activity, Fitch Solutions.

In retailing, in the face of rising costs, prior to 2018 many U.S. firms had already begun the process of resourcing inputs from outside China, as with Thailand, Vietnam and Cambodia, among others in South East Asia as the main beneficiaries. But tariffs on a wide range of Chinese products has accelerated the process. In a wide range of goods from household items to clothing to bicycles, U.S. retailers are turning away from long-standing Chinese suppliers. When a lasting resolution to the trade dispute is reached, will they be able to turn back?

Supply chains in retail and manufacturing may be less reversible than elsewhere. Stated one major retailer, Morris Goldfarb, CEO of G-III Apparel in Gray (2019): "Once you get your production out of China. . . you can't bring it back. Those factories will go out of business," adding "you still need to keep a foothold [in China], until we fully recognize the depth and term of the problem."

Reversal Misfortune

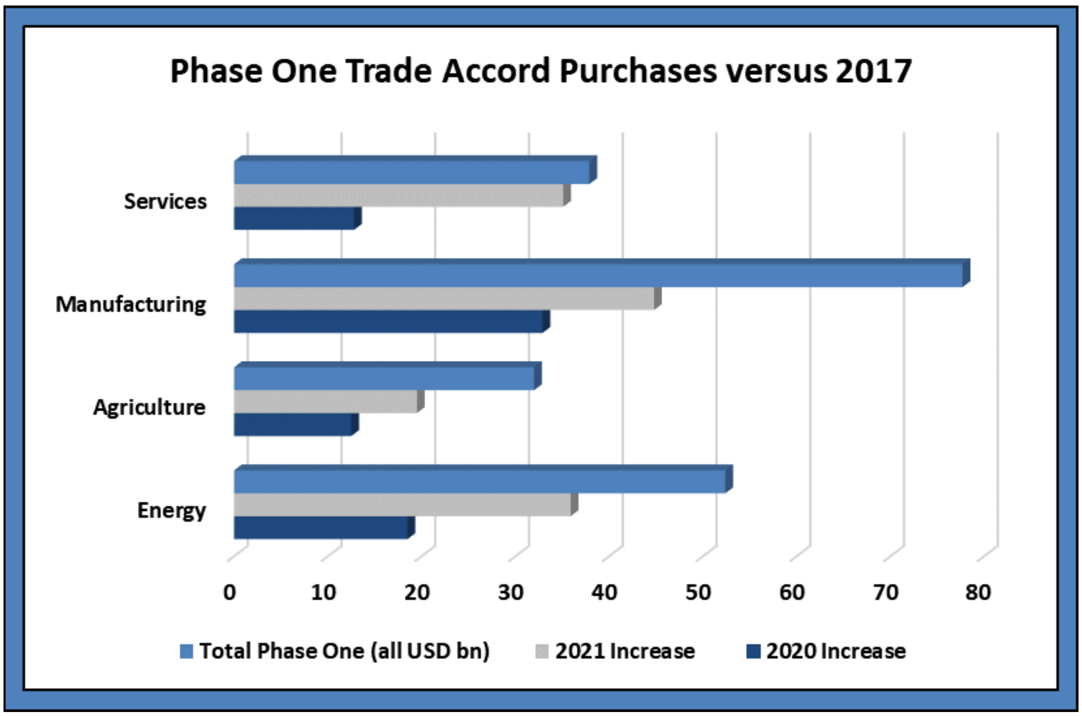
The impact of tariffs or indeed outright embargos on raw commodity imports can be gauged and is calculable, as well as potentially reversible, if one party, i.e. China has a clear, gaping void in its current supply network, even after allowing for additional supplies from new entrants. This is likelier to be the case with protein and other agricultural foodstuffs given that the U.S. presumably is still a willing legacy supplier, at the ready to return to fill the gap.

However, where outsourcing of production facilities is concerned, involving long-term investment decisions and suppliers who in turn are also dependent on their own secondary supply channels, the opportunity to restore old relationships and revive prior supply channels is far from obvious, as illustrated above for the manufacturing and retailing sectors.

In agriculture, despite the likely long-term damage to Chinese import levels of U.S. produce, the targets announced by the U.S. administration at the Phase One signing for agricultural purchases in the 2020-21 period not only diverged in the opposite direction: official pronouncements suggested that exports to China must not only rebound but also grow to sharply *higher* levels than they were prior to 2018. Instead of returning to around the previous levels of $25bn over time, or somewhat less, on January 15th, 2020, the White House confirmed a Chinese pledge to increase agricultural purchases by no less than $32bn over two years, benchmarked against a 2017 baseline.

Within the Phase One deal, similar pledges were received for purchases of manufactured goods (plus $77.7bn over two years), energy (plus $52.4bn) and services (plus $37.9bn) by the end of 2021, all increased pledges gauged against 2017 rather than 2019 levels.

Figure 5



Source: Economic and Trade Agreement between the Government of the United States of America and the Government of the People's Republic of China, Washington, DC, January 15, 2020.

Investment Battered

There are few winners as markets become paralyzed and decisions are made under irrational circumstances. The long-term stability needed for capital investment has been badly shaken by the trade dispute too, and due to its nature will doubtless take longer to recover when tensions recede. Overseas fixed investment into the U.S. declined in 2018-19 compared to 2015-16 levels according to the U.S. Department of Commerce; after peaking at average levels of $150-$200bn per quarter in 2015 and 2016, quarterly total Foreign Direct Investment (FDI) into the U.S. now averages between $50-$100bn. While China was not traditionally a top FD investor into the U.S. compared to Western Europe, Japan and Canada, its share had been growing rapidly in the past decade, a trend which has now stalled as a result of the trade dispute.

For portfolio investors too, keeping up with market opportunities resulting from new trading approaches requires a different analytical framework with strategies crafted to handle what has until now been a volatile, see-sawing environment. Talks which lead to deals that in turn can be cancelled or modified only contribute to raised uncertainty.

In equities trading, initiatives to enhance China's financial reform and eventual freedom of capital movement such as the Shanghai-London Stock Connect and the Qualified Foreign Institutional Investor (QFII) program may also be put in jeopardy. Cost curves, pricing and revenue projections are forced to take a back seat to geopolitical analysis and speculation surrounding summitry as the essential tools of investment decision making, a serious albeit second-level distortion of free trade.

To attest to the fact that we have entered a totally new supply chain order whose influences hail from well beyond the world of business and economics, the examples of the long running social-political strife over Hong Kong's future form of government, as well as the U.S. and Iran edging to the brink of war in the early days of the New Year, serve as two poignant examples. Furthermore, by the spring of 2020, with China recovering but the U.S. still in the midst of its struggle to overcome COVID-19, recriminations relating to the pandemic's initial outbreak and spread seemed likely to further cloud broader U.S.-China relations.

2020 will be a crucial year for both the U.S. and China in stabilizing and redefining their domestic political arrangements as well as in their commercial and political relations with each other. In the introduction to this article a historical framework for analysis was outlined suggesting that the events of the past two-plus years of the trade dispute can be viewed very differently by actors on the Chinese side to those in the U.S., with the former very much looking at the long term and with the sense that the current tide of history is on its side. If pragmatism and compromise prevail, this perspective could still coexist whoever is the next occupant of the White House and whatever the composition of the next U.S. Congress.

The maintenance of smoothly functioning supply chains will remain critical for both countries going forward. But in the of wake of the public health emergencies of 2020 in both countries, the emphasis in future talks is likely to be markedly different from what came before.

Commodity supply channels as we have known them until recently are only partly within the control of the negotiations. Their future shape will depend partly on the speed with which trade deals are completed as well as the flexibility and relative economic strength of third parties outside the conflict. As seen in this discussion, in many cases it may be too late for these to resume their previous configuration which would then present further opportunities for new actors as well as more uncertainty for incumbents.

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Author Biography

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Mr. 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 global macro fund until 2008 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 the *GCARD* in 2018.

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Mr. 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: *Paul Kagame and Rwanda* (2004) and *Charles Taylor and Liberia* (2011). He also contributed the chapter, "Collision: Investing for the New World Commodity Order," in the book, *Intelligent Commodity Investing* (2007).

Mr. Waugh previously contributed to the Winter 2017 issue of the *GCARD* on the "Convergence in World Natural Gas Prices."

The Big Oil Short: This Time is Different

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Introduction

As of the writing of this article, the Saudi-Russian oil supply dispute and the global health crisis had both thrown the oil market into crisis. Clearly, the U.S. president stepped in to end a price war which put a floor to a devastating oversupply and pushed OPEC+ back from a self-initiated volume strategy back to a "traditional" price strategy. While oil markets should recover from the extreme price lows that have been due to these supply-and-demand shocks, we argue that difficult structural changes will remain for the global oil industry. In this article, we review the history of Investment and Exploitation phases in the oil markets, and then note how this time may be different because of pressures to substitute away from oil, especially in Europe.

A Review of Oil's Investment and Exploitation Phases

Commodity supply cycles can be divided into Investment and Exploitation phases, sometimes also called an Oil Supply-constrained World and an Oil Demand-led World. These phases coincide with times that oil prices find support in times of (fear of) shortages or fall in times of (belief in) abundancy. At the start of this new decade, investors face two important questions. Will we eventually enter a new phase of tighter markets, and thus higher oil prices, due to a lack of investment with the current Exploitation phase coming to an end at some point? That is, is today comparable with 1998/1999 when oil prices dived to the low tens, and from there rose steadily to $50 a barrel in 2005? Or will a decline in the demand for oil lead to a continuation of ample supply and thus lower prices while we enter what we call a final "Oil Substitution phase"? But perhaps even a more pressing question would be the decisions the industry will take when higher prices signal to invest more in oil, while societal and investor demands ask them not to do so, particularly in Europe.

The Investment and Exploitation phases historically created on average a full 22- to 27-year supply cycle; see Figure 1 on the next page. Excluding the first short boom-bust cycles at the start of the modern oil industry, we are currently in an Exploitation phase, which started in 2012, the 7th since 1859. In this article the focus is on the last two cycles. The second-last investment cycle started in 1974 and ended in 1984. It was characterized by rapidly rising oil prices and, more importantly, attractive returns for producers that induced investment in new capacity, during this period notably in Alaska, the Gulf of Mexico, Mexico and the North Sea. All those regions required high oil prices and the unconditional belief that they would stay high long enough to persuade oil companies to develop those high-cost reserves. However, the investments in new supply eventually overwhelmed demand growth and created the next Exploitation phase, where the market "exploits" the existing capacity built up during the preceding

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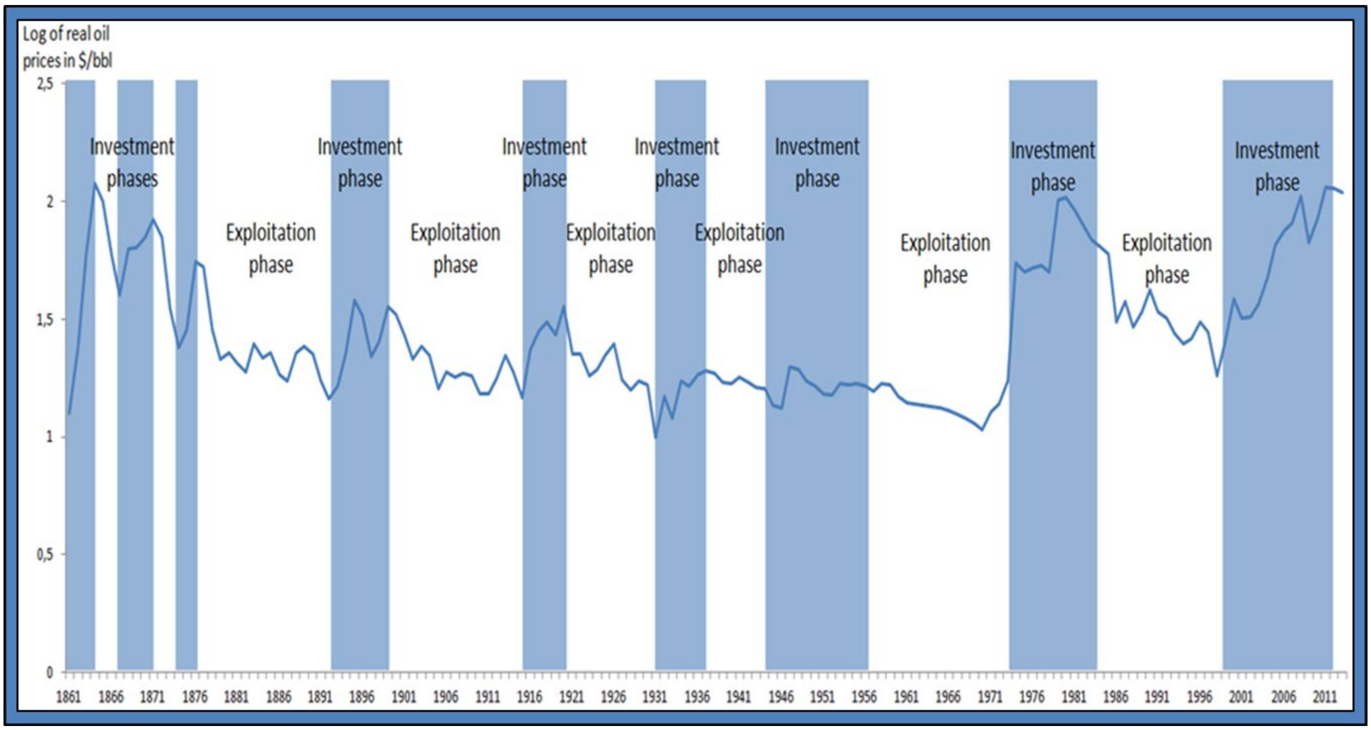
Investment phase. This build-up was huge and unprecedented: OPEC spare capacity peaked at an all-time high of 13.5 million b/d in 1985, or about 22.5% of global oil demand. Started by the price collapse of 1986, the Exploitation phase extended over the rest of the 1980s and the 1990s and cumulated into a further price collapse in 1998 with an average oil price of $12.50 per barrel in that year. At the time there was a widespread belief that oil prices would continuously stay low (the *Ten Dollar Oil World*). The ink of a very comprehensive study on oil prices for the board of Royal Dutch/Shell, where company analysts were mandated to "proof up" that prices would stay low (in line with Shell's New Game scenario of 1998), was not yet dry when oil prices started to recover. In 2000 the annual average price was already $28.50 per barrel. By the turn of the century, all excess oil was eventually absorbed by a growing market and slowing investments during the long Exploitation phase. OPEC cuts through quotas became less fashionable and could eventually be reduced from 2000 onwards. New oil was needed. The start of a new Investment phase became reality.

Figure 1
Investment and Exploitation Phases Since 1861



Source: Goldman Sachs.

Note: From 2012 onwards the oil industry moved to the 7th Exploitation phase.

It is important to emphasize that when the market outlook starts to deteriorate and the oil market moves into surplus and thereby transitions into the Exploitation phase, oil prices collapse and margins compress, as happened in 1986 and again in 2014. Many of the market dynamics of the previous Investment phase are inverted during the Exploitation phase (and vice versa.) Producers are forced to shift their focus away from investing and towards improved operating performance and capital discipline - with a strong focus on ROACE improvements and diversification, and to deliver shareholder value. ROACE stands for the Return on Average Capital Employed, which is a useful ratio when analyzing businesses in capital-intensive industries such as oil. In this context the publication of a grand strategy study, "The Atomization of Big Oil" by McKinsey in 1997 spoke volumes about their view of the industry (Bleakley *et al.*, 2007). Their advice was embraced by many Oil Majors, who moved into electricity, renewables, capital solutions services, in combination with super-mergers. Improved operating performance (of the core oil & gas upstream business) through restructuring was the way to substantially improve capital and labor productivity, creating strong downward cost pressure, the benefits of which could be returned to shareholders to maintain investor returns.

During the Investment phase the behavior is basically moving in the opposite direction. A combination of strong demand growth against the backdrop of supply constraints pushes oil prices rapidly higher. Fast rising oil prices, in turn, give a strong signal to the industry to invest more. A strong preference develops to think big and spend fast. Allocation of labor and capital resources moves away from operations into growth projects. A "Valhalla"[1] is created for engineers and developers who get a free hand to build the largest and most complex projects ever. Oil price moves in 2004 to 2007 from $38 to $72 per barrel led to a doubling of oil & gas investments, ultimately leading to higher non-OPEC supply half a decade later. In the meantime, rich cash flows drove rapid international expansion, while market perception of long-term supply shortages incentivized much smaller Exploration and Production (E&P) companies to step up their ambitions and to become operators of major developments across the globe. However, the Investment phase of the cycle also reinforces higher inflationary costs through excessive spending and the urgent need of new oil services equipment. At the same time, operational cost performance tends to deteriorate severely during this phase with serious cost overruns and project delivery delays, but high and rising oil prices more than offset the resulting increase in production costs and cost inflation of the projects under construction.

One of the key drivers behind the last Investment phase of the 2000s was the urgent need to develop a whole new set of highly expensive equipment. This was needed for the drilling of the most complex wells in ever deeper waters and in ever more hostile environments, as well as for construction of new production units to be installed in these Deepwater and frontier regions. Only high oil prices, and the expectation that they could go higher still - at the top companies such as Gazprom quoted $200 oil - would allow the oil companies to grant long-term charter rates, which enabled the service industry to order new equipment. In other words, the day rates rose above the full cost of a single investment, promising fantastic returns. Similar to the 1974-1984 Investment phase, the Investment phase of 1998-2012 delivered far more than anticipated new oil ready for development and extraction, including in Iraq, Brazil, Canada, and in Russia, and most importantly through shale oil in the U.S. And similarly, as in the early 1980s, it again created a sustained period of overinvestment, notably during the first half of the last decade and, due to U.S. shale, continued even longer. This eventually led to a new Exploitation phase around 2012 and the collapse of oil prices in 2014.

Shale Oil Led to a Different Type of Exploitation Phase

The current Exploitation phase where we "exploit" the discoveries and newly available and economically recoverable resources unlocked in the preceding Investment phase is different than earlier periods because of a new oil & gas revolution led by U.S. E&P companies. They unlocked 100+ billion barrels of U.S. shale oil resources. The U.S. shale revolution was different than prior cycles due to the fact that the planning for development (PFD) was shortened to less than a year, followed by smaller investment decisions that led to a production profile with a short plateau and steep decline requiring additional investment. This was significantly different from projects sanctioned during the prior investment phase. While the incentive to continue investment disappeared everywhere outside the U.S. well before the 2014 price collapse, supply growth continued. This growth continued because of the aggressive drilling and completion of new shale oil wells in combination with the completion of new conventional oil projects elsewhere around the globe that had already been approved before 2014. This new reality put even more pressure on costs than ever before and has triggered a long period of cost deflation.

Exploitation Phase to End Soon? What's Next?

Under normal circumstances the current Exploitation phase would eventually come to an end and would be succeeded by a next Investment phase, continuing the cycles of the last 150 years. However, this expectation is partly "neutralized" by the massive reserve-life of U.S. shale oil, which is still running its course. That said, the current extremely long reserve-life has already come down materially, driven by rapidly growing production, likely making U.S. shale oil a mature business in the coming years. Additionally, while there are vast shale resources outside of the U.S., other countries have not been able to replicate the U.S.'s success. At the same time, capital markets finally had enough of the wealth destruction due to U.S. shale companies continuing to outspend their cash flows. Since 2019, Wall Street has basically been closed for the marginal, underperforming and overleveraged producers, especially in the U.S. shale oil & gas space. Without access to investment capital and large debts coming closer to their final maturity date, there is no alternative than to shift focus from aggressive volume growth to a focus on (a) capital discipline, (b) strengthening balance sheets and (c) providing a competitive return to investors. The coronavirus has turned this process instantly into a very serious problem with oil prices dropping to below cash cost levels as demand crashed by 20 million b/d.

Hence, annual shale oil production growth is slowing down now faster than already projected before corona; year-on-year it should decelerate materially in the next four quarters, from more than 800 thousand b/d in the 4th quarter of 2019 to about 400 thousand b/d in the 4th quarter of 2020. This would result in less than 1 mln b/d yoy total U.S. liquids growth in 2020 compared with 2.2 mln b/d in 2018 and close to 1.6 mln b/d in 2019. But today, this decline in U.S. supply is tentatively estimated at -2 million b/d a year from now from 1st quarter 2020 levels. Meanwhile non-OPEC ex-U.S. shale production is now in its final year of growth as the last wave of long-cycle projects sanctioned in 2013 and 2014 are now coming onstream and reach their production plateau soon. Underinvestment and the abrupt slowdown in the pace of sanctioning new oil projects since 2015 will thus start to impact production growth beyond 2021. Again, the COVID-19 virus has caused a deferral of circa 75 percent of all projects ready to be sanctioned for development this year. Several might be postponed indefinitely. We will therefore see a much thinner pipeline of big long-cycle conventional oil developments, leading to overall declining production early in the 2020s, and a deceleration in U.S. shale growth owing to higher declines from a larger overall production base, a reduction in profitable drilling locations, and slowing productivity improvements not much later. Together, this will ultimately have an impact on the supply side of the oil supply-demand equation. On top of these "natural" industry pressures also comes the increased pressure from investors through new Environmental, Social and Governance (ESG) demands. This new pressure will reduce the ability of the Majors to accelerate oil field developments and will contribute to the future supply-demand dynamics of oil. With fast growing debt levels rising to (or beyond) the top of their target ranges, money will become a scarce commodity for them as well.

To Invest, or Not to Invest? That's the Question

It is very well possible that within a few years, apart from a deep and long structural economic recession, we will see the current Exploitation phase coming to its natural end, and the beginning of a new price boom. This might come as a surprise to many though, as the broader public sees low oil prices as an enduring phenomenon like they did in 1998. But oil prices will find a new upward trajectory once the worst part of the corona impact is behind us, supported by the long-term signals OPEC+ has given about the duration of their production cuts. With shale oil starting to show fatigue, after the immense oil inventories currently building up have been drawn, there will be a moment that allows OPEC+ to start unwinding its production quotas. The big question then is if oil companies will respond to higher prices and embark on a new Investment phase. An even more pressing question is how strong such an Investment phase will be, and hence how far oil prices will rise. Some argue that it will be weak and relatively immaterial as the world will quickly move into the ultimate "Oil Substitution phase," which will "neutralize" the demand for higher oil investments. In such a case, temporarily higher oil prices will not lead to more upstream oil supply investments but to more renewable investments (as they become more competitive vs. oil and gas). Longer-term, the expectation of oil prices going lower will not help either. The big National Oil Companies (NOCs) and the International Oil Companies (IOCs) might thus decide to "underinvest" in their upstream businesses and let their oil production levels be stable at best, or more likely to gradually and naturally decline over time.

The bigger free cash flows from higher oil prices will then be used by the IOCs - notably the European ones - to transform their companies from oil & gas companies into truly energy companies in the next decade. The NOCs will also need to restrain their investments and utilize their excess rents from higher oil prices to restructure their "old" economies into "new" ones and become less dependent on oil revenues instead, while finding new ways to monetize their oil reserves. Hence, the industry shows growing characteristics of a constrained rentier state, while investors – only those who are still willing and allowed to invest in Big Oil – demand increasingly higher returns. Meanwhile those big oil companies which decide to embrace the transition from "Big Oil" to "Big Energy," and thus make bigger investments in renewables will have to find ways to keep their Return on Equity and ROACE at levels comparable with those they have historically made in oil & gas. So far, the Majors have struggled with this as they need big businesses in renewables comparable to the size of their oil & gas businesses to be relevant, and those big businesses have had utility types of returns. Moreover, the Majors' corporate capital structure with low leverage is too expensive to compete in the renewables business and hence to successfully grow, as long as their Weighted Average Cost of Capital (WACC) is around 10 percent and rising and their leverage is about 25%. In other words, as long as their "Oil" required capital structure and cost of funding is also applied to acquiring renewables businesses at a large scale, it will not be surprising if they lose in their acquisition endeavors from companies who have access to cheaper funding and can accept lower returns than the oil industry's WACC. Hence, overall profitability could come under immense pressure, only kept up by higher oil, gas and energy prices, while their renewable energy ambitions reduce their ability to accelerate oil field developments when needed. The current impact from COVID-19, forcing the Majors to borrow heavily for dividend purposes, will only further constrain them in investing in lower-return projects. In the meantime, they will maximize value and longevity of their core production basins and reengineer their upstream portfolios for resilience. Compensation by investing in large-scale expensive carbon capture, utilization and storage (CCUS) will be part of their solution. Moreover, this pressure on the IOCs is directed mainly at publicly traded (Western European) companies and impacting Chinese and other Asian state companies less. This could lead to a change in ownership of new oil field developments. In addition, a more concentrated and constrained industry could lead to lower volume growth.

Oil Substitution Goals Lead to Shifts in Investments

Oil substitution goals are reshaping the traditional oil and gas industry fast and in an unprecedented way. COVID-19 will contribute to this shift in an uncertain way. The above-mentioned pressures on the Majors are increasingly coming from capital markets, both equity and credit, and also from institutional investors. Likewise, banks and bondholders are tightening financing for oil (and to a certain extent natural gas) assets, as well as for the oil services industry. This may not be a temporary phenomenon: it could be a structural event and increase in pace as demonstrated by the shift in sentiment and buying patterns of Millennials. Western European banks are mostly looking to discontinue financing new oil projects over the longer term. The JOSCO Energy Finance and Strategy Consultancy expectation is that those banks, historically the world's largest arranging banks for syndicated loans to the oil industry, will steadily decrease their total one-obligor exposure and will become increasingly unwilling to finance new oil field developments and renew corporate loans to the industry. Tightening financial conditions on new oil and natural gas developments would lead to a consolidation and higher barriers to entry in the traditional oil and gas industry. While demand for good returns on investments (i.e., oil companies' dividends) remains equally important, younger and more ESG conscientious investors are increasingly less interested in buying old-economy "oil and natural gas" shares. They have a growing negative perception of the oil & gas industry. Instead, they show a high willingness to invest in renewable companies. Today, there is still a material difference between location and age, where Northwest European investors, banks and capital markets in general are most outspoken against oil & gas while emerging markets are far less so. But it may be just a matter of time before the push from new ESG regulations will further accelerate and negatively impact traditional hydrocarbon activities. Nevertheless, post-corona oil demand is likely to stay robust for the foreseeable future, fueled by rising prosperity and population growth in developing countries, notably in Asia. Demand changes and oil substitution is only taking place slowly in the coming decade. Post 2030, a more radical change is possible but is still a monumental task. While not (yet) forecasted, global oil demand might not bounce back straight to the 100 million b/d we had in 2019. This might take longer than currently projected due to structural socioeconomic changes in the global economy post-corona. But at the same time, the current demand crash will likely result in a permanent loss of oil production. The question is how the balance will pan out.

Temporarily higher oil prices will not trigger higher investments next time as long as oil companies foresee a bleaker picture with lower demand and oil prices in the first ten years of production. Given that it still takes five years on average to develop big long-cycle conventional oil fields, it only makes sense to sanction those new developments if they have truly low and competitive break-even prices. In addition, markets may become increasingly focused on a transition away from hydrocarbon resources. Moreover, having reengineered their upstream portfolios for resilience towards natural gas and left with a more concentrated oil portfolio, there are not many new oil basins available to support a next Investment phase. Arguably, there is now no new oil region waiting to be developed, other than in the Oil sands, Arctic, or in war zones. This is different than in the past when (a) new discoveries were made in the North Sea, Alaska and Mexico in the 2nd half of the 1970s and the first half of the 1980s and higher oil prices triggered an investment spree, and when (b) further projects were developed in Iraq, Brazil, Canada, Russia and in U.S. shale oil during the investment boom of the 2000s and first years of the 2010s. For future growth we may have to do with known oil basins, and most of that is in the Middle East, and to a lesser extent in the "Golden Triangle" Atlantic deepwater basins. It is very well possible that as a result, each continent will move in its most favorable direction: the U.S. counting on domestic shale oil; Europe accelerating an energy transition away from oil; and Asia looking increasingly to the Middle East, Russia and other oil producing countries in the developing world. In the meantime, central banks and other global financial institutions have to manage any upheaval, especially at a time when oil prices and inflationary pressures start to increase, recognizing that there is a risk of crisis if the "ultra-low interest rate era" ends. There is a danger then that the debt levels in emerging markets and in parts of the developed world, fueled by the era of very low interest rates, become a serious concern if and when we enter into the next Investment phase, at a time when the forecasted Substitution phase is not yet strong enough to take over the helm. The massive increase of fiscal and monetary stimulus - valued at over $5 trillion - to help neutralize the devastating socioeconomic impact of the coronavirus will only worsen world debt levels for which new solutions will have to be found.

Big Energy Facing Crossroads. How Explicit Will They Communicate Their Strategies?

Nobody ever said that an energy transition would be smooth and easy, and corona will not help either. The above-mentioned picture stands diametrically opposed to a shift into the next Investment phase. It suggests that we might move directly from today's Exploitation phase into the final Oil Substitution phase. In the latter case, oil companies will likely be faced with a rapidly deteriorating share price as the value from their traditional upstream business faces both a gradual decline in production volumes and possibly lower oil prices in the next decade. Current investors, expecting cash returns (dividends and buybacks), would become insecure about whether the oil industry will be able to successfully transform into big energy companies. They may start questioning whether their non-oil businesses (i.e., natural gas/LNG and renewables) and trading businesses will deliver enough cashflow. If this substitution does not materialize and the oil world starts showing all the characteristics of a new Investment phase, the question is whether the short-term gains would be higher than the long-term pain. Short-term higher oil prices would result in excess cash ready for accelerated investments in renewables, but long-term pain could come from lower oil production and lower prices further out when, indeed, the Oil Substitution phase could develop in earnest. This means that any investor in oil today must decide if it is better to short Big Oil, or enter long positions anticipating that the world will find itself short of oil in say five years' time.

Endnotes

1 "Valhalla" refers to the storied, Viking heaven and metaphorically evokes a glorious time.

For further coverage of the crude oil markets, one can read past *GCARD* articles on these markets.

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Machine Learning – A Machine's Perspective on Positioning

Mark Keenan
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Book Overview and Summary

Advanced Positioning, Flow and Sentiment Analysis in Commodity Markets is a new book focusing on positioning dynamics in commodities. The book covers substantial new material, but also updates and builds significantly on some of the work in the previous book, *Positioning Analysis in Commodity Markets – Bridging Fundamental and Technical Analysis*, by Mark Keenan. New material includes analytics based on the analysis of flow, the decomposition of trading flows, trading activity in the Chinese commodity markets, the inclusion of newsflow into Positioning Analysis and how machine learning can provide insight into trading relationships.

Behavioral patterns driven by positioning and flow dynamics can change and evolve as different types of market participants enter and leave the market and as new price drivers emerge, which can lead to the formation of new patterns and relationships. The book provides new and alternative ways of thinking about commodity markets with new tools and analytics to help understand them better, track how these relationships evolve to improve trading performance, and risk management.

The ideas, insights, and concepts behind the signals, indicators, and models in the book have been developed over the last 20 years throughout a variety of different market conditions and regime changes. In many cases, their construction is unique, but in all cases, the approach is robust, intuitive, and accessible to commodity market participants and risk managers on a variety of levels and in different areas of the market.

This digest article is based on the final chapter of the book on machine learning. It introduces decision trees and random forests as ways of potentially uncovering relationships between changes in positioning and changes in commodity prices.

The objective is to use a machine to identify which aspects of positioning are the most useful in helping to understand commodity markets from a machine's perspective.

It shows that machine learning is particularly useful in the analysis of positioning data, with "feature importance" a powerful way of identifying new patterns and new relationships in positioning.

The results provide alternative insights that can help improve how other positioning signals, indicators, and models are interpreted and used.

Introduction to Machine Learning (ML)

> Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence.
>
> Machine learning algorithms build a mathematical model of sample data, known as "training data", in order to make predictions or decisions without being explicitly programmed to perform the task.
>
> Machine learning algorithms are used in the applications of email filtering, detection of network intruders, and computer vision, where it is infeasible to develop an algorithm of specific instructions for performing the task.
>
> Machine learning is closely related to computational statistics, which focuses on making predictions using computers. The study of mathematical optimization delivers methods, theory and application domains to the field of machine learning.
>
> Data mining is a field of study within machine learning and focuses on exploratory data analysis through unsupervised learning. In its application across business problems, machine learning is also referred to as predictive analytics.
>
> Source: https://en.wikipedia.org/wiki/Machine_learning

The main objective of Machine learning is to uncover predictive relationships within datasets. It is broadly divided into two areas: supervised learning and unsupervised learning. In supervised learning, an algorithm is first calibrated (or trained) on a dataset to identify relationships between a group of input variables (X) and an output variable (Y). In unsupervised learning, the algorithm seeks to identify patterns within the input variables.

In this article, decision trees (classification and regressions trees) and the random forest algorithm (classification and regression random forests) are introduced as ways of uncovering relationships between changes in positioning and changes in commodity prices - specifically to learn which aspects of positioning are the most useful in helping to better understand commodity markets, from a machine learning perspective.[1]

Tree-based learning algorithms – including decision trees and random forests – are amongst the most-used learning methods and can map non-linear relationships easily.[2] One advantage of ML is that the results are often easily interpreted and can easily be used alongside other signals, indicators, models, and analyses to provide additional/alternative insight in Positioning Analysis.

To generate the decision trees, to produce the random forest and to do the feature importance analysis in this article, the application XLSTAT is used. XLSTAT was chosen due to its ease of use, its stability and detailed help files. Furthermore, to use XLSTAT, no programming knowledge is required, and it runs within the Excel application as an add-in. Python is an excellent alternative, and arguably one of the leading programming languages in ML, but it naturally requires some programming skill.[3]

Decision Trees

The objective of this section is to provide a full explanation in a series of stages and examples, of how decision trees are constructed and how they can be used in Positioning Analysis.

A decision tree is a supervised learning algorithm designed to predict an output variable, for example the weekly return of crude oil (WTI). The output variable can also be called the target variable.

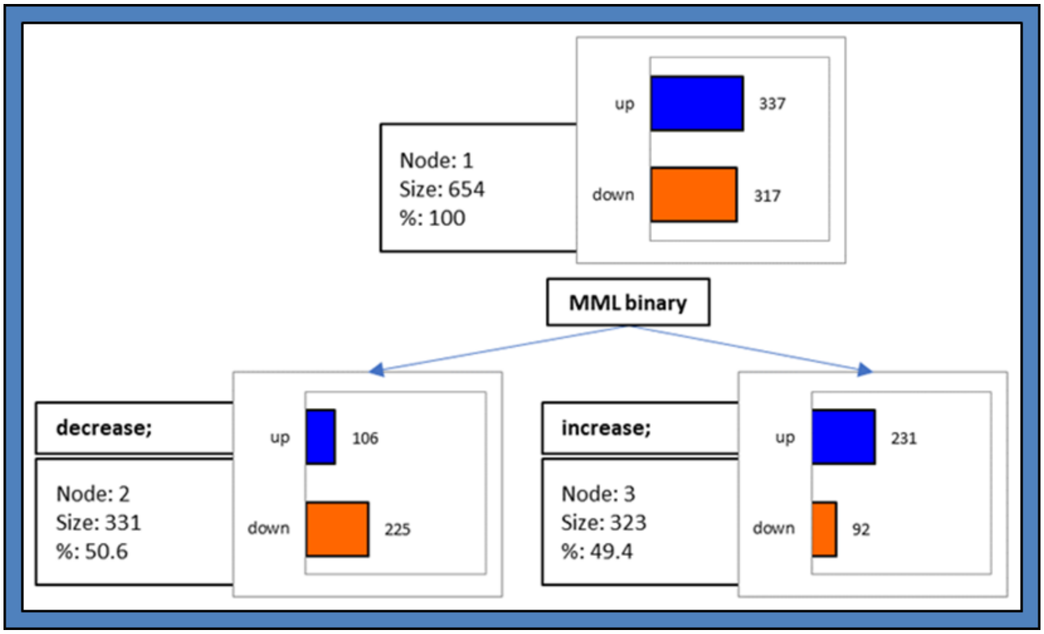
The function of a decision tree is to split the output dataset (the price returns) into two or more subsets, for example positive and negative returns, using specific decision rules derived from the input dataset, for example changes in positioning data. The variables contained in the input dataset are known as the features.

The decision tree identifies the most differentiating features in the input dataset, as well as the threshold values that best split the output dataset into the most homogeneous subsets.

Decision Trees Using Binary Data

Figure 1 on the next page gives a simple example of a binary decision tree set-up to predict whether prices of crude oil (WTI) increased or decreased over the week based on binary changes in Money Manager Long (MML) and Money Manager Short (MMS) open interest, as reported by the CFTC in the Disaggregated Commitments of Traders (COT) report every Friday.[4] The decision tree identifies the variable (either MML or MMS) that best separates the weeks where prices increased from those where prices decreased. The underlying algorithm used here only uses two binary features: whether MML or MMS increased or decreased their positions in terms of open interest.

Figure 1
Decision Tree Based on Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices)



Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The underlying data consists of 654 weeks (June 2006 to December 2018) of MM positioning data and price data. The weeks run from Tuesday to Tuesday, to be aligned with the COT release schedule and prices are therefore contemporaneous to the positioning data.

The algorithm then identifies the "best question to ask" to generate the most homologous (most uniform) child nodes. The question is: whether MMLs (as opposed to MMSs) changed their position. The underlying algorithm is explained fully in "The Decision Tree Algorithm – How Does it Work?" on the following pages.

Observations from the decision tree diagram in Figure 1:

- Node 1 (also referred to as the root node) shows the 654 weeks divided into 337 weeks where crude oil (WTI) prices increased and 317 weeks where they decreased. It is therefore also called an up-node.

- Node 2 shows that out of the 654 weeks, MMLs decreased their position in 331 weeks. Out of those 331 weeks, crude oil (WTI) prices rose in 106 of the weeks (32%) and fell in 225 of the weeks (68%). It is therefore also called a down-node.

- Node 3 shows that out of the 654 weeks, MMLs increased their position in 323 weeks. Out of those 323 weeks, crude oil (WTI) prices rose in 231 of the weeks (72%) and fell in 92 of the weeks (28%).

The confusion matrix below, a table displaying the number of successful and unsuccessfully-classified observations for each of the categories shows that 69.72% of points in the entire dataset of 654 weeks were correctly classified by this tree – a good percentage. Simply put, this means that increases (decreases) in MML position are associated with up (down) moves in crude oil (WTI) prices.

Table 1
Confusion Matrix Based on Binary Input Changes (MML and MMS) and Binary Output Changes (Crude Oil (WTI) Prices)

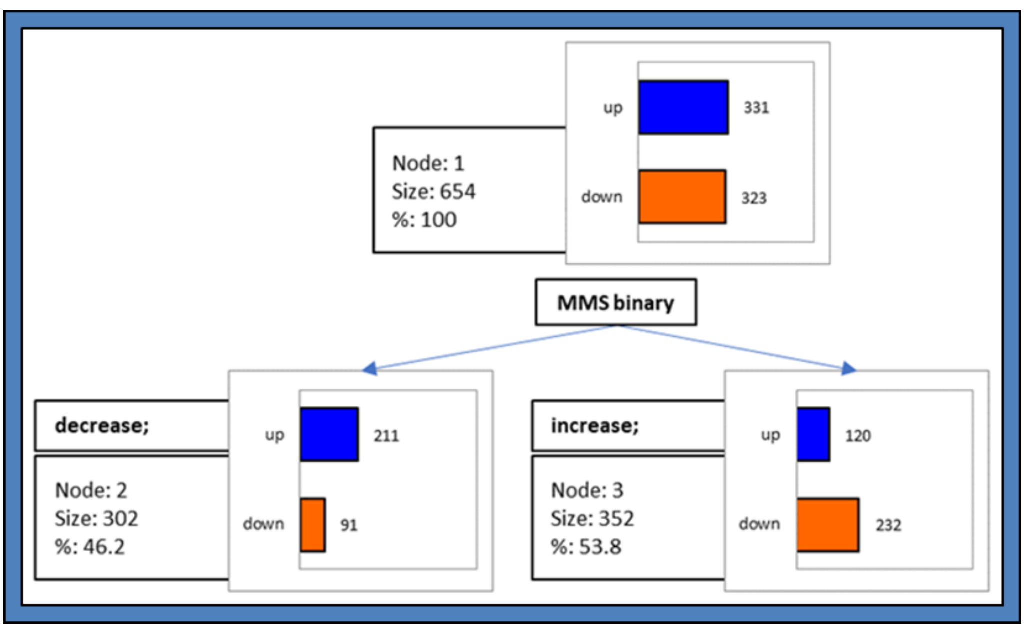
Confusion matrix

from \ to	up	down	Total	% correct
up	231	106	337	68.546
down	92	225	317	70.978
Total	323	331	654	69.72477

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Figure 2 shows a similar decision tree, but for natural gas (NG). Here the tree, set up in the same way as the tree in Figure 1 identifies the "best question" to ask as whether MMSs (as opposed to MMLs) changed their position.

Figure 2
Decision Tree Based on Binary Input Changes (MML and MMS) and Binary Output Changes (Natural Gas Prices)



Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The Decision Tree Algorithm – How Does it Work?

The decision tree in Figure 1 splits the tree according to whether MMLs changed their position, whereas for natural gas in Figure 2, it was the opposite, asking whether MMSs changed their position.

The criterion used here to split the tree is the Gini index. It is a measure of dispersion within a dataset and measures the degree of homogeneity. A value of 0 means the dataset is perfectly homogeneous, while values near 0.5 represent a heterogeneous dataset (0.5 is the highest value). In this binary example, where prices either increased or decreased, a homogeneous sample would consist solely of price increases or price decreases, whereas a heterogeneous set would consist of a mix of price increases and price decreases.

The Gini index is calculated as follows:

$$Gini = 1 - \left(\left(\frac{\text{number of price increases}}{\text{number of observations}}\right)^2 + \left(\frac{\text{number of price decreases}}{\text{number of observations}}\right)^2 \right)$$

The Gini index for the root node in Figure 1 is calculated to be:

$$Gini = 1 - \left(\left(\frac{337}{654}\right)^2 + \left(\frac{317}{654}\right)^2 \right) = 0.500$$

To then split a branch into two, all the possible Gini scores of all the possible splits are calculated. In this example there are two possible splits, by changes in MMLs or by changes in MMSs. The split that yields the two branches with the highest degree of homogeneity on average, computed as the lowest weighted average Gini score, is chosen.

For example, after a split by changes in MMLs, two branches containing 331 and 323 observations are generated. The Gini score of the left branch is 0.435 while the Gini score of the right branch is 0.407. As a result, the weighted average Gini score is:

$$Weighted\ Average\ Gini = \frac{(331 * 0.435) + (323 * 0.407)}{(331 + 323)} = 0.421$$

Splitting by changes in MMS would have generated two branches (this is not shown, but can be calculated from the underlying data), each containing 333 (left branch) and 321 (right branch) observations. The Gini score of the left branch would be 0.444, while the Gini score for the right branch would be 0.460. Here the weighted average Gini score would be:

$$Weighted\ Average\ Gini = \frac{(333 * 0.444) + (321 * 0.460)}{(333 + 321)} = 0.452$$

As the weighted-average Gini score is lower in the first case (0.421 is less than 0.452) and therefore more homogeneous, the algorithm decides to split the data by looking at MML positions.[5]

Validating the Tree

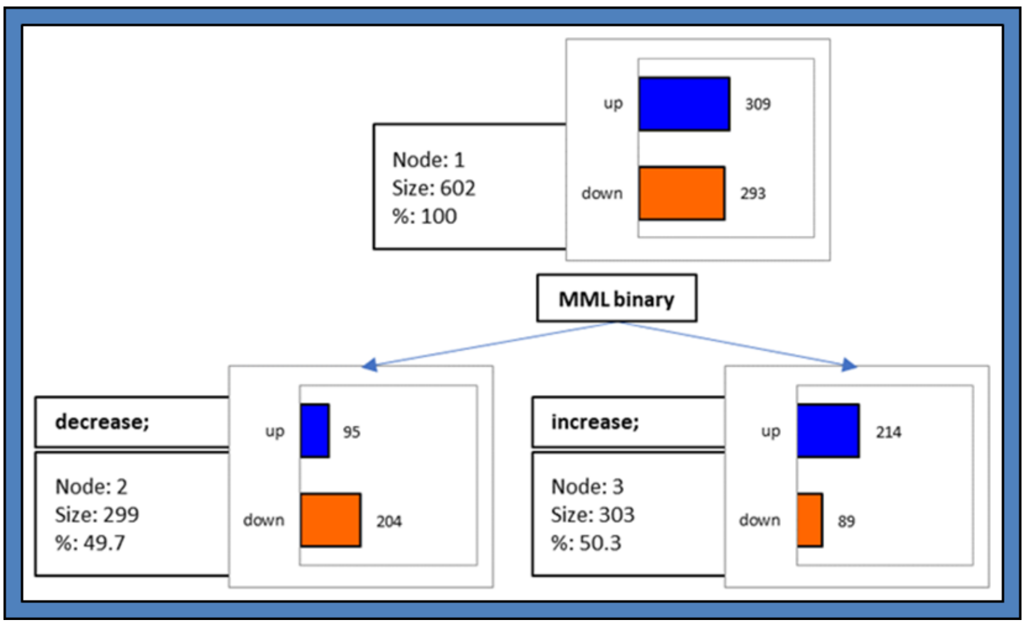
In the decision trees above, the entire dataset of 654 weeks has been used. To validate the robustness of the tree in Figure 1, it must be tested on unseen data.

The approach is to first "train" the algorithm on some portion of the data and then "test" it on another portion of data. The testing portion could, for example, be the last 52 weeks of the dataset and the training portion the 602 weeks before that.

Figure 3 shows a new decision tree trained only on the first 602 weeks of data (the training dataset).

Figure 3

Decision Tree Based on Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks



Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

This tree identifies the same question to ask first as the tree in Figure 1 – whether MMLs increased or decreased their position.

Applying the decision tree to last 52 weeks in the dataset (the testing dataset) there were 38 weeks (73%) where the algorithm correctly predicted price direction by asking whether MMLs increased or decreased their position.

When two datasets are used, two confusion matrices can now be generated: one for the training set (602 weeks) and one for the testing set (52 weeks). These are shown in Table 2 on the next page. In the training set, 69.44% of the points were correctly classified, and in the testing set, 73.10% of the points were correctly predicted – an improvement of a few percentage points.

Table 2
Confusion Matrix Based on Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
up	214	95	309	69.256
down	89	204	293	69.625
Total	303	299	602	69.435

Confusion matrix (testing)

from \ to	up	down	Total	% correct
up	17	11	28	60.714
down	3	21	24	87.500
Total	20	32	52	73.077

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

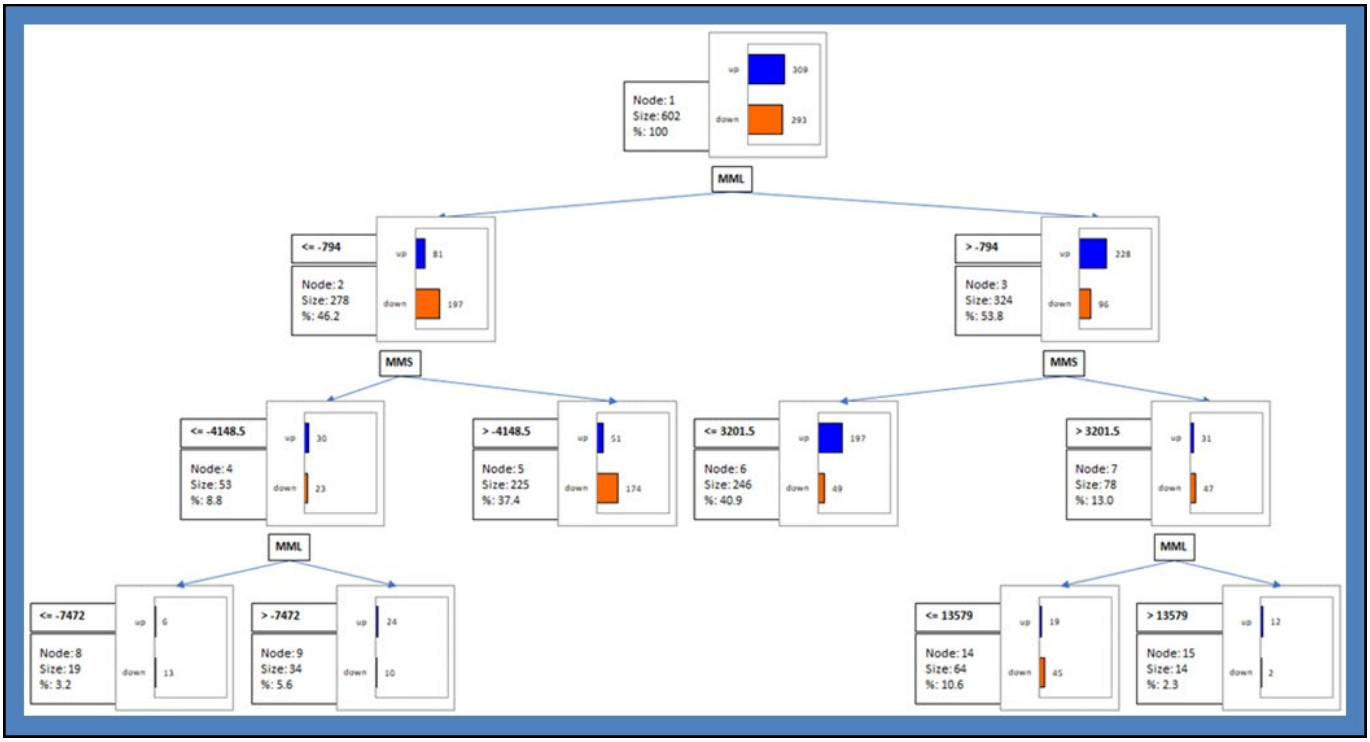
Decision Trees Using Non-Binary Data

Only binary data has been used so far – either an increase or a decrease in MM positioning and whether prices were up or down. The algorithm also works with non-binary data, deciding not only which feature to best split the tree with, but also at what threshold.

With greater possibilities, non-binary trees can grow exponentially during training as they fit the data, and ultimately, without any constraints, they will fit all the data as every scenario would be captured. If they grow too big, however, they become overfitted, and they risk performing poorly when applied to testing samples. One solution is to cut the tree before it gets too big.

Figure 4 on the next page shows the non-binary decision tree to predict whether prices of crude oil (WTI) increased or decreased over the week based on changes in MML and MMS positions over that week. The tree is cut at three levels of depth. The data has again been divided into a training set (602 weeks) and a testing set (52 weeks) as explained previously in "Validating the Tree." The first question the decision-tree asks now is whether MMs changes their position by more or less than -794 contracts.

Figure 4
Decision Tree Based on Non-Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks



Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Focusing on the first three nodes in the tree:

- Node 1 in Figure 4 shows the 602 weeks divided into 309 weeks where crude oil (WTI) prices increased and 293 weeks where they decreased (this is the same as Figure 3).

- Node 2 shows that out of the 602 weeks, MMLs changed their position by less than or equal to -794 contracts in 278 weeks. Out of those 278 weeks, crude oil (WTI) prices rose in 81 of the weeks and fell in 197 of the weeks.

- Node 3 shows that out of the 602 weeks, MMLs changed their position by more than -794 contracts in 324 weeks. Out of those 324 weeks, crude oil (WTI) prices rose in 228 of the weeks and fell in 96 of the weeks.

The complete tree structure for Figure 4 is shown below in Table 3. This provides a detailed description of key statistics and actions at each node in the tree.

Table 3
Tree Structure Based on Non-Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree structure

Nodes	Objects	%	Improvement	Purity	Split variable	Values	Predicted values
Node 1	602	100.00%	50.060	51.33%			up
Node 2	278	46.18%	9.225	70.86%	MML	<= -794	down
Node 3	324	53.82%	18.483	70.37%	MML	> -794	up
Node 4	53	8.80%	3.011	56.60%	MMS	<= -4148.5	up
Node 5	225	37.38%	3.639	77.33%	MMS	> -4148.5	down
Node 6	246	40.86%	4.094	80.08%	MMS	<= 3201.5	up
Node 7	78	12.96%	6.178	60.26%	MMS	> 3201.5	down
Node 8	19	3.16%		68.42%	MML	<= -7472	down
Node 9	34	5.65%		70.59%	MML	> -7472	up
Node 14	64	10.63%		70.31%	MML	<= 13579	down
Node 15	14	2.33%		85.71%	MML	> 13579	up

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The tree rules for Figure 4 are shown in Table 4 below. This table provides a description of the actions at each node.

Table 4
Decision Rules Based on Non-Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree rules

Nodes	Price binary (Pred.)	Rules
Node 1	up	
Node 2	down	If MML <= -794 then Price Tues binary = down in 46.2% of cases[6]
Node 3	up	If MML > -794 then Price Tues binary = up in 53.8% of cases
Node 4	up	If MML <= -794 and MMS <= -4148.5 then Price Tues binary = up in 8.8% of cases
Node 5	down	If MML <= -794 and MMS > -4148.5 then Price Tues binary = down in 37.4% of cases
Node 6	up	If MML > -794 and MMS <= 3201.5 then Price Tues binary = up in 40.9% of cases
Node 7	down	If MML > -794 and MMS > 3201.5 then Price Tues binary = down in 13.0% of cases
Node 8	down	If MML <= -794 and MMS <= -4148.5 and MML <= -7472 then Price Tues binary = down in 3.2% of cases
Node 9	up	If MML <= -794 and MMS <= -4148.5 and MML > -7472 then Price Tues binary = up in 5.6% of cases
Node 14	down	If MML > -794 and MMS > 3201.5 and MML <= 13579 then Price Tues binary = down in 10.6% of cases
Node 15	up	If MML > -794 and MMS > 3201.5 and MML > 13579 then Price Tues binary = up in 2.3% of cases

"Price Tues" is the price on Tuesday based on the 2nd nearby futures contract.

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Table 5
Confusion Matrix Based on Non-Binary Input Changes (MML and MMS) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
up	233	76	309	75.405
down	61	232	293	79.181
Total	294	308	602	77.243

Confusion matrix (testing)

from \ to	up	down	Total	% correct
up	14	14	28	50.000
down	2	22	24	91.667
Total	16	36	52	69.231

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The confusion matrices in Table 5 above show that for the training set (602 weeks) 77.24% of the points were correctly classified, and in the testing set, 69.23% of the points were correctly predicted. For the training dataset, the results are higher than the binary tree in Table 2, but a little lower for the testing dataset. This could suggest that the direction of MM activity is sufficient in predicting prices, and adding threshold information, does not add any significant incremental value.

The robustness of decision trees as an analytical tool is covered later in the section on "Random Forests."

Extending the Tree to All Trader Groups

The decision tree in the section on "Decision Trees Using Non-Binary Data" uses only the MML and MMS groups as features. In the following two pages, Table 6 shows the tree structure after including all trader groups (Other Reportables (OR), Producer/Merchant/Processor/User (PMPU) and Swap Dealers (SD), with the corresponding confusion matrix shown in Table 7. The full decision tree diagram is not shown in the interest of space.

The Appendix explains the various trader groups as reported in the Disaggregated COT report.

Table 6
Tree Structure Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree structure

Nodes	Objects	%	Improvement	Purity	Split variable	Values	Predicted values
Node 1	602	100.00%	50.060	51.33%			up
Node 2	278	46.18%	9.225	70.86%	MML	<= -794	down
Node 3	324	53.82%	18.483	70.37%	MML	> -794	up
Node 4	53	8.80%	3.011	56.60%	MMS	<= -4148.5	up
Node 5	225	37.38%	4.090	77.33%	MMS	> -4148.5	down
Node 6	246	40.86%	5.383	80.08%	MMS	<= 3201.5	up
Node 7	78	12.96%	7.109	60.26%	MMS	> 3201.5	down
Node 8	19	3.16%		68.42%	MML	<= -7472	down
Node 9	34	5.65%		70.59%	MML	> -7472	up
Node 10	17	2.82%		52.94%	SDS	<= -15562.5	up
Node 11	208	34.55%		79.81%	SDS	> -15562.5	down
Node 14	26	4.32%		92.31%	SDS	<= -4014	down
Node 15	52	8.64%		55.77%	SDS	> -4014	up

SDL = Swap Dealer Long, SDS = Swap Dealer Short

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The initial nodes within the tree are still split along MM features, with the SD category featuring at node 10 onwards. Overall this shows that the algorithm still chooses the MM group as the most important feature in predicting price direction.

Table 7
Confusion Matrix Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (WTI Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
up	259	50	309	83.819
down	90	203	293	69.283
Total	349	253	602	76.744

Confusion matrix (testing)

from \ to	up	down	Total	% correct
up	17	11	28	60.714
down	12	12	24	50.000
Total	29	23	52	55.769

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Whilst the algorithm shows the MM group to be the most important feature, it is also important to understand that these results do not infer causality – especially when the data are set up in a contemporaneous way (as in all the examples so far.) Just because the trees mostly identify the MM group as an important feature in predicting prices, it does not mean that MMs are driving prices. It could easily mean that MMs are following prices.

Looking at natural gas and copper, a similar profile emerges with the MM group continuing to be the most important feature. Table 8 shows the tree structure, and Table 9 on the next page documents the confusion matrix for all trader groups for natural gas.

Table 8
Tree structure Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (Natural Gas Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree structure

Nodes	Objects	%	Improvement	Purity	Split variable	Values	Predicted values
Node 1	602	100.00%	41.179	50.00%			up
Node 2	209	34.72%	9.320	75.12%	MMS	<= -3631	up
Node 3	393	65.28%	12.211	63.36%	MMS	> -3631	down

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Table 9
Confusion Matrix Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (Natural Gas Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
down	157	144	301	52.159
Total	52	249	301	82.724
up	209	393	602	67.442

Confusion matrix (testing)

from \ to	up	down	Total	% correct
up	20	10	30	66.667
down	5	17	22	77.273
Total	25	27	52	71.154

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Table 10 shows the tree structure, and Table 11 on the next page provides the confusion matrix for all trader groups for copper.

Table 10
Tree Structure Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (Copper Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree structure

Nodes	Objects	%	Improvement	Purity	Split variable	Values	Predicted values
Node 1	602	100.00%	60.294	52.16%			up
Node 2	251	41.69%	17.921	74.50%	MML	<= -241.5	down
Node 3	351	58.31%	18.510	71.23%	MML	> -241.5	up
Node 4	31	5.15%	3.433	77.42%	MMS	<= -1778.5	up
Node 5	220	36.54%	4.188	81.82%	MMS	> -1778.5	down
Node 6	282	46.84%	5.142	79.43%	MMS	<= 1227	up
Node 7	69	11.46%	6.652	62.32%	MMS	> 1227	down
Node 14	63	10.47%		68.25%	SDS	<= 1373.5	down
Node 15	6	1.00%		100.00%	SDS	> 1373.5	up

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Table 11
Confusion Matrix Based on Non-Binary Input Changes (All Groups) and Binary Output Changes (Copper Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
up	254	60	314	80.892
down	65	223	288	77.431
Total	319	283	602	79.236

Confusion matrix (testing)

from \ to	down	up	Total	% correct
down	6	24	30	20.000
up	16	6	22	27.273
Total	22	30	52	23.077

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

As mentioned above, the robustness of decision trees as an analytical tool is covered later in the section on "Random Forests."

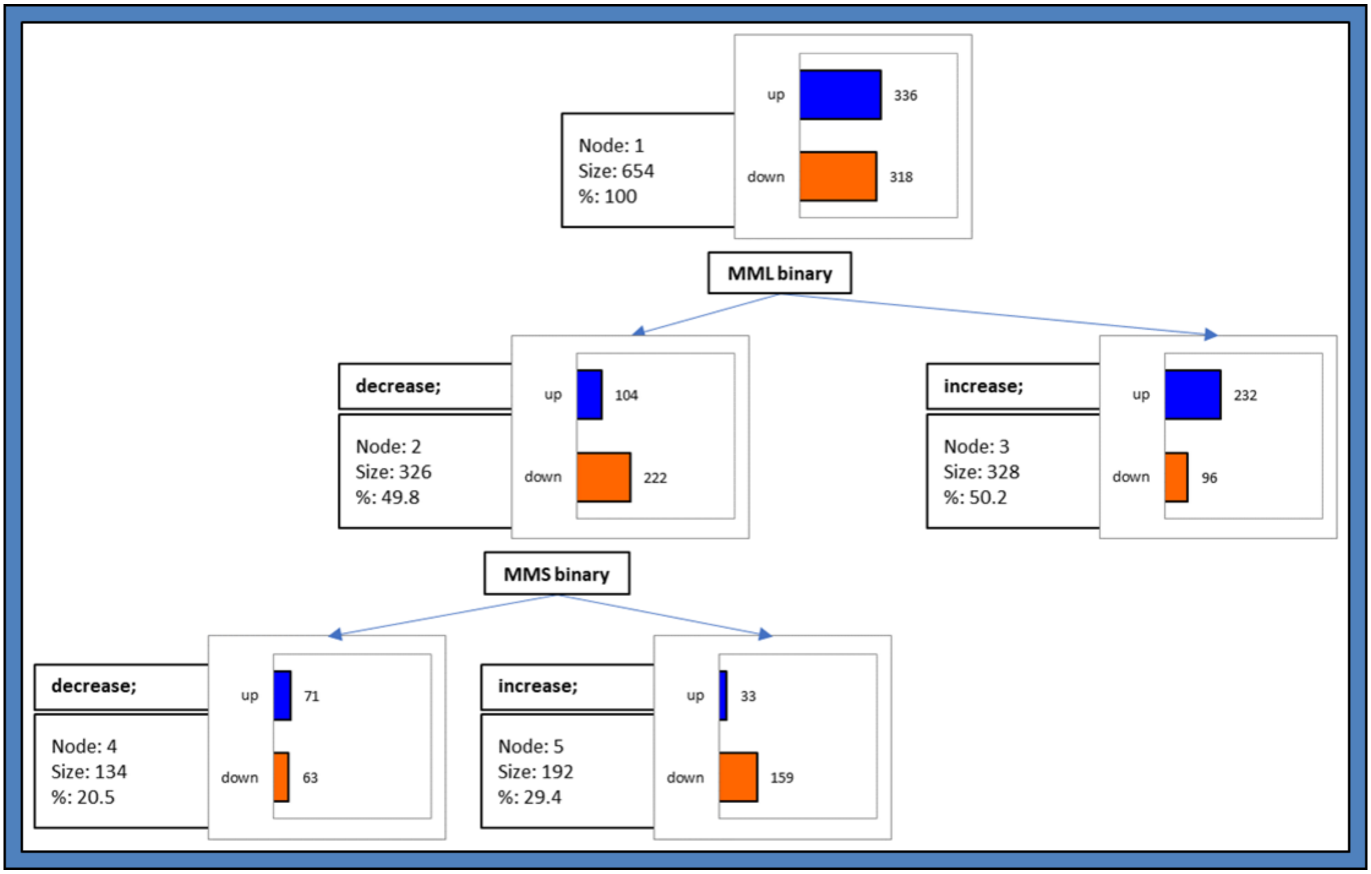
Feature Importance

An essential attribute of decision trees, by virtue of their underlying algorithm, is their ability to identify the most important features when predicting the target variable. This is called feature importance, and in the context of Positioning Analysis refers to identifying the trader groups whose changes best explain price direction.

Feature importance can be calculated by looking at the decrease in the average Gini score, the increase in homogeneity, of all the nodes split along a given feature, weighted by the number of observations in those nodes.

Figure 5 is a binary decision tree to predict whether prices of copper increased or decreased over the week based on absolute changes in MML and MMS positions over that week. The decision tree initially identifies the variable MML at the first level and followed by the variable MMS at the second level.

Figure 5
Decision Tree Based on Binary Input Changes (MML and MMS) and Binary Output Changes (Copper Prices)



Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

The Gini score at each of the five nodes in Figure 5, calculated previously in the section on "The Decision Tree Algorithm – How Does it Work?" are:

Table 12
Gini Scores at:

Node number	Gini
Root Node (Node 1)	0.500
Node 2	0.434
Node 3	0.414
Node 4	0.498
Node 5	0.285

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

At the first level of the tree, where the tree is split along the MML feature, the weighted average Gini score is:

$$Weighted\ Average\ Gini = \frac{(326 * 0.434) + (328 * 0.414)}{(326 + 328)} = 0.424$$

The decrease in Gini at this level is = 0.500 – 0.424 = 0.076. This is attributable to the MML feature.

At the second level, where the tree is split along the MMS feature, the weighted average Gini score is:

$$Weighted\ Average\ Gini = \frac{(134 * 0.498) + (192 * 0.285)}{(134 + 192)} = 0.373$$

The decrease in Gini at this level is = 0.424 – 0.373= 0.051. This is attributable to the MMS feature.

The individual feature importance is then calculated as:

$$Feature\ importance_{MML} = \frac{0.076}{0.076 + 0.051} = 60\%$$

$$Feature\ importance_{MML} = \frac{0.051}{0.076 + 0.051} = 40\%$$

Random Forests

By way of a summary – in the previous section on "Decision Trees," single decision trees were used to classify specific datasets. To verify the robustness, the dataset was split into a training set (602 weeks) and a testing set (52 weeks). The objective of the training set was to calibrate the model before then testing it on the testing set. Confusion matrices then report the success of the predictions in each of these datasets.

The problem with this approach is there is the risk of overfitting, making the robustness questionable. To address overfitting issues and to increase the robustness of the decision tree approach, random forests are a satisfactory solution.

<u>The Random Forest Methodology</u>

In a random forest many different decision trees are generated. Each tree is trained on a random subset of the training dataset also using a subset of the available features.

Each of these trees is then applied to the testing data and its prediction of the target variable made. Each prediction is then averaged using a voting mechanism within the algorithm across all the trees.

For example, a random forest could be "grown" as follows:

- 100 different subsets from the training set (with replacement) are created, each containing 100 weeks of data.[7] Each sample can include intermittent (i.e. non-consecutive) points, and because the sampling is done with replacement, a given observation may appear several times in any given sample.

- 100 different trees are then generated, each of which is trained on one of the 100 subsets. Instead of using the full set of eight features however, each tree only uses *n* randomly selected features. Using the square root of the total number of features is widely considered to be a good value for *n*. This means that for a total set of eight features, each tree would use three randomly selected features.

- Once all the trees are trained, the forest is then applied to the testing data with each tree in the forest making its own independent prediction. The final results are then voted upon. If for example, 75 trees predict a price increase, and 25 predict a price decrease, the forest is then said to predict a price increase.

The usefulness of random forests, above and beyond that of decision trees, lies in the robustness of the approach and the ability to overcome overfitting. By having many different (random) trees generate independent predictions based on different subsets of the features, the variance in predictions is reduced and much of the risk in overfitting reduced. Random forests rely on the "wisdom of crowds": individual trees (as described throughout the section on "Decision Trees") can make classification mistakes, but on average, the whole forest will make more robust and accurate predictions.

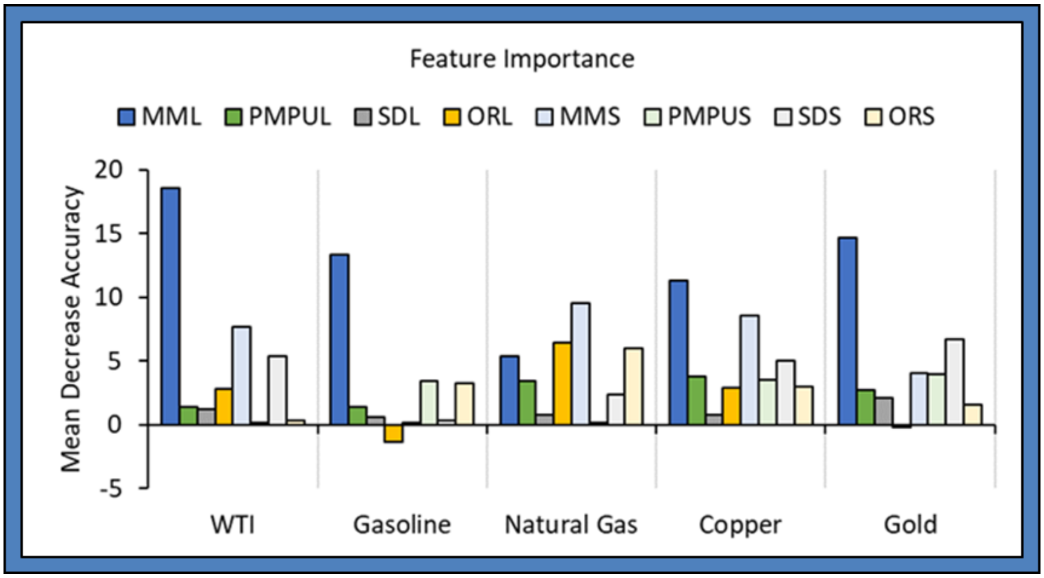
Random Forest Feature Importance

In the same way that feature importance is calculated for a single decision tree, the feature importance from a random forest can also be calculated. The advantage is that the results are also more robust. The feature importance from a random forest provides meaningful insight into the trader group changes that best explain price changes.

Two different measures of importance are given for each feature in the random forest. The first is based on the decrease of Gini score as described in the section on "Feature Importance." The second, called the Mean Decrease Accuracy, is based on how much the accuracy decreases when a variable is excluded.[8] The XLSTAT application uses the second method.

Figures 6 and 7 on the next page show the feature importance profiles for 10 major commodities for the entire dataset between 2006 and 2018.

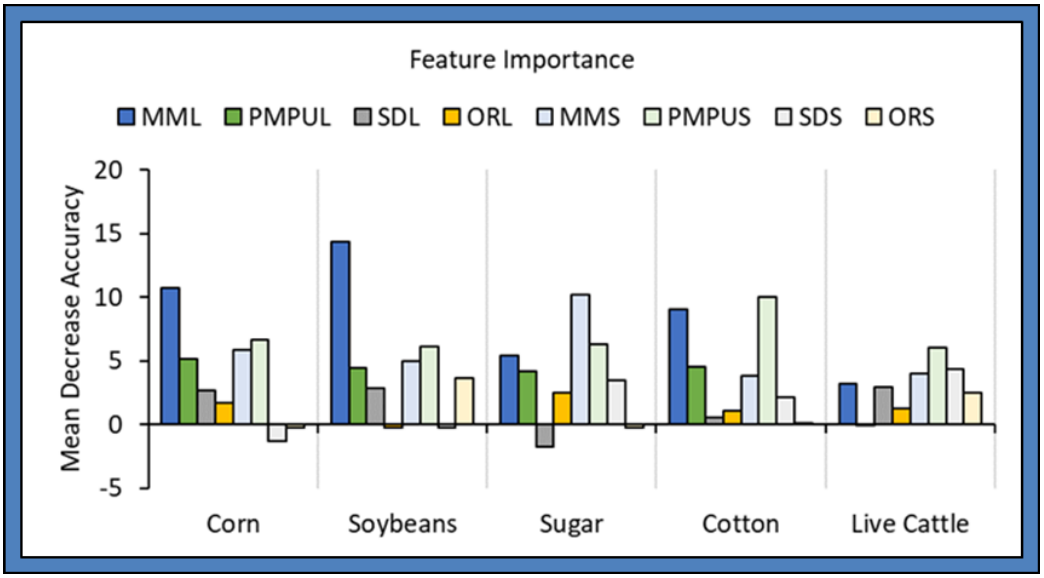
Figure 6
Feature Importance (i)



Source: Based on data from Bloomberg.

Producer/Merchant/Processor/User (PMPU), Swap Dealer (SD), Money Manager (MM), Other Reportables (OR). The L or S suffix further splits between Long and Short.

Figure 7
Feature Importance (ii)



Source: Based on data from Bloomberg.

Producer/Merchant/Processor/User (PMPU), Swap Dealer (SD), Money Manager (MM), Other Reportables (OR). The L or S suffix further splits between Long and Short.

For crude oil (WTI), gasoline, gold and soybeans, the MML group is the most important, whereas for natural gas and sugar it is the MMS group. For cotton and live cattle, the PMPUS group is the most important.

Dynamic Feature Important and Alternative Features

By using a rolling window approach, or an anchored walk forward approach, the evolution of feature importance can be tracked over time as new data becomes available. This provides insight into shifts and changes in the market structure or in trader behavior.

The variables included as features have so far have been focused only on changes in the directional (long and short) open interest of trader groups, but spreading data could also be included. The number of traders can also be used, either as an exclusive set of variables or in combination with the open interest variables.

Feature importance can be a compelling way of identifying new patterns and relationships in positioning that can help improve how other positioning signals, indicators, and models are interpreted and used.

Using ML to Trade

In each of the sections in this article, the price (output) variable has always been contemporaneous to the positioning (input) variables as the objective of the approach has been entirely analytically driven. ML has been used to uncover relationships between changes in positioning and changes in commodity prices - specifically, as described at the outset of the piece, which aspects of positioning are most useful in helping to understand commodity markets from a machine-learning perspective.

Having the price variables contemporaneous to the positioning variables means the model is not directly tradeable. Naturally the insights revealed in "Random Forest Feature Importance," for example, can be used to enhance trading strategies based on positioning data, but the results have not been generated from a tradeable framework.

The data release schedule of COT positioning data is fully explained on the CFTC website, but to summarize, positioning data is released every Friday (with all CFTC related data after the market close and ICE COT data just before the market close) and refers to the previous Tuesday.[9] Changes in positioning in this article run from Tuesday to Tuesday and the price changes have been set to the same schedule also.

To make the relationship tradeable, the price information in the decision tree needs to be changed from Tuesday to Tuesday to the following Monday to Monday. This is because the COT data is released on Friday, mostly after the market closes, and the earliest opportunity to trade is Monday.

Tables 13 and 14 on the next page are like the tree structure in Table 8 and confusion matrix in Table 9, except the decision tree now predicts whether prices of natural gas increased or decreased in the following week, running from Monday to Monday, but still based on changes in positioning from the previous week. Simply, when the positioning data is released on the Friday (for the previous Tuesday) the algorithm predicts whether prices will rise (fall) in the upcoming Monday to Monday period. In having shifted the price data, this now makes the model "tradeable", allowing any trades to be placed on the close on Monday night.[10]

Table 13

Tree Structure Based on Binary Input Changes (All Groups) and Absolute Output Changes (Natural Gas Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Tree structure

Nodes	Objects	%	Improvement	Purity	Split variable	Values	Predicted values
Node 1	602	100.00%	5.460	51.99%			
Node 2	127	21.10%	4.341	61.42%	PMPUL	<= -5746.5	1
Node 3	475	78.90%	4.447	55.58%	PMPUL	> -5746.5	1
Node 6	470	78.07%	3.489	56.17%	SDL	<= 23064	3
Node 7	5	0.83%		100.00%	SDL	> 23064	3
Node 12	7	1.16%		100.00%	ORL	<= -13033	6
Node 13	463	76.91%		57.02%	ORL	> -13033	6

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Table 14

Confusion Matrix Based on Binary Input Changes (All Groups) and Absolute Output Changes (Natural Gas Prices) – Training Dataset 602 Weeks, Testing Dataset 52 Weeks

Confusion matrix (training)

from \ to	up	down	Total	% correct
up	264	49	313	84.345
down	199	90	289	31.142
Total	463	139	602	58.804

Confusion matrix (testing)

from \ to	up	down	Total	% correct
up	18	10	28	64.286
down	14	10	24	41.667
Total	32	20	52	53.846

Source: Based on data from Bloomberg. Output taken directly from XLSTAT.

Interestingly, the tree structure in Table 13 shows the addition of four more nodes due to having shifted the price data. Different features throughout the tree are also seen compared to Table 8 which highlights the significance of the change.

The confusion matrix in Table 14 shows a large deterioration in performance, due to the lag in the price data. Table 14 shows 58.80% of points in the training dataset are classified correctly but falling to 53.84% for the testing dataset. Similar deteriorations are seen for other commodities and at this level the success of the model is close to being random.

Extending this single tree to a random forest framework also does not improve the results. Importantly, this suggests that ML as a trading tool based on positioning data used in this way is unsatisfactory. The requirement to lag the price data to make the model tradeable, reduces the performance of the results significantly.

It is important to understand that the performance of ML in a tradable framework in no way renders ML an ineffective tool for analysis.

On the contrary, ML can be highly effective in identifying new patterns and relationships in the data that would be extremely challenging to identify through other channels. As mentioned above, ML can help improve how other positioning signals, indicators, and models are interpreted and used.

Appendix

Disaggregated COT Report Categories

Producer/Merchant/Processor/User (PMPU)
A "producer/merchant/processor/user" is an entity that predominantly engages in the production, processing, packing or handling of a physical commodity and uses the futures markets to manage or hedge risks associated with those activities.

Producer/Merchant/Processor/User (PMPU)
A "producer/merchant/processor/user" is an entity that predominantly engages in the production, processing, packing or handling of a physical commodity and uses the futures markets to manage or hedge risks associated with those activities.

Swap Dealer (SD)
A "swap dealer" is an entity that deals primarily in swaps for a commodity and uses the futures markets to manage or hedge the risk associated with those swap transactions. The swap dealer's counterparties may be speculative traders, like hedge funds, or traditional commercial clients that are managing risk arising from their dealings in the physical commodity.

Money Manager (MM)
A "money manager," for the purpose of this report, is a registered commodity trading advisor (CTA); a registered commodity pool operator (CPO); or an unregistered fund identified by the CFTC. These traders are engaged in managing and conducting organized futures trading on behalf of clients.

Other Reportables
Every other reportable trader that is not placed into one of the other three categories is placed into the "other reportable" category.

Source: https://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm

Endnotes

This article is excerpted from Chapter 14 of *Advanced Positioning, Flow and Sentiment Analysis in Commodity Markets*, which was published by Wiley in January 2020.

1 Decision trees where the target variable is discrete are called classification trees. Decision trees where the target variable can take continuous values are called regression trees.

2 Non-linear relationships are where the change in one entity does not correspond with constant change in another entity.

3 https://www.xlstat.com/en/

4 Please see the Appendix for a description of each trader category.

5 Besides the Gini index, other decision criteria exist, including some based-on information theory (entropy) and intra-group variance. Only the Gini index is used in the article.

6 The percentage cases represent the proportion of the sample size at that node.

7 Any number for samples can be taken of any length.

8 The importance measure used in the XLSTAT application for a given variable is the mean error increase of a tree when the observed values of this variable are randomly exchanged in the OOB (Out-Of-Bag) samples.

For each tree, the prediction error on the out-of-bag data is computed. Then the same is done after permuting each explanatory variable. The difference between the two is then averaged over all trees, and according to the choice of the user, normalized or not by the standard deviation of the differences. If the standard deviation of the differences is equal to 0 for a variable, the division is not done.

In classification, in addition to the impact of permutations on the overall error of the forest, we also measure the impact on each of the modalities of the response variable. Source: XLSTAT help files (https://www.xlstat.com/)

9 https://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm

10 The trades can be placed at any time on a Monday, but the final settlement price of the day is used as this is tradeable (via futures executed at TAS (Trade at Settlement) or via S&P GSCI or BCOM excess return indices) and no estimates for slippage effectively need to be factored into account. Whilst the model has been trained to predict prices over the full week Monday to Monday, a trade can naturally be exited earlier, and the model can also be configured for shorter price periods – for example over a single day.

Author Biography

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Mr. Mark Keenan is Head of Research and Strategy at Engelhart Commodity Trading Partners (ECTP) and previously Managing Director, Global Commodities Strategist, and Head of Research for Asia-Pacific at Société Générale Corporate & Investment Bank (SG CIB). He has over 20 years of experience in commodity quantitative analysis, research and strategy across all the major energy, metal, agriculture and soft commodities markets.

Author of *Advanced Positioning, Flow and Sentiment Analysis in Commodity Markets*, published by Wiley and also *Positioning Analysis in Commodities Markets – Bridging Fundamental and Technical Analysis*, Mr. Keenan appears regularly on CNBC and

Bloomberg television and is quoted widely in global press and media channels. He has a Master's degree in Molecular and Cellular Biochemistry from Oxford University.

Mr. Keenan previously provided two expert analyses for the *GCARD*. He contributed to the Summer 2018 issue of the *GCARD* where he described positioning analysis in the commodity markets; and he also co-authored an article for the Winter 2018 issue on cryptocurrencies, Bitcoin and blockchain.

Part 2: Trend's Not Dead (It's Just Moved to a Trendier Neighborhood)

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J. Scott Kerson
Senior Managing Director and Head of Systematic Strategies, Gresham Investment Management

In Part 2 of 2 we use a novel dataset of alternative commodity markets to show that the "trendiness" of less mainstream markets, selected based on a set of simple criteria, is inherently higher and that trend following in these markets has continued to be significantly better. Part 1, "Trend, My Friend, Is This the End?", appeared in the Winter 2019 edition of the GCARD.

Alternative Markets

Our hypothesis is that markets that exhibit certain characteristics should be inherently more "trendy." Namely:

- Are dominated by hedgers, not speculators – less competition, natural alpha transfer
- Are structurally insulated from risk on/off and typical macro factors – no policy driven capping/flooring of trends
- Exhibit fixed or inelastic supply/demand – forces prices to do all the work to clear markets
- Lack fungibility and temporal arbitrage – maintain diversification, inherit lots of carry

Alternative Commodity Markets: One Such Neighborhood?

We believe that *Alternative Commodity* markets demonstrate these characteristics, identifying 95 markets (that we currently trade.) For example, one can trade freight futures based on the Panamax[1] Timecharter Index. The availability of these ships is a classic case of inelastic supply and demand since it takes between 1 and 3 years to construct a new ship and that ship can then be in service for 25 to 30 years.

Another example is coal. Commissioning a new coal mine requires a large investment in time and capital and once opened, the cost of decommissioning is very high. This means that market prices can exceed the marginal cost by a large amount for significant periods of time before new mines are developed. Equally, it means that mines will run at a loss on low coal prices for longer than market economics might suggest.

We choose to represent inherent trendiness via the cumulative autocorrelation term from Lo (2002) since this provides a simple and intuitive measure of the extent to which a returns time series is autocorrelated over extended periods. See the second square-root term in Equation 1 on the next page.

(Equation 1) $$\sigma_{annual} = \sqrt{n}\sigma_{daily}\sqrt{1 + 2\sum_{i=1}^{n}\frac{n-i}{n}\rho_i}$$

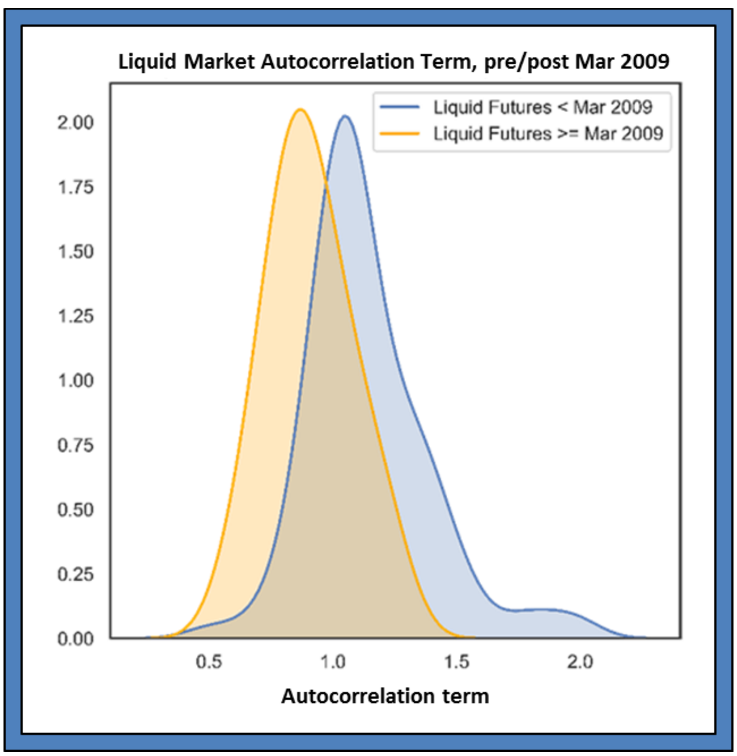
We measure this for both 100+ liquid futures markets pre-/post- the Global Financial Crisis (GFC)[2] (Figure 1) and also compare to alternative commodities post-GFC (Figure 2), considering autocorrelation lags out to 1 year. Two observations can be made:

i) Just as with the smile trend densities examined in Babbedge and Kerson (2019a) and Babbedge and Kerson (2019b), we see a decline in autocorrelation "trendiness" for liquid futures for the recent period; and

ii) We see that alternative commodity markets tend to have a larger autocorrelation trendiness term, as per the hypothesis.

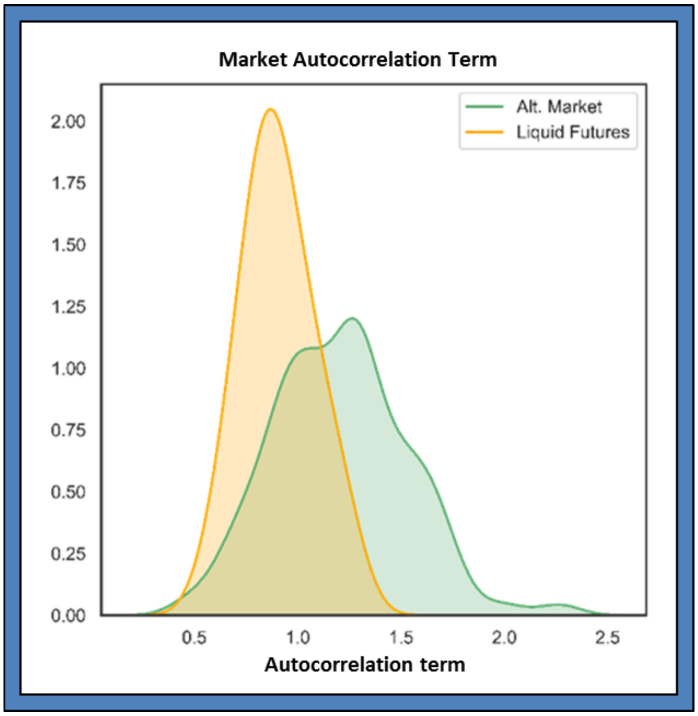
We note that adoption, instead, of the Hurst exponent leads to similar observations so those results are not reproduced here. (This statistical measure was originally proposed in Hurst (1951).)

Figure 1
Trendiness for Liquid Futures Pre- and Post-GFC, Showing the Reduction in the Measure Post-GFC



Sources: Gresham Investment Management (GIM), Bloomberg.

Figure 2
Trendiness of Liquid Futures as Compared to Alternative Commodities for the Post-GFC Period, Showing the Higher Level in Alternative Commodities



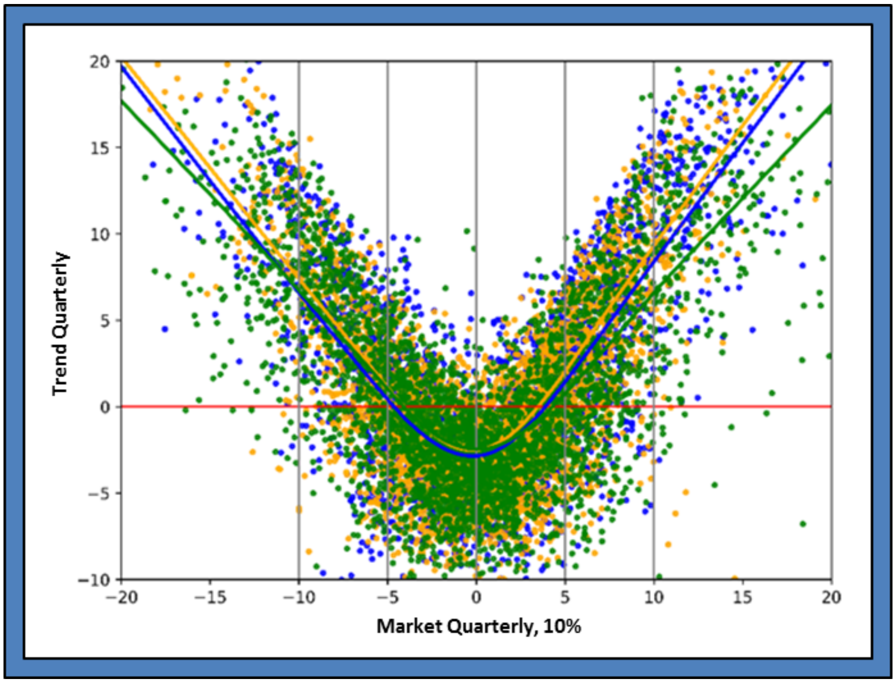
Sources: GIM, Bloomberg.

Trend Following in Alternative Commodities

We run a medium-speed trend-following backtest on both the set of 100+ liquid futures markets and on the set of 95 alternative commodity markets, being careful to apply realistic trading cost estimates based on our proprietary dataset of actual trading costs. We then plot risk-adjusted quarterly returns of futures markets[3] versus the resulting simulated quarterly return from trend following[4] on those individual markets. The quarterly timeframe is chosen since it is similar in timeframe to the horizon of medium-speed trend followers and is therefore the most relevant timeframe for comparison. For the liquid markets there is sufficient history to split the data into pre- and post-GFC. In each case we overlay a LOESS line of best fit. Please see Figure 3 on the next page. The resulting convex "CTA smile" is a well-known result and demonstrates how trend following is akin to a synthetic long straddle (e.g., Merton (1981)).

As per Babbedge and Kerson (2019b), it is remarkable how consistent that fit is across the three datasets, meaning that for a given risk-adjusted quarterly market move one can essentially "look up" the resulting return from trend following that market, *modulo* some scatter.

Figure 3
Quarterly Return CTA Smile for Liquid Futures in Two Periods (blue = pre-GC, orange = post-GFC) and for Alternative Commodities post-GFC (green). LOESS Fits Indicated. Market Quarterly Returns are Risk-Adjusted to 10% Annualized Risk.

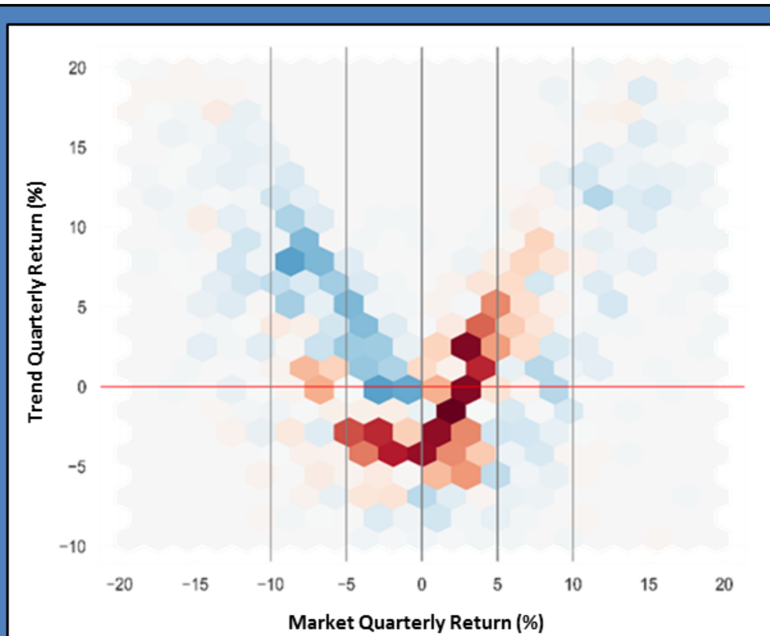


Sources: GIM, Bloomberg.

Crucially, when we compare the relative frequency of market risk-adjusted quarterly returns between liquid futures and alternative commodities post-GFC[5], we find that the alternative commodities exhibited an *increased* density of *large* quarterly market risk-adjusted returns and a *decreased* occurrence of *small* moves. Since the key to the profitability of trend following is the relative population of the edges of the CTA smile compared to the center of the smile (where trend makes losses), this difference is central to the observation that trend following in alternative commodities has been significantly better.

In Figure 4 we present the differential density chart comparing alternative commodities to liquid futures post-GFC and provide fractions in Table 1 below.

Figure 4
Differential Density Chart Comparing Alternative Commodities to Liquid Futures Post-GFC



Sources: GIM, Bloomberg.

Notes: This figure shows increased occurrences in blue and decreased in red when comparing alternative commodity markets to liquid futures markets. We see higher rates of large quarterly market returns and lower rates of small market moves for the alternatives.

Table 1
Occurrence Counts for Small and Large Market Quarterly Returns

	Small Trend (|Mkt Retn| < 5%)	Large Trend (|Mkt Retn| > 10%)
Liquid Futures pre-GFC	59% of quarters	10% of quarters
Liquid Futures post-GFC	68% of quarters	5% of quarters
Alt Comms post-GFC	*56% of quarters*	*14% of quarters*

Comparison to the Mainstream

Finally, we construct a portfolio of alternative commodities and compare the simulated cumulative performance after all fees and costs to that of the Barclay CTA Index in Figure 5. In Table 2 we provide correlations to major representative macro factors.

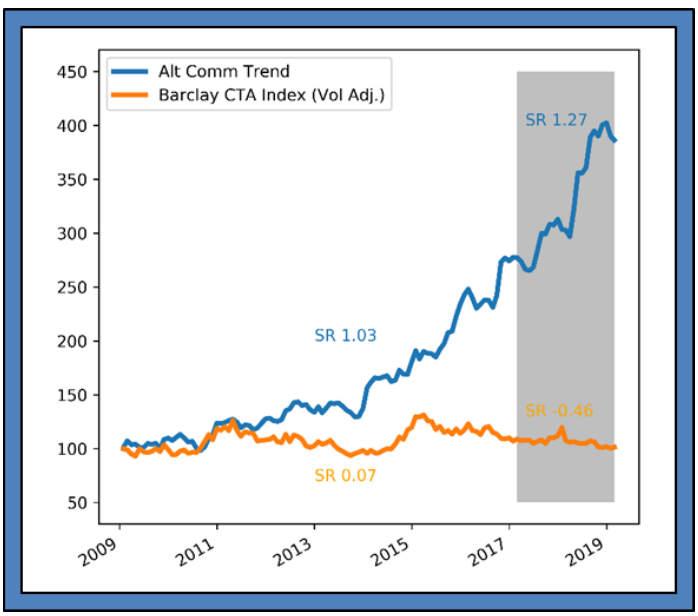
As per the original hypothesis we observe that simulated historical performance of the alternative commodities trend following has been far better than similar strategies applied to liquid futures markets in the post-GFC period, while exhibiting low correlation to more mainstream factors.

Table 2

	Alt Comm Trend	Barclay CTA	S&P 500	BCOM
Barclay CTA	0.15			
S&P 500	0.06	0.43		
BCOM	0.17	0.26	0.67	
Barclays Ag. Bond	0.14	0.19	-0.07	-0.19

Abbreviations: BCOM stands for the Bloomberg Commodity Index while Barclays Ag. Bond stands for the Barclays Capital U.S. Aggregate Bond Index.

Figure 5
Performance Comparison for the Barclay CTA Index and the Alternative Commodity Trend Strategy. Shaded Region Indicates Period Where the Strategy Was Live Traded.



Sources: GIM, Bloomberg.

Concluding Remarks

We looked to identify markets that should, in principle, exhibit stronger trending behaviors. We found that a novel dataset of *alternative commodity markets*, selected based on a set of simple criteria, had inherently higher trendiness and that, as a result, trend following in these alternative markets has continued to be significantly better than for the mainstream. Thus, it seems, "trend is not dead – it has just moved to a more trendy neighborhood."

Endnotes

1 The largest size of ship able to navigate the Panama Canal.

2 With March 2009 as the start of the post-GFC, although exact date choice has minimal impact on conclusions.

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

4 Again, targeting 10% annualized risk.

5 Due to shorter histories there is insufficient data to meaningfully populate the pre-GFC period for Alternative Commodities.

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Dr. Thomas Babbedge has over 10 years of experience building and assessing quantitative trading systems for the world's largest CTA. After obtaining a Ph.D. in Extragalactic Astrophysics from Imperial College London, he worked as a post-doctoral researcher at Imperial and a visiting researcher at Caltech. In 2007 Dr. Babbedge joined Winton Capital Management where he worked as a Senior Researcher, Head of Investment Analytics, and Personal Researcher for David Harding. In 2016 he joined GreshamQuant within Gresham Investment Management to develop Alternative Market strategies. Dr. Babbedge is an author/co-author of over 50 peer-reviewed scientific papers in international journals including *Nature*, with citations totaling to 6,000.

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Mr. J. Scott Kerson is responsible for GreshamQuant's strategy research at Gresham Investment Management. Prior to joining Gresham, Mr. Kerson was a partner at AHL Partners, LP, where he was Head of Commodities and a member of the AHL Research Advisory Board. Previously, Mr. Kerson held a variety of commodity research and trading positions, including Commodities Model Owner in Barclays Global Investors systematic macro group, discretionary trader and quant at Ospraie and Amaranth, and Managing Director at Deutsche Bank and Merrill Lynch. Mr. Kerson holds a B.A. in Economics with Highest Honors from the University of California at Santa Cruz and departed "AbD" with a M.A. in Financial Economics from Duke University.

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An Update on the Evolving Developments in Sustainable Banking

Tina Marie Reine
Senior Carbon Market Developer – North America, World Fuel Services

Sustainability has hit center stage across all economic sectors, including in commodities. Shareholders and clients are responding to sustainability challenges, and the banking sector has been listening. Banks are making environmental, social and governance (ESG) issues much more of a priority and are diversifying their offerings to include socially responsible investment products. This is a big change from a few years ago when sustainability was more of a fringe issue in banking.

In traditional banking, lending decisions were based on a basic risk and return analysis. Banks analyzed cash flow and probability of default and then weighed factors that related to internal risk diversification and capital adequacy. Two things seem to have changed to push banking to respond to sustainability challenges.

First, the general political atmosphere, especially in Europe, has swung in favor of considering environmental issues. Second, again in Europe and now starting to arrive in the U.S., is a keen awareness that both clients and shareholders are increasingly prioritizing sustainability challenges in terms of how this impacts their global brand. To the extent that companies want to be perceived as moving toward sustainability targets, they have worked with banks to develop new capital markets products that emphasize ESG objectives.

Let's explore a few developments a little more deeply.

Coal. European banks have effectively stopped lending to the coal industry. Used extensively to generate electricity, coal is viewed negatively from a public relations perspective. European banks simply have backed away from the sector almost completely. Of course, banks were pushed, as there is national legislation in European countries that forced the banks to move in that direction.

Even in the U.S., where the politics of the coal remain divisive, coal usage has declined mostly due to the very low price of natural gas, a relatively clean competitor in the arena of electricity generation. It is worth noting that certain industrial companies have made it clear they will pay a premium for inputs, such as aluminum, that are processed with electricity from cleaner energy sources. Such considerations have become an important brand issue for companies such as BMW and Airbus, as seen at the huge BMW factory in South Carolina or the Airbus facility in Alabama. U.S. banks have not been blind to this change in sentiment.

Capital Market Products. European banks have started to experiment with back-up credit lending facilities that have a small portion of the interest rate tied to ESG objectives and audited by an external

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party. That is, if a company can achieve specified ESG objectives, with clear metrics that are externally verified, it can shave a few basis points off their credit costs.

Many banks have started to create sustainability teams associated with their ESG lending and capital market products. Typically, sustainability teams are small in size (3 or fewer people). This means it is important for team members to be able to leverage relationships across the organization in order to coordinate sustainability initiatives. It also means in order to have an impact on sustainability, ownership of the sustainability agenda must cut across the entire organization.

Standards. As banks become more focused on how sustainable lending impacts their own brand and investor relations, they have had to confront the ambiguity of the metrics available. No common metrics exist to measure sustainability practices. Definitions of sustainability vary greatly across industries. This uncertainty and ambiguity has created confusion in aligning best practices across the globe.

The default for banks has been to rely on emerging reporting standards. For companies that are being considered for loans and capital market products by an ESG banking team, the first litmus test is whether the companies are reporting ESG metrics at all. To measure and disclose shows transparency and awareness of environmental impacts. The next question is what standards and metrics they report. There are a number of sustainability reporting standards, and they each assess sustainability a bit differently. They all factor in the 17 SDGs (sustainable development goals) which are targets set by the United Nations to achieve a sustainable future. On net, the evolution in sustainability banking has been to consider the targets for the 17 SDGs in their lending plans and capital market activities.

Emerging Trends in Sustainability Finance. Here is our perspective on the five key trends in ESG and how the next legs of the sustainability movement in finance is progressing.

- **Supply chain accountability.** The demand for green products is rising. That means companies are being pressured to disclose what is in their products so they can relay this to consumers.

- **Plastic pollution.** More than 60 countries have introduced measures to limit single-use plastic waste through bans or levies.

- **Energy efficient transportation.** The electric vehicle (EV) market appears poised for expansion. By 2021, virtually every major automobile manufacturer will be offering innovative and competitive EV vehicles from the low-end to the high-end and everything in between. Younger generations have embraced sustainability and the percent of EV sales is likely to have a sharp rise in the decade of the 2020s. Moreover, transportation efficiency is likely to increase dramatically over the next decade. Autonomous vehicles offer the possibility of large savings in fuel efficiency – long haul trucking is one example. We also note that the Sustainability Accounting Standards Board (SASB) has provided some guidance and focus.

- **Data transparency.** We have already discussed the growing importance of ESG reporting in regard to banking. The same trend is equally important to the funds management industry as they develop ESG indexes and Exchange-Traded Funds (ETFs) based on these indexes. Already, there has been a backlash against some fund managers who launched ESG products in name but failed to follow through on their own enforceability standards.

- **Water challenges.** Water scarcity will be one of the most significant problems of the 21st century. Nearly half the world's population—3.3 billion people—already lacks access to clean water or soon will. As water scarcity becomes more dire, the sustainability dialogue could shift to local, community-based solutions in developing regions.

Bottom line. Sustainability financing is moving from an innovative backwater to a front and center priority. ESG awareness has arrived in the C-suite of banking.

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Prior to her role as senior carbon market developer in North America for World Fuel Services, Ms. Tina Reine held senior level positions in carbon markets at J.P. Morgan in New York City, Cantor Fitzgerald in London, and at NextEra Energy where she received the Innovation Award for creating a new financial product. She has an M.B.A. from Columbia Business School.

Ms. Reine previously contributed to the Summer 2019 issue of the *GCARD*, providing a book review of *Economics Gone Astray*.

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EDITORIAL ADVISORY BOARD MEMBER NEWS

Council of Petroleum Accountants Societies (COPAS) – Colorado

The Executive Director of the JPMCC, **Thomas Brady**, Ph.D., presenting at the Colorado chapter of the Council of Petroleum Accountants Societies.

On February 12, 2020, **Thomas Brady**, Ph.D., presented his outlook for the markets and the economy during a COPAS-Colorado event, which was attended by well over 200 professionals. Dr. Brady is the Executive Director of the JPMCC and a Member of the *GCARD*'s Editorial Advisory Board. COPAS, in turn, is recognized throughout the petroleum industry as a leader in its field with a strong membership of professionals dedicated to quality service to the petroleum industry.

Dr. Brady's most recent article for the *GCARD* discusses "Practical Considerations for Commodity Investment Analysis," and he is interviewed in the current issue of the *GCARD* regarding his dynamic plans for the JPMCC.

Colorado's Energy Future

Lance Titus, Managing Director, Uniper Global Commodities and Member of the *GCARD*'s Editorial Advisory Board, participated in a panel discussion on Colorado's advancements in energy. The event, which took place on October 4, 2019, was co-hosted by the JPMCC and the University of Colorado Denver's School of Public Affairs. The discussion was co-moderated by Yosef Bonaparte, Ph.D., the Academic Program Director for the JPMCC and by Mark Safety, the Wirth Chair Scholar in Residence and Adjunct Professor at the University of Colorado School of Law. The event had about 120 attendees with representatives from both the Chinese and Canadian consulates in attendance.

Mr. Titus is also a Member of both the JPMCC's Research Council and Advisory Council.

The panelists of the forum on "Colorado's Energy Future" were from left-to-right: Jeff Lyng, Xcel Energy; Kelly Nordini, Conservation Colorado; **Lance Titus** (with microphone), Uniper Global Commodities; and Will Toor, Colorado Energy Office.

Battle Blitz: Breakfast in China

Kaifeng (Kevin) Chen, Ph.D., Chief Economist for Horizon Financial, gave the keynote speech at the "Battle Blitz: Breakfast in China" event in New York City on August 13, 2019. This forum featured experts in alternative data and hedge fund management, who discussed the opportunities for trading both China A-Shares and equities of worldwide corporations with exposure to China. Dr. Chen is also a Member of the *GCARD*'s Editorial Advisory Board and is a past presenter at one of the JPMCC's international commodity symposia. In addition, he is an Adjunct Associate Professor at New York University's School of Professional Studies Center for Global Affairs.

Kaifeng (Kevin) Chen, Ph.D., presenting during a JPMCC international commodity symposium at the University of Colorado Denver Business School. To Dr. Chen's left is Jodie Gunzberg, CFA, who is a Managing Director and Chief Investment Strategist at Graystone Consulting, a business of Morgan Stanley. Ms. Gunzberg is also a Member of the *GCARD*'s Editorial Advisory Board.

Commodity Trading Strategies

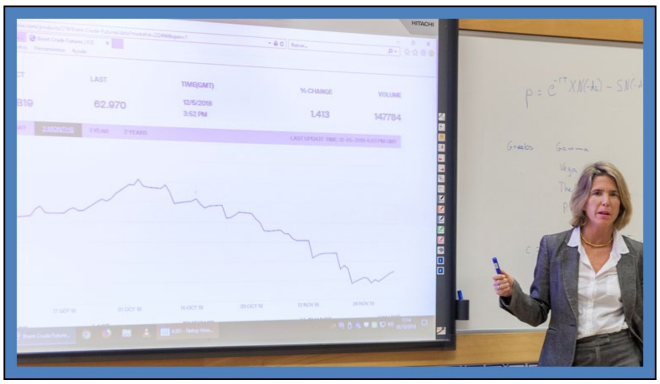
Hilary Till, Contributing Editor of the *GCARD*, presenting at a commodities investment event at the Chicago Mercantile Exchange.

The EDHEC-Risk Institute published a paper on "Commodity Trading Strategies" by **Hilary Till** and **Joseph Eagleeye** in December 2019. Ms. Till is the Contributing Editor of the *GCARD* and a Principal of Premia Research LLC; and Mr. Eagleeye is the Chief Financial Officer of Organic Valley and a Member of the *GCARD*'s Editorial Advisory Board. Ms. Till is also a Research Associate at the EDHEC-Risk Institute (France).

Ms. Till presented the content of this paper at (1) ESSEC Business School's Energy and Commodity Finance Research Center (France); (2) the Commodity and Energy Markets Conference at Oxford University; and at (3) a Cass Business School (City, University of London) Finance Research Workshop. The Director of the ESSEC Business School's Energy and Commodity Finance Research Center, in turn, is Andrea Roncoroni, Ph.D., who is also a Member of the *GCARD*'s Editorial Advisory Board. In addition, the organizer of the Cass Business School Finance Research Workshop is Ana-Maria Fuertes, Ph.D., who is a Member of the *GCARD*'s Editorial Advisory Board as well.

Mild Explosivity in Recent Crude Oil Prices

The most recent publication (in press) by **Isabel Figuerola-Ferretti Garrigues**, Ph.D., is on "Mild Explosivity in Recent Crude Oil Prices" in *Energy Economics*. The paper's findings have meaningful policy implications regarding the factors driving large changes in oil prices. Dr. Figuerola-Ferretti is an Assistant Professor and Head of the Quantitative Finance Group at Universidad Pontifica Comillas, Madrid, Spain. She is also a Member of the *GCARD*'s Editorial Advisory Board.



Professor Isabel Figuerola-Ferretti Garrigues, Ph.D., lecturing on Brent crude oil futures markets at Universidad Pontifica Comillas, Madrid, Spain.

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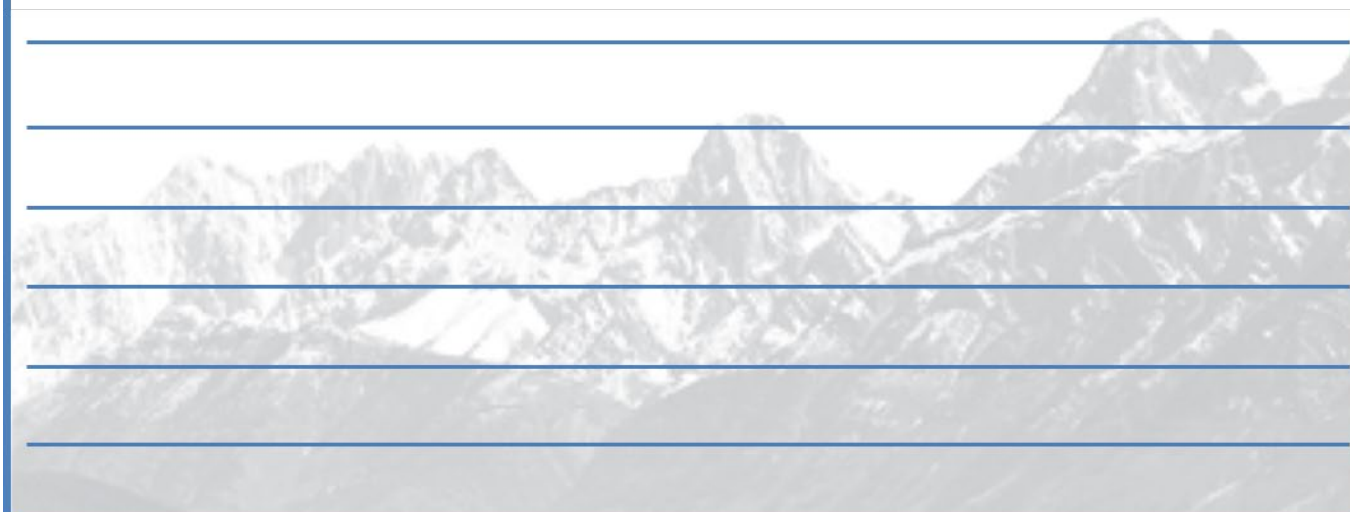

GLOBAL COMMODITIES
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The *GCARD* is edited by Ms. Hilary Till, the JPMCC's Solich Scholar, http://www.jpmcc-gcard.com/hilary-till, whom can be contacted at till@jpmcc-gcard.com.

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