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

GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

SUMMER 2022

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Vol. 7, No. 1: Summer 2022

Index of Articles

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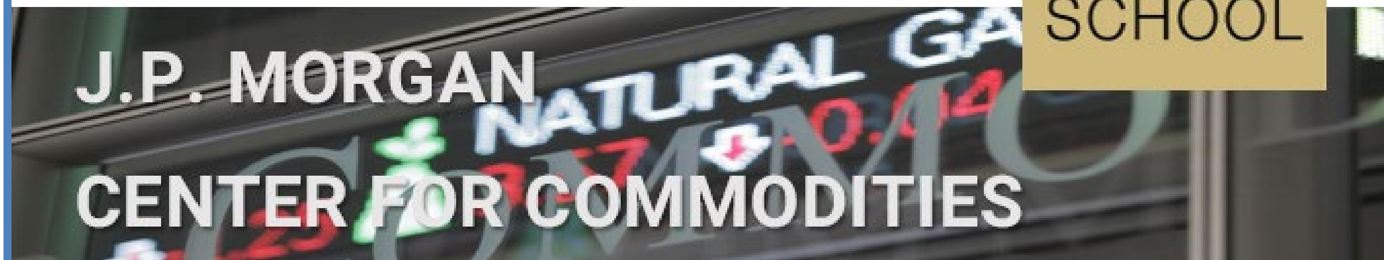

The JPMCC is positioned as a collaboration between business and academia across the broad agriculture, metals, and energy commodity sectors. Our focuses include Commodity Business Education, Applied Commodity Research, and Commodity-Related Public Forums & Discourse.

Specialization in Commodities

We offer a commodities specialization certificate to both undergraduate and graduate-level students. Starting in Fall 2022, all graduate courses will be taught in an 8-week, fully online format. We will be also offering our new undergraduate courses in a 16-week, in-person format, targeting topics that will support students in acquiring internships and jobs in the commodities sector.

Professional Education Opportunities

We offer various professional education courses throughout the year. Our classes are currently:

Energy & Commodity Analytics for Analysts | Masterclass in Commodity Trading & Hedging

Sustainable Commodities Production, Markets, and Supply Chain

Leadership in Commodity Trade & Supply Networks

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 Erica Hyman for more information or to schedule a visit to the Business School.

Erica.Hyman@ucdenver.edu; 303-315-8019

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

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

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

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

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

Complimentary subscriptions to the *GCARD* are available at: http://www.jpmcc-gcard.com/subscribe. Periodic updates on *GCARD*-related activities can be found at: https://www.linkedin.com/company/jpmcc-gcard/.

The *GCARD* benefits from the involvement of its distinguished Editorial Advisory Board. This international advisory board consists of experts from across all commodity segments. The board is composed of academics, researchers, educators, policy advisors, and practitioners, all of whom have an interest in disseminating thoughtful research on commodities to a wider audience.

The *GCARD* also benefits from its academic and professional society partnerships in furthering the international recognition of the digest. These partners include ECOMFIN (a co-sponsor of the publication), the IAQF, and CAIA. Specifically, the Director of the Energy and Commodity Finance Research Center (ECOMFIN) at the ESSEC Business School (France, Singapore) serves on the *GCARD*'s Editorial Advisory Board while the *GCARD*'s professional society partners include the International Association for Quantitative Finance (IAQF) and the Chartered Alternative Investment Analyst (CAIA) Association.

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

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

As noted, the *Global Commodities Applied Research Digest* (*GCARD*) is produced by the J.P. Morgan Center for Commodities (JPMCC) at the University of Colorado Denver Business School *in association with Premia Education, Inc.*

PREMIA EDUCATION, INC.

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

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

Update from the Executive Director

This article provides a brief update from Dr. Thomas Brady on the many events and initiatives that have taken place this year, including (a) the addition of four new Industry Advisory Council members; (b) the appointment of four new G*CARD* Editorial Advisory Board members; (c) the Center's outreach & applied research, which has included energy transition webinars with the Commodity Trading Alumni Association (of Geneva, Switzerland); (d) the redesign of graduate and undergraduate courses; (e) the JPMCC's professional education courses, including the Center's partnership with Erasmus University Rotterdam in the "Leadership in Commodity Trading & Supply Networks" Executive Program; and (f) the JPMCC's 5th Annual International Commodities Symposium. The symposium, in turn, was co-organized by Dr. Jian Yang, CFA, the JPMCC's Research Director, and Dr. Brady with Erica Hyman, the JPMCC's Assistant Director, providing logistical coordination.

Executive Director's Commentary

Research Director Report

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Research Council Corner

The authors put in context how the oil markets responded to the Omicron news shock in late November 2021, noting how the markets followed a pattern seen on other event risk days. They also provide useful real-time metrics for interpreting a market's response during eventful periods.

Research Digest Articles

This paper investigates the predictive content of a risk-neutral skewness (RNSK) signal for the dynamics of commodity futures prices. A trading strategy that buys futures with positive RNSK and sells futures with negative RNSK generates a significant excess return, which suggests a positive RNSK-return nexus. The risk premia that can be extracted through the RNSK signal is more pronounced in the contango than backwardation phase. After accounting for traditional commodity futures predictors, the RNSK signal exhibits a relatively stable and prolonged predictive ability. The directional-learning hypothesis is able to rationalize the positive nexus in terms of arbitrage risks and illiquidity (positive RNSK) and overpricing (negative RNSK).

This paper shows that rare disaster concern, defined as the news-implied volatility, performs very well at predicting the return of index commodity futures throughout the whole nearly century period of 1926 to 2016. This result holds after controlling for the current business cycle conditions, the macroeconomic variables, and the Volatility Index (VIX). The paper finds that rare disaster concern performs very well at predicting index commodity futures returns out-of-sample. The results remain robust while considering different macroeconomic conditions such as recession (expansion), contango (backwardation), or increased (decreased) inflation.

This research explores the reasons behind the low financial development (materialized by the use of derivatives trading) of the rice market, unique within the realm of large commodity markets. Through a comparison with crops with highly liquid futures markets (coffee, sugar and wheat), this article argues that the low financial development of rice is not due to one impeding factor but the accumulation of many instead. Of these, the most prominent are the disincentives for the participation of financially sophisticated (Continued on the next page.)

Research Digest Articles
(Continued)

actors, and the politicization of rice. The author argues that both factors find their root in the geographical organization of the market, which is highly concentrated in developing economies.

This study examines the long-term reversal effect in commodity spot markets using seven centuries of data. The research is the longest study of the long-term reversal effect covering 52 agricultural, industrial and energy markets from 1265 to 2017 employing U.K.- and U.S.-based commodity prices. Returns over the previous one-to-three years negatively predict subsequent performance in the cross-section of returns. The long-run reversal effect is strong and robust after surviving a variety of robustness checks. The effect cannot be explained by statistical biases, extreme events, or macroeconomic risks. The study reveals that the long-run reversal effect is driven by supply-and-demand adjustments in physical commodities through time.

Advisory Council Analysis

This article discusses potential opportunities in California's cap-and-trade carbon emissions market. It discusses how cap-and-trade works, California's Carbon Allowances (CCAs), as well as Environmental, Social and Governance (ESG) considerations of CCA investing. The article also provides two valuation methods and an outlook for the California carbon allowance market.

Editorial Advisory Board Analysis

The author discusses how a new economic and political reality has engulfed Europe, its populations, policy makers and larger economic actors, regionally as well as internationally, as a result of the outbreak of major conventional warfare on the European continent for the first time in over 80 years. The situation has required a radical re-ordering of resource allocation, with concomitant shocks to corporate, public and personal finances that this will inevitably entail.

Industry Analyses

(Continued of the next page.)

Industry Analyses
(Continued)

Interview

CU Denver Business School Global Energy Management (GEM) Program

Editorial Advisory Board News

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

We are happy to celebrate the 10th anniversary of the J.P. Morgan Center for Commodities (JPMCC)! In our first decade, the JPMCC has enrolled over 450 students in our commodity-focused classes, awarded over $280K in scholarships, published thirteen issues of the *Global Commodity Applied Research Digest* (*GCARD*), held five Applied Commodity Research Symposiums, as well as hosted timely webinars, podcasts, speaking and networking events.

At this milestone, we want to thank members of both the JPMCC's Research and Advisory Councils, who continue to support this publication and the overall Center by providing insightful commodity-related articles from both academia and industry.

Industry Advisory Council

Dr. Tom Brady, the CoBank Executive Director of the J.P. Morgan Center for Commodities, would like to introduce four new additions to our prestigious Industry Advisory Council: Froydis Cameron-Johansson, Bernadette Johnson, Thomas Lord, and Deanna Reitman (in alphabetical order.)

Dr. Thomas Brady, Ph.D., presenting at a JPMCC international commodities symposium. Dr. Brady is the JPMCC's CoBank Executive Director at the University of Colorado Denver Business School and is also a Managing Director at Capitalight Research in Canada.

Industry Advisory Council (Continued)

Our new Council members have the following affiliations: Froydis Cameron-Johansson is the Group Head of International Government and Sustainability Relations at Anglo American; Bernadette Johnson is the Senior Vice-President and Head of Power and Renewables for Enverus; Deanna Reitman is Of Counsel in the Finance, Energy & Commodities Practice of DLA Piper; and we welcome the return of Thomas Lord, who is currently a Senior Risk Consultant at Norton Rose Fulbright. We look forward to adding their expertise to our Advisory Council as we improve our Center offerings in areas from classes to internship opportunities, research and scholarships.

***GCARD* Editorial Advisory Board**

We are also happy to announce the appointment of four additional commodity experts to the *GCARD*'s Editorial Advisory Board (EAB): Dr. Jennifer Considine, Dr. Adrian Fernandez-Perez, David Fyfe, and Adila Mchich (in alphabetical order.) Jennifer Considine is a Visiting Researcher at the King Abdullah Petroleum Studies and Research Center (KAPSARC) in Saudi Arabia and a Senior Research Fellow at the Centre for Energy, Petroleum and Mineral Law & Policy, University of Dundee in the U.K.; Adrian Fernandez-Perez is the Acting Director of the Auckland Centre for Financial Research in New Zealand; David Fyfe is the Senior Economist for Argus Media in the U.K.; and Adila Mchich is a Director in Energy Research & Product Development at the CME Group. Each of the *GCARD*'s new EAB members have been generous contributors to the Center's digest.

Adila Mchich, Director in Energy Research & Product Development at the CME Group and **Hilary Till**, Contributing Editor of the *GCARD*, at the International Association for Quantitative Finance (IAQF)/Northfield Information Services annual award dinner at the Yale Club in NYC in May 2022. Mchich recently joined the *GCARD*'s Editorial Advisory Board; and Till is also a board member of the IAQF.

Center Outreach & Applied Research

This past Spring the JPMCC and the Commodity Trading Association (of Geneva, Switzerland) hosted a three-part webinar series with industry experts discussing implications of the Energy Transition, including critical minerals and financing challenges. Of note, the Commodity Trading Association is a professional society partner for the *GCARD*.

The Center is also in the midst of working on applied research projects with JPMCC graduate students and two partnering firms. The projects include the creation of a commodity carbon-neutral index and the forecasting of pork prices.

The Redesign of Graduate and Undergraduate Classes

Starting in August 2022, we launched our updated eight-week, fully online graduate courses to allow for more student enrollment across the U.S. and the globe. We are also offering our new undergraduate courses in a sixteen-week, in-person format, targeting topics that will support undergraduates in acquiring internships and jobs in the commodities sector. Additional scholarship support from our industry partners will allow us to offer increased financial aid to our students as they complete their commodity education.

Professional Education Courses

Energy and Commodity Analytics for Analysts: Dr. Daniel Jerrett taught this four-week online course during March and April of this year. This course is intended for analysts and technical professionals who want to 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 the analysis of real-world data. Students learn commodity data analysis utilizing both Python and analytics software. Of note is that Dr. Jerrett is also an Industry Advisory Council member of the JPMCC and was featured in a *GCARD* article that is available here.

Leadership in Commodity Trading & Supply Networks: This three-month program, which is offered by Erasmus University (The Netherlands), in partnership with the J.P. Morgan Center for Commodities and Singapore Management University, began at the end of March. CU Denver Business School's J.P. Morgan Center for Commodities hosted the North American section of the "Leadership in Commodity Trade and Supply Networks Executive Program" in May.

The JPMCC section's unique and exclusive curriculum is available here. The comprehensive program covers risk & compliance, technology & innovation, sustainability, geopolitics, and trading asset acquisition, scenario planning, and new commodity markets. The program is interdisciplinary and focuses on developing leadership skills and strategic thinking. It is theoretically informed but interactive, hands-on and with real world cases to provide a true learning experience across three continents. The leadership perspectives allow participants to reflect upon intercultural aspects, ethics, and the importance of courage required to drive change.

Left-to-Right at the University of Colorado Denver Business School: **Dr. Jian Yang**, CFA, the JPMCC's Research Director; **Dr. Thomas Brady**, the CoBank Executive Director of the JPMCC; and **Dr. Wouter Jacobs**, the "Leadership in Commodity Trading & Supply Networks" Program Director at Erasmus University Rotterdam (The Netherlands). Dr. Jacobs is also a member of the JPMCC's Industry Advisory Council.

Program participants had a fascinating trip to the gold mine of Newmont Corporation at Cripple Creek & Victor in Colorado. After a Mining 101 lecture by the JPMCC's CoBank Executive Director, Dr. Tom Brady, Newmont provided a tour of the mine, presenting historical context, the geological features and the economics of running the mine. Central in the discussion was the Environmental, Social, and Governance (ESG) policies of a large mining operation. Community development and mitigating various environmental externalities are critical for keeping a license to operate. Also, the tour provided program participants with a fundamental understanding of the complexities of mining the metals and minerals that are crucial for the energy transition.

This prestigious program will be held again in the Spring of 2023.

Research Symposium

The J.P. Morgan Center for Commodities held its 5th annual research symposium in person with a virtual option on August 15 and 16, 2022. Symposium attendees were able to network and connect with commodities colleagues in industry and academia in Denver while allowing those unable to travel to participate and learn from our academic research presenters and industry panelists. Panel topics included carbon markets, commodity investment in the current environment, and emerging technologies.

Of note, "[t]op policy researchers from the U.S. Federal Reserve and other central banks as well as scholars from more than a dozen world-class academic institutions … address[ed] new directions in commodities research. … Representatives from major policy institutions such as the U.S. Fed, the International Monetary Fund and Bank of Canada, not to mention top academics from Cambridge, Tsinghua, Yale and other leading universities" participated in the symposium, reported Shicong (2022).

The symposium was co-organized by Dr. Jian Yang, CFA, J.P. Morgan Endowed Chair and Research Director and Dr. Tom Brady, the CoBank Executive Director of the JPMCC. Erica Hyman, the JPMCC's Assistant Director, executed symposium logistics and registration.

Deanna Reitman, Of Counsel, DLA Piper and **Thomas Lord**, Senior Risk Consultant, Norton Rose Fulbright participated in the JPMCC's 5th Annual International Commodities Symposium in August 2022 during the "Commodities & Carbon Markets" industry panel. They both recently joined the JPMCC's Industry Advisory Council.

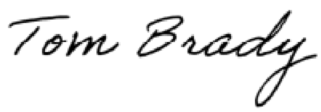
CoBank Executive Director's Concluding Note

I welcome *GCARD* readers staying up to date on the JPMCC's numerous activities by visiting the Center's website or by following the Center and *GCARD* on our two LinkedIn sites, https://www.linkedin.com/school/cu-denver-center-for-commodities/ and https://www.linkedin.com/company/jpmcc-gcard.

CoBank Executive Director's Concluding Note (Continued)

We hope you enjoy reading this latest issue and always feel free to contact me for further information and questions.

Best Regards,



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

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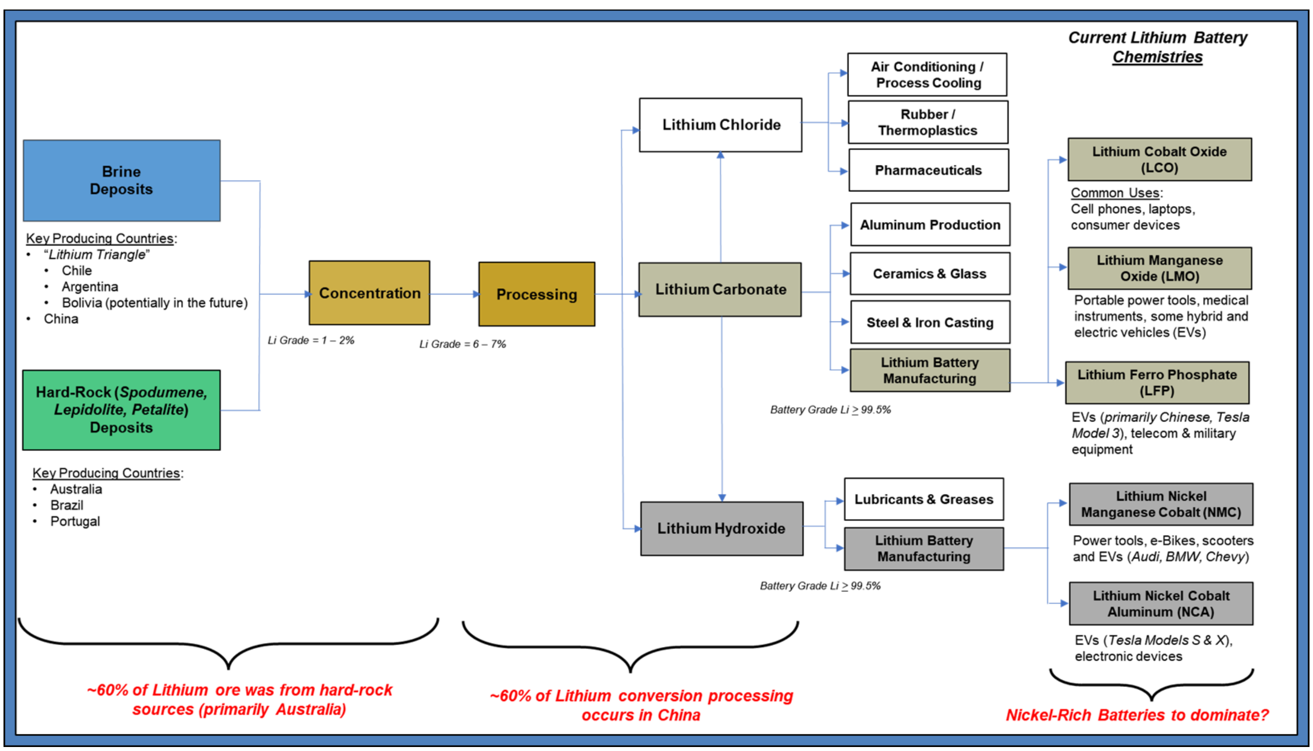
An Overview of the Lithium Supply Chain

Thomas Brady, Ph.D.
CoBank Executive Director, J.P. Morgan Center for Commodities, University of Colorado Denver Business School; and Managing Director and Editor, *Commodities Report*, Capitalight Research, Canada

In this digest article, we provide an overview of the global lithium supply chain from the mining of ore through the processing of intermediate compounds, to the manufacture of lithium-ion batteries (Figure 1). Driven by increasing global demand for batteries, the search for new mine supply sources and processing techniques alongside the evolution of battery chemistries, this supply flow is guaranteed to change in the future.

Currently, the majority of lithium mining occurs from either brine or hard-rock deposits.[1] Brine deposits are primarily mined from areas within the "*Lithium Triangle*" (which includes Argentina, Chile and potentially, in the future, Bolivia) and is also mined in China. Actual mining from brine deposits involves the pumping of saline groundwater enriched with dissolved lithium from underground reservoirs to the surface for solar evaporation in successions of ponds. Hard-rock sources are dominated by spodumene deposits, primarily located in Australia. The Greenbushes operation, presently the world's largest lithium mine, is located in Western Australia.

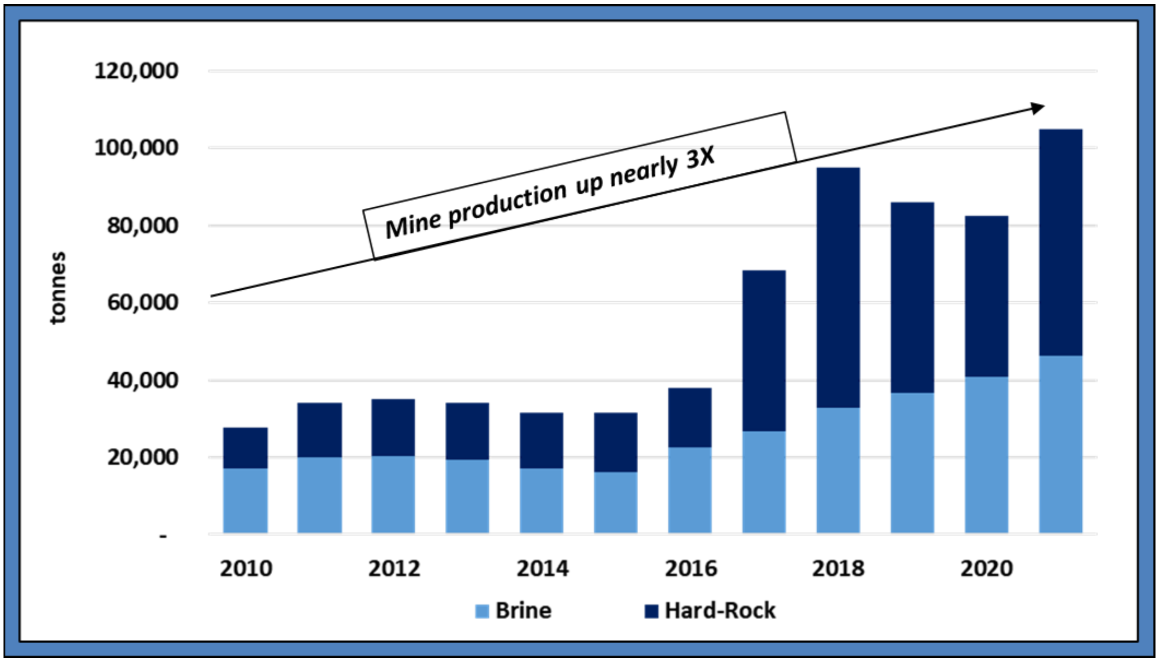
Figure 1
Global Lithium Supply Chain



Source: Capitalight, as adapted from Talens Peiró *et al*. (2013).

Figure 2 summarizes annual global lithium mine production by deposit type since 2010. As shown, global supply has increased from ~28K tonnes in 2010 to ~105K tonnes last year, a nearly 3-fold increase. Lithium mine production from brine deposits dominated annual totals until 2017. Over the last five years however, production from hard-rock sources has averaged slightly under 60% of the annual global total.

Figure 2
Global Lithium Production by Deposit Type



Sources: Capitalight and United States Geological Survey (USGS) Mineral Commodity Summaries.

As shown in Figure 1, across deposit types, mining ore grades are generally low (1% to 2%), making these uneconomic for transport. As such, ore concentration activities typically occur at the mine site. Concentration of brine mined ore occurs through solar evaporation in successions of ponds to increase the grade. At hard-rock deposits, run of mine ore is initially processed through grinding and screening to separate lithium from surrounding materials in the ore. Following concentration, lithium grades are generally in the 6% to 7% range (Bednarski, 2021).

Lithium Processing/Conversion

Following ore concentration, the next step in the lithium supply chain is processing and conversion. As shown in Figure 1, lithium carbonate is a first intermediary chemical in the lithium supply chain, which is used in various manufacturing processes (including ceramics and glass, aluminum and steel castings) as well as some electric vehicle (EV) battery types. Lithium carbonate may also be further processed to obtain lithium chloride and lithium-hydroxide, the latter of which is used in the manufacture of nickel containing (often called "nickel rich") lithium-ion batteries.

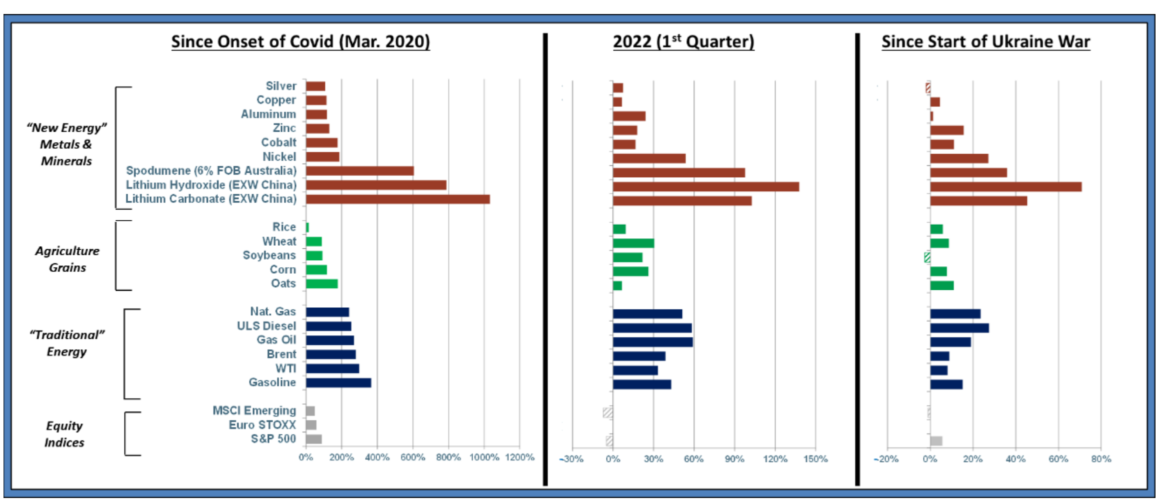
As depicted with the multiple arrows under the processing steps in Figure 1, the conversion of hard-rock (spodumene) lithium concentrate is more flexible in terms of production processes. It allows for a streamlined production of lithium-hydroxide while the processing of lithium from brine concentrates produces lithium carbonate, which must then be further processed to obtain lithium hydroxide (*Innovation News Network*, 2021).

The processing of lithium ore is difficult and becomes more so as the mineral moves through the supply chain to the eventual material used in battery cathodes. Further, battery chemistries are fragile which means that processing facilities must be able to produce consistent lithium intermediate products such as lithium-carbonate and lithium-hydroxide. Critical to this processing is the control of the many impurities that may coexist with lithium in concentrated ore such as magnesium, sodium and potassium that negatively impact battery cathode performance further down the supply chain (Bednarski, 2021).

Through the conversion steps, whether in the form of lithium carbonate or lithium hydroxide for eventual use in EVs or batteries for other electronic devices, the purity of lithium is increased to >99.5%. In terms of geopolitical risks within the lithium supply chain, currently over 60% of the facilities that convert lithium ore into the intermediate products of lithium carbonate and lithium hydroxide are located in China (Tarry and Martinez-Smith, 2020).

Figure 3 displays price returns for representative commodities and equity indices (a) since the onset of the COVID-19 Pandemic, (b) over the 1st quarter of 2022, and (c) since Russia invaded Ukraine in late February 2022. While not as widely reported as price increases in traditional energy (including West Texas Intermediate (WTI) and Brent crude oil, natural gas and gasoline), metals and minerals associated with the energy transition (labeled "New Energy" on the figure) have experienced significant gains over the three identified periods. As shown in the figure, price increases in lithium hard-rock (spodumene) ore and the lithium carbonate and hydroxide intermediate compounds have each far exceeded traditional energy and agricultural grains. These sharp increases, along with the price climbs in cobalt and nickel are sure to drive higher battery prices (and overall EV prices) over the coming months.

Figure 3
Lithium Compounds & Select Commodities Price Performance



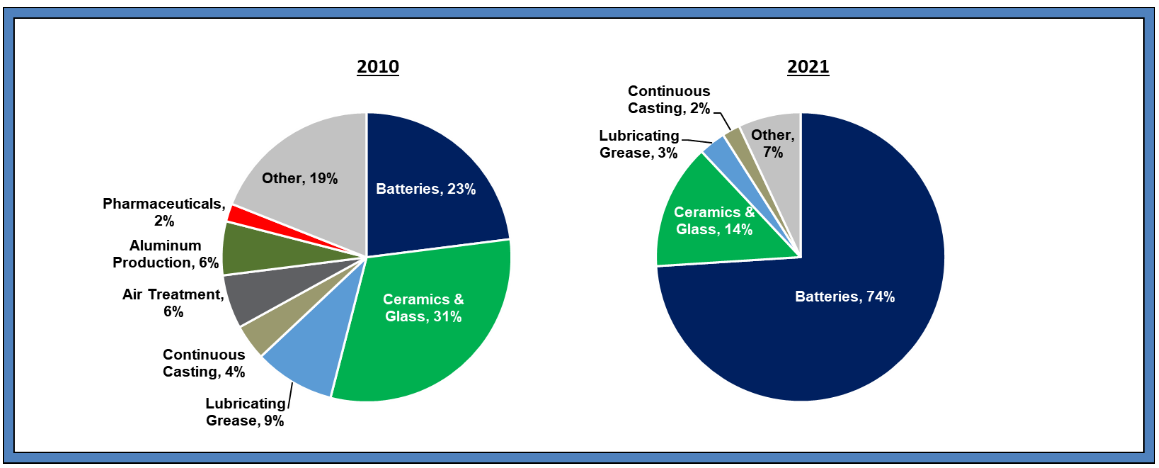
Sources: Capitalight and Bloomberg.

Lithium Demand

Progressing further through the supply chain (as illustrated in Figure 1), following the conversion to the aforementioned intermediate products, are various manufacturing and end-use applications. These include air conditioning and industrial process cooling, thermoplastics, pharmaceuticals (for bipolar and depression), as an alloy in aluminum production to add strength and corrosion resistance. In the manufacture of glass and ceramics, lithium carbonate allows for lower processing temperatures and thus lower energy input. Other uses include steel casting applications and finally in the manufacturing of lithium-ion batteries.

Figure 4 displays how the demand for lithium has evolved over the last ~10 years. In 2010, ceramics and glass demand dominated global demand, accounting for nearly one third of the total, followed by battery applications required nearly 25% of the total.[2] Spring forward to 2021, reflecting the huge increase in demand needs for EVs and other consumer electronics, batteries now amount to ~75% of annual global demand.

Figure 4
Global Lithium Demand



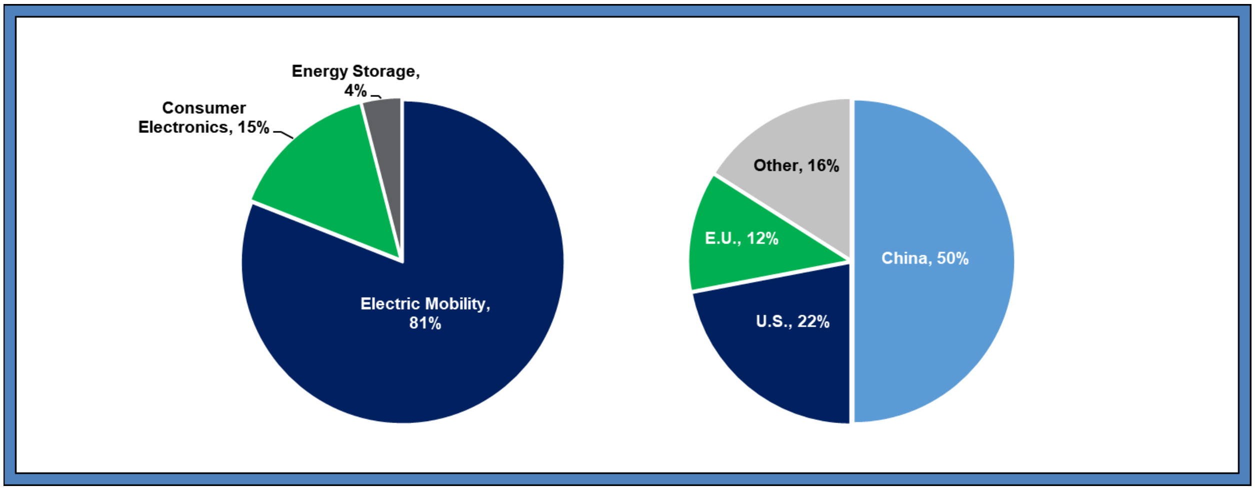
Sources: Capitalight and USGS Mineral Commodity Summaries.

Lithium-Ion Battery Manufacturing and Demand

Continuing down the lithium supply chain, Figure 1 also displays the major types of current lithium-ion batteries that have come to dominate the portable electronics, energy storage and EV markets. Key to lithium batteries are the relatively higher energy densities (higher power and lower weight) compared to non-lithium ion battery types. For EVs, higher energy density translates into more power and higher mileage ranges. As shown on Figure 1, at present there are five general types of lithium-ion battery chemistries including lithium cobalt oxide (LCO), lithium manganese oxide (LMO), lithium ferro (or iron) phosphate (LFP), lithium nickel manganese cobalt (NMC), and lithium nickel cobalt aluminum (NCA).[3] While some of these common battery types may or may not include cobalt (a topic for a future article), all contain lithium. Actual manufacturing of lithium-ion batteries occurs primarily in China, Japan, and South Korea.

Figure 5 displays demand for lithium-ion batteries by end-use and by country for 2020. As shown, electronic mobility (primarily EVs but also includes e-bikes, and scooters) dominates demand at over 80%. Consumer electronics (laptops, medical devices, cell phones to name a few) account for 15%, followed by energy storage (4%). China by far leads in the global demand for lithium-ion batteries with over half, followed by the U.S. (22%) and the EU at 12%.

Figure 5
Lithium-Ion Battery Demand by Use and Country (2020)



Sources: Capitalight and Liu *et al.* (2022).

Lithium-Ion Battery Types & Pros and Cons

Specifically, the following summarizes the benefits and challenges associated with current five general chemistries utilized in the cathode of lithium-ion batteries.[4]

Lithium-Cobalt Oxide (LCO) – These batteries are most commonly used in smaller, portable electronics including mobile phones, tablets, laptops, and cameras. A key attribute of this battery type is the ability to deliver power over long periods for low power-requirement applications. Negatively, these batteries suffer from relatively short lifespans, losing effectiveness after 500 to 1,000 life cycles (or charging periods.) These batteries also have poor thermal stability: there are many reported incidents of batteries overheating due to overcharging and/or poor performance in extremely hot or cold environments.

Lithium-Manganese Oxide (LMO) – In comparison with LCO batteries, this chemistry offers improved thermal stability. LMO batteries are commonly used in power tools and medical instruments. Early EVs such as the Nissan Leaf used LMO batteries which suffer from relatively short driving ranges of 80 to 100 miles. LMO batteries have shorter life cycles in the 300 – 700 charging cycles range.

Lithium-Ferro-Phosphate (LFP) – Along with LMO batteries, LFP chemistries have the benefit that these do not contain cobalt (another mineral critical to the "New Energy Future" whose prices have also climbed, as shown in Figure 3.) In addition, cobalt brings significant geopolitical risk as >80% of world supply is from the Democratic Republic of Congo. LFP batteries offer a relatively longer life span (1,000 to 2,000 charge cycles.) These batteries are known to be relatively safe, however performance can suffer in low temperatures. In addition to not using cobalt, LFP batteries use iron rather than more costly nickel. Average costs are currently lower than nickel-rich chemistries. At present, the current trend appears to be heading toward LFP batteries. Nearly 60% of EVs produced in China during 2021 use LFP batteries (Pressman, 2022). Also, Tesla recently migrated its entry-level Model 3 to use LFP.

Lithium-Nickel-Cobalt-Manganese (NCM) – Within the cathodes of NCM batteries, manganese is added to nickel to provide additional thermal stability. These batteries are known for having relatively long life spans (similar to LFPs). NCM batteries are widely used in power tools, e-bikes, and scooters. Higher end Chinese EVs such as the BYD Qin Pro use NCMs as does the VW ID.4 and Chevy Bolt.

Lithium-Nickel-Cobalt-Aluminum (NCA) – NCA batteries are widely used in the EV marketplace as they perform well under high-load applications and offer long battery life. NCA batteries can offer ~30% more energy density (more energy per unit of weight) compared to LFPs. Tesla's higher-end models (the S, X and Y) use NCA battery types.

Currently the "nickel rich" batteries appear the preferred battery type in the U.S. and Europe.

Outlook

In an attempt to shore up domestic supply chains, on March 31st, the Biden administration announced plans to use the Defense Production Act to ramp up the mining and processing of key minerals used in batteries for renewable energy and electric vehicles.[5] Under the order, companies could receive funding for feasibility studies to extract lithium, nickel, cobalt, graphite, and manganese. Two initial concerns arise with this announcement. First, while companies may obtain assistance for the study of potential domestic projects, it does not appear that the U.S. government will help with actual capital expenses associated with building mining operations. Second, as highlighted in this article, the significant risks associated with the lithium supply chain lie in the processing of lithium carbonate and hydroxide intermediate compounds necessary for eventual EV battery manufacture. Sixty percent of this processing occurs in China. The Chinese have been working 10+ years on refining processes to transform lithium containing ores into the exacting and precise materials required by battery manufacturers for eventual use in EVs and other critical electrical equipment used in industry and by consumers.

In our view, many in the Western countries of the world have unrealistic expectations for the "Energy Transition." As a representative example, global automobile sales are expected to approach 125M units by 2030, a nearly 45% increase from 2021 (*Business Wire*, 2021). If the world is to build toward a "Net Zero Carbon by 2050" scenario, this will require nearly 60% of these 2030 sales to be for EVs. However, rolling back through the lithium supply chain, this would require mine supplies to be ~5-times higher than the 100K tonnes mined last year. When one contemplates the actual time required for (a) companies to explore, study and model potential resources, (b) the negotiation and finalization of national, state and local permits, (c) the extensive efforts to solidify buy-in from local communities and other stakeholders, (d) the raising of capital funds and (e) the actual construction of a mine, this level of expansion (all within <8 years) is extremely unlikely.[6] As the world operates today and Congress will discover, it is much easier to state proclamations such as: *"The U.S. Government will end gas-powered vehicle purchases by 2035"* than to fulfil that proclamation.

Endnotes

1 Traditionally, extracting lithium clay hosted sediments was considered too complex and uneconomic; however, a number of U.S. based projects are currently under evaluation, including Thacker Pass in Nevada, which is noted as having the largest resource in the U.S.

2 Note that in the mid-1990s only ~7% of global lithium demand was allocated to batteries. Remember the hand-held Sony Camcorder?

3 Another common battery chemistry uses lithium titanate (LTO) which replaces graphite used in the anode of the battery with lithium titanate for use in the LMO or NMC as the cathode chemistries (Dragonfly Energy, 2021).

4 This section relies heavily upon Dragonfly Energy (2021) and Liu *et al.* (2022).

5 The U.S. Defense Production Act allows the president to respond to a national emergency by requiring that companies prioritize federal contracts for whatever goods or materials it deems necessary.

6 Further, this quick calculation ignores the requirements in electronic and medical devices as well as the building requirements for the lithium needed in actual EV charging stations.

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Author Biography

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Dr. Thomas Brady is a mineral and commodity sector economist and is currently the CoBank Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School and founder of Brady Commodity Advisors, LLC. Most recently Dr. Brady was the Chief Economist at Newmont Mining Corporation responsible for generating key commodity price, foreign exchange and other financial assumptions used throughout the company. Previously at Newmont, he led the Strategic Planning function that developed and implemented portfolio modeling analytics and also held positions in Investor Relations, Treasury and Corporate Development.

Prior to rejoining 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.

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

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

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

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

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

In this report, the research director will provide updates about recent JPMCC research activities from October 2021 through March 2022.

Closer Collaboration with the World Bank on Applied Commodity Research

In mid-December 2021, the JPMCC research director was invited to participate as a discussant in the seminar titled, "From Quantities to Prices: Commodity Price Cycles and Their Determinants," by the Prospects Group at the World Bank. The discussion was primarily focused on a chapter on commodity markets in the January 2022 edition of *Global Economic Prospects*, the World Banks' flagship publication. The seminar also covered a related policy research working paper by the World Bank.

In late February 2022, the JPMCC research director was invited to participate as one of three panelists in a commodity market outlook webinar, jointly organized by the Policy Center for the New South in Morocco and the World Bank. The main presentation was made by Dr. John Baffes, who heads the Commodities Unit and is in charge of the *Commodity Markets Outlook* at the World Bank. The event was moderated by Dr. Otaviano Canuto, a former Vice President at the World Bank, and livestreamed on Youtube, Twitter and Facebook. Dr. Baffes is also a Research Council member of the JPMCC and an Editorial Advisory Board member of the JPMCC's *Global Commodities Applied Research Digest*.

A Study Investigating the Price Discovery Function of China's Crude Oil Futures

In the mid-December 2021, the research director made a keynote speech at the Symposium on Commodity Market Development and Risk Management, which was hosted by Hunan University in China. The keynote speech was based on the research paper titled, "Price Discovery in China's Crude Oil Futures Markets: An Emerging Asian Benchmark?". Some of the main findings were also exclusively featured in a media article in English published by *Yicai Global*, in addition to some media exposure in Chinese.

Briefly speaking, while there has been some skepticism about the functioning of China's INE (*i.e.*, Shanghai International Energy Exchange) crude oil futures contracts, evidence shows that China's crude oil futures market did perform the price discovery function reasonably well for major oil spot prices in Asia. There was a long-run relationship between China's INE futures price and each of the original seven deliverable spot crude oil prices. Each of the deliverable crude spot prices and the INE crude oil futures price reacted to each other in the long run. Nevertheless, there is still much room for the improvement of the price discovery function of the INE crude futures. In particular, the deliverable spot prices still played a more important role than the INE crude oil futures price in the price discovery process. The degree of influence of spot prices on the INE futures prices increases significantly over time, explaining about 2/3 of the INE futures prices at a monthly time horizon.

On a related note, the JPMCC research director was also recently notified by Wiley that the director's first research project on China's crude oil futures contracts, which was published in the *Journal of Futures Markets* in 2020, was "a top cited article" for the journal during 2020-2021; as of March 2022, the article was the No. 1 most cited with 14 Social Sciences Citation Index/Science Citation Index (SSCI/SCI) citations. This article was also included with a brief summary of research findings in the 2022 annual development report of the Shanghai International Energy Exchange (INE).

Media Interviews on Commodity Prices and Inflation

In early February 2022, the research director shared his viewpoint with the Marketplace program, which has 14 million audience (plus another 7 million via their digital platform) every week and is produced by the second largest public radio producer in the U.S., the American Public Media. A main point was that more inflation would be on the way rather than being transitory, pushed by rising commodity prices. The important role of energy prices was also underscored.

In mid-February 2022, the research director expressed the serious concern that the rising U.S. inflation rate could challenge the U.S. economy down the road. This interview was featured in a weekly headline article prepared by the editor-in-chief of *Yahoo! Finance* (which is reported to have a monthly audience of about 270 million in December 2021.) The article captured much attention and had more than 1,000 comments by the readers on the website, and it was also shared by others in social media (*e.g.*, Facebook, Reddit, Twitter, and LinkedIn.) As a caveat, only part of the interview was featured in the article.

The 5th Annual International Commodities Symposium in 2022

The JPMCC held the 5th annual international symposium at the University of Colorado Denver Business School, which took place in a hybrid format (both in person and virtually on the Zoom) from August 15 through August 16, 2022. The "Research Director Report" in the Winter 2022 edition of the *GCARD* will cover the symposium in depth. In addition, the *Journal of Futures Markets* (*JFM*) will continue to sponsor a special issue for the 2022 JPMCC symposium, under the new editorship of Professor Bart Frijns in Netherlands. (The *JFM* special issue on the 2021 symposium was also published in May 2022). For the August 2022 symposium, we received dozens of paper submissions from researchers in (at least) twelve countries, including Canada, Chile, China, France, Germany, Greece, India, Norway, Spain, Switzerland, the U.K., and the U.S. (in alphabetical order). A partial listing of author affiliations includes Cambridge (Judge Business School), Columbia, Tsinghua, Peking University, and the University of California, Berkeley (again in alphabetical order), along with various policy institutions (*e.g.*, the International Monetary Fund, the United Nations Conference on Trade and Development (UNCTAD), the U.S. Federal Reserve Board, and the Bank of Canada).

Like the 4th symposium in 2021, the JPMCC's Executive Director, Dr. Tom Brady, was the co-organizer for the 2022 symposium and took the lead in organizing the program of industry panels. Erica Hyman, the JPMCC's Assistant Director, served as the coordinator for the symposium.

Conclusion

While we are apparently seeing the light at the end of the tunnel, COVID-19 has greatly impacted each of us, including the format of working modes and conference gatherings. Despite the challenges, we were happy to see so many of you in person at our 2022 symposium. We wish everyone a healthy and safe rest of your summer!

Best Regards,

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

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The Day Oil Markets Reacted to Omicron

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Dr. Bluford Putnam, Ph.D., Chief Economist at the CME Group, presenting at an industry panel during a J.P. Morgan Center for Commodities' international commodities symposium held at the University of Colorado Denver Business School. To Dr. Putnam's right is Hilary Till, the *GCARD*'s Contributing Editor, who moderated the panel.

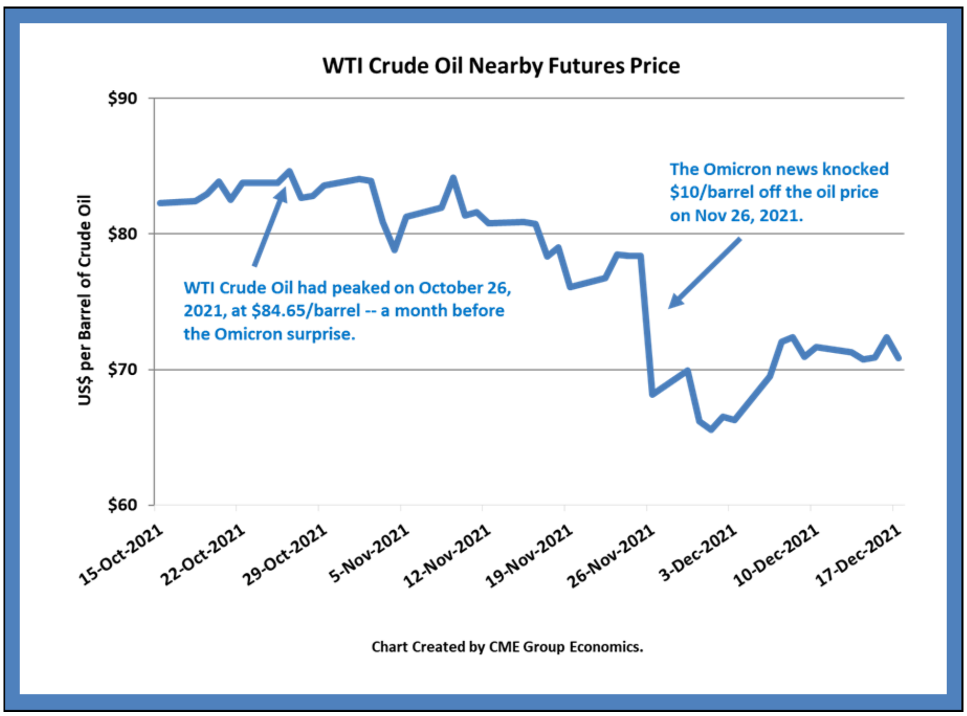
News of the arrival of the Covid-variant named Omicron began to spread on November 25, 2021, a Thursday and notably the Thanksgiving Day holiday in the United States, which meant U.S. futures markets were closed. They opened the next trading session at 5:00pm U.S. Central Standard Time (i.e., CST, Chicago time) on the Thanksgiving afternoon for a holiday-shortened day ending at 12:45pm CST on Friday, November 26, 2021. The Friday after a Thursday holiday is typically a very light volume day, as many traders follow the French tradition of "le pont" – by taking the day off as "the bridge" to the weekend. With the surprise Omicron news, the Friday, November 26, 2021, trading session was extremely active. Our research interest is to examine the trading activity on a typically low-volume day to observe how the futures markets reacted to the surprise news of a new Covid variant that was expected to be highly contagious and spread rapidly.

Oil Markets Were Impacted the Most

For the trading session on Friday, November 26, 2021, the active WTI crude oil futures contract was the January 2022 maturity date. The oil futures price opened at $78.39/barrel and closed on the Friday session at $68.15, a $10 drop, or about a 13% decline in the trading session; see Figure 1. The S&P500® futures contract also dropped 2.2%; see Figure 2 on the next page.

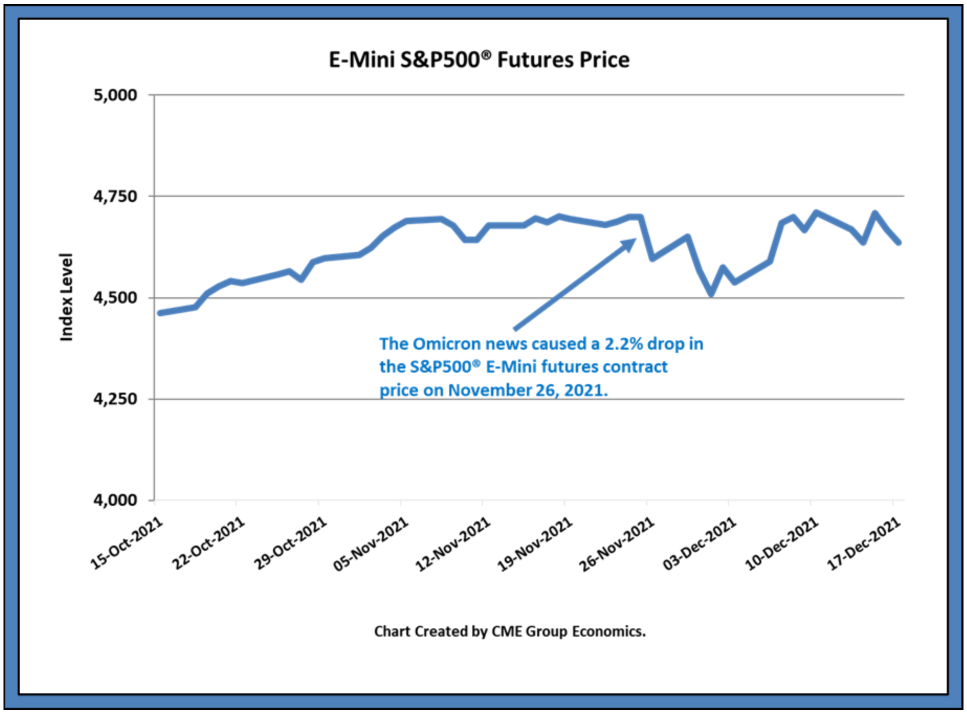
Context matters, and it is important to note a couple of things about why the oil market was more highly impacted than equities or bonds. First, oil is largely used as a transportation fuel in its refined state. Consequently, when the Omicron virus news hit, the conclusion many traders reached very quickly was that the budding signs of a recovery in international travel would be reversed. Second, oil prices were already in a modest decline, having declined by $6/barrel from an October peak of $84.65. When uncertainty hits a market that already has downward momentum pressure, the resulting price slide can be exacerbated.

Figure 1



Source: Bloomberg Professional (WTI Oil Futures = CL1).

Figure 2



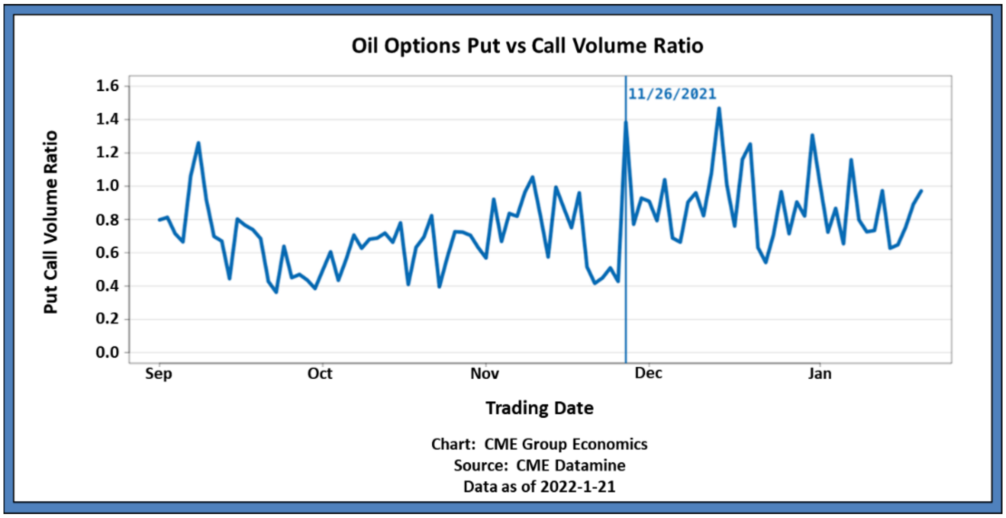
Source: Bloomberg Professional (ES1).

Not Just an Increase in Volatility, but a Downward Price Gap, Too

One might be tempted to view the Omicron news as causing an increase in market volatility. Certainly, looking backwards, the typical standard deviation measure of price volatility showed a rise. But that simplified interpretation ignores the importance to market participants, especially options market participants, of an unexpected price gap.

Options traders monitor the implied volatility of the markets they trade with great scrutiny. The challenge related to price gaps is that the versions of the Black-Scholes-Merton options pricing models[1] that are typically used for implied volatility calculations have an embedded assumption of continuous price movements – that is, the possibility of discreet price gaps are explicitly assumed not to exist. This assumption makes the mathematics of the options pricing model much easier, but it can be hazardous to the health of a risk manager. For anyone using a delta-hedging strategy related to options positions, price gaps can cost considerable money if the gap goes in the wrong direction related to the underlying options positions that is being risk-managed through delta-hedging in the futures markets. As a consequence, a surprise price gap[2] is likely to be accompanied by an asymmetry in options trading with elevated activity on the side of the options market that is being impacted – in this case with a downward price gap, we would expect outsized trading activity in put options. Indeed, this is what occurred; see Figure 3 on the next page.

Figure 3
Put versus Call Options Volume



Bid-Ask Spreads Initially Widened, Then Narrowed

Liquidity is often measured by bid-ask spreads, and one would expect that a news event would result in wider bid-ask spreads. This is what happened in oil futures markets when the Omicron news broke; however, the intra-day pattern is highly informative.

Remember, when thinking about liquidity, we are dealing with a typically light-volume day after the Thursday Thanksgiving holiday in the U.S. What we observed in the Omicron news trading session was that bid-ask spreads were wider than usual, during the first part of the trading session; however, they narrowed considerably in the second half, before rising at the end of the session, which is quite common in many markets, not just oil, especially ahead of a holiday weekend.

The Data Science team at CME Group closely monitors liquidity and how the bid-ask spread can impact the cost of trading.[3] The cost to trade different lot sizes is analyzed separately. One usually would expect small trading lots, say one to three contracts, to be less impacted than larger trade sizes. In this case we provide examples for three-contract lot size and for 10-contract lot size to show the difference – or in this case the similarities in Figures 4 and 5 respectively on the next page.

Figure 4
Cost to Trade 3 Lots

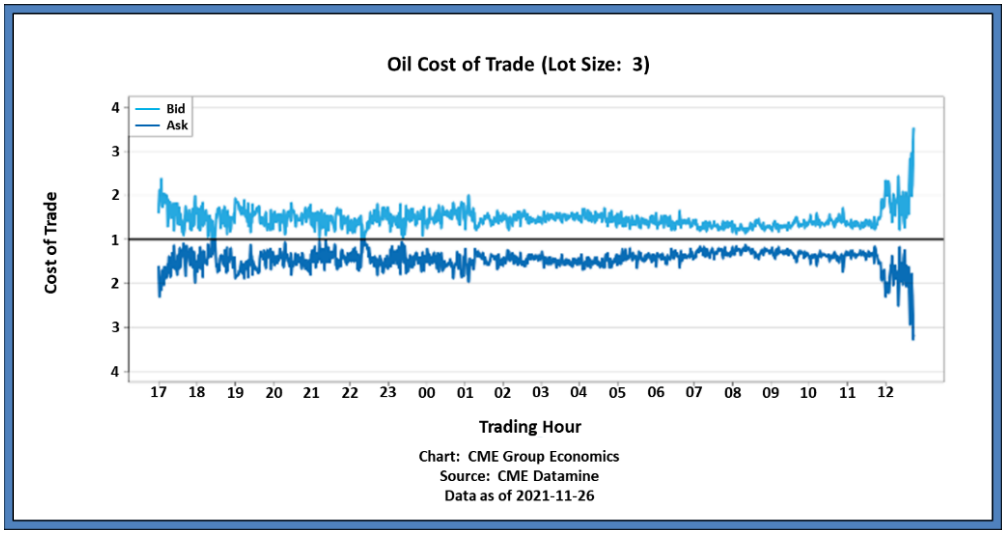
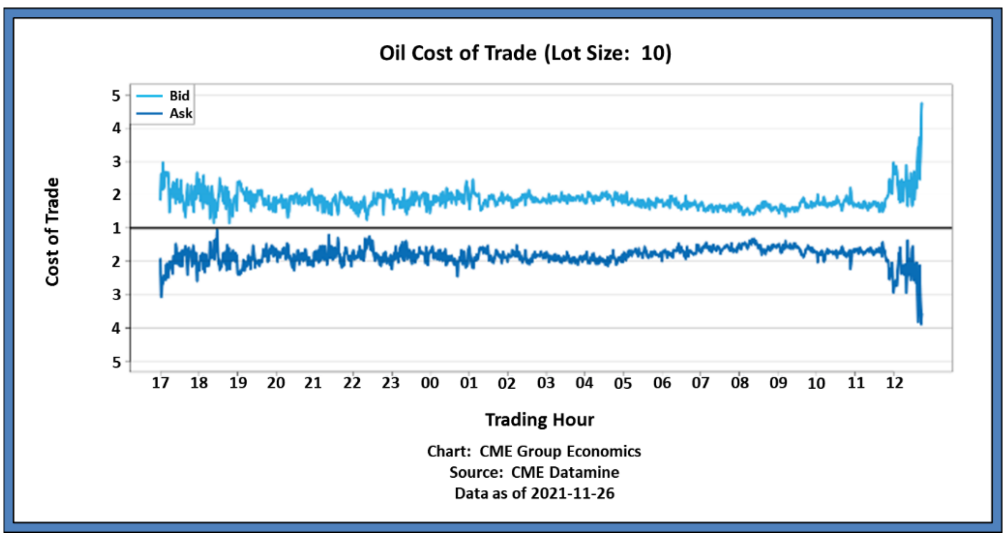


Figure 5
Cost to Trade 10 Lots



Empirical models suggest that the widening of the bid-ask spread in the first part of the trading session was in the range one might expect given the elevated volatility. It is not uncommon for the bid-ask spread to widen during times of heightened volatility. Liquidity in the first part of the trading session responded more or less to the increased risks of the surprise news as it would have on any other day, despite it being a shortened trading day ahead of a holiday weekend.

What happened in the second half of the trading session was even more interesting. The bid-ask spread narrowed to what might be seen on any given trading day, even without a surprise event. We have observed this behavior before in our analysis of event risk,[4] where the event date is known but the outcome is not and where market prices are expected to go abruptly in one direction or the other depending on the outcome. One can think of elections as examples of this type of event risk. In our studies of the 2016 U.S. Presidential election and the 2016 U.K. Brexit referendum, among others, we observe a clear outcome "discovery" period with wider bid-ask spreads followed quite quickly in the same trading session by a "rebalancing" period with narrower bid-ask spreads after the outcome has become widely known and initial reactions have been digested by the market.

Follow-up: What Happened in the Next 60 Days

We would be remiss if we did not provide some analysis of how markets reacted to the Omicron news in the days, weeks, and months following the surprise. Equity markets, as represented by the S&P500 recovered their losses relative to the pre-shock price in just 15 trading days, by December 15, 2021. It took the crude oil market 29 trading days, to January 6, 2022, to get back to the pre-shock price.

Economists are fond of assuming *ceteris paribus*, that is everything else equal, in their academic models. In the real world of oil trading, many other factors entered into the analysis of the oil market in the two months following the Omicron shock, from soaring natural gas prices in Europe to geopolitical tensions between Russia and the Ukraine, to a realization that the Omicron virus was more contagious yet potentially resulting in less severe health outcomes than the previous Delta variant. The combination of these factors and more helped oil make a full recovery and then some, in the 60 days after the Omicron news shock. By January 25, 2022 WTI crude oil was trading around $85/barrel, compared to the $78/barrel on the day before the Omicron shock, and the local low point of just below $66/barrel on December 1, 2021.

Bottom Line

Our preliminary conclusions, subject to further research, are that the Omicron news shock followed a pattern seen on other event risk days. While Omicron news came on what was expected to be a light-volume, holiday-shortened trading session, liquidity quickly was provided to the market, at first with somewhat higher bid-ask spreads as the news was being digested, and later with narrow spreads as the initial market reaction was better understood. As would have been expected, options traders were especially energized on the put side of the market, due to the downward nature of the price gap that occurred.

Endnotes

Dr. Putnam is a regular contributor to the *GCARD*'s Economist's Edge section. In addition, for further coverage of the crude oil markets, one can also read past *GCARD* articles on this topic.

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

1 See Black and Scholes (1973) and Merton (1973).

2 Price gaps are not always surprises, at least to some traders. See Putnam (2020) on the CME Group's market sentiment research regarding event risk.

3 See CME Group (2022).

4 See Putnam *et al*. (2018).

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Risk-Neutral Skewness and Commodity Futures Pricing

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Comprehensive Paper Published in: *Journal of Futures Markets*, 2022, Vol. 42, No. 4, April, pp. 751-785

This paper investigates the predictive content of a risk-neutral skewness (RNSK) signal for the dynamics of commodity futures prices. A trading strategy that buys futures with positive RNSK and sells futures with negative RNSK generates a significant excess return, which suggests a positive RNSK-return nexus. The risk premia that can be extracted through the RNSK signal is more pronounced in the contango than backwardation phase. After accounting for traditional commodity futures predictors, the RNSK signal exhibits a relatively stable and prolonged predictive ability. The directional-learning hypothesis is able to rationalize the positive nexus in terms of arbitrage risks and illiquidity (positive RNSK) and overpricing (negative RNSK).

Introduction

Many studies have documented the pricing ability of skewness in equity markets. The commodity literature on this subject is much sparser, and the latest comprehensive empirical research is by Fernandez-Perez *et al*. (2018) who estimate Pearson skewness over past 1-year windows of daily returns and find a negative-return relation in the global futures market. However, there is no study on the option implied (risk-neutral) skewness pricing impact for the global futures market, and this paper seeks to fill this void.

This paper contributes to the commodity futures literature by formulating and empirically addressing various questions: Does risk-neutral skewness predict the futures return in the subsequent period? Is the risk-neutral skewness a more informative measure than the realized skewness measure (*i.e.*, Pearson skewness)? What is the potential mechanism underlying this option implied skewness pricing ability?

Deploying the methodology developed by Kozhan *et al*. (2013), the authors estimate at the weekly frequency a sequence of risk-neutral skewness signals for 22 commodities from agriculture, livestock, energy and metal sectors over a 10-year period. Then they construct a fully-collateralized long-short portfolio by buying (selling) commodities with the most positive (negative) risk-neutral skewness and rebalance it at a weekly frequency. This portfolio delivers an 13.18% annual return and an annualized alpha of 12.62% after taking into account the compensation for exposure to the traditional commodity risk factors (market long-only portfolio, term structure, momentum and hedging pressure) and the Pearson skewness. The authors show that the risk-neutral skewness is a more robust signal (less sensitive

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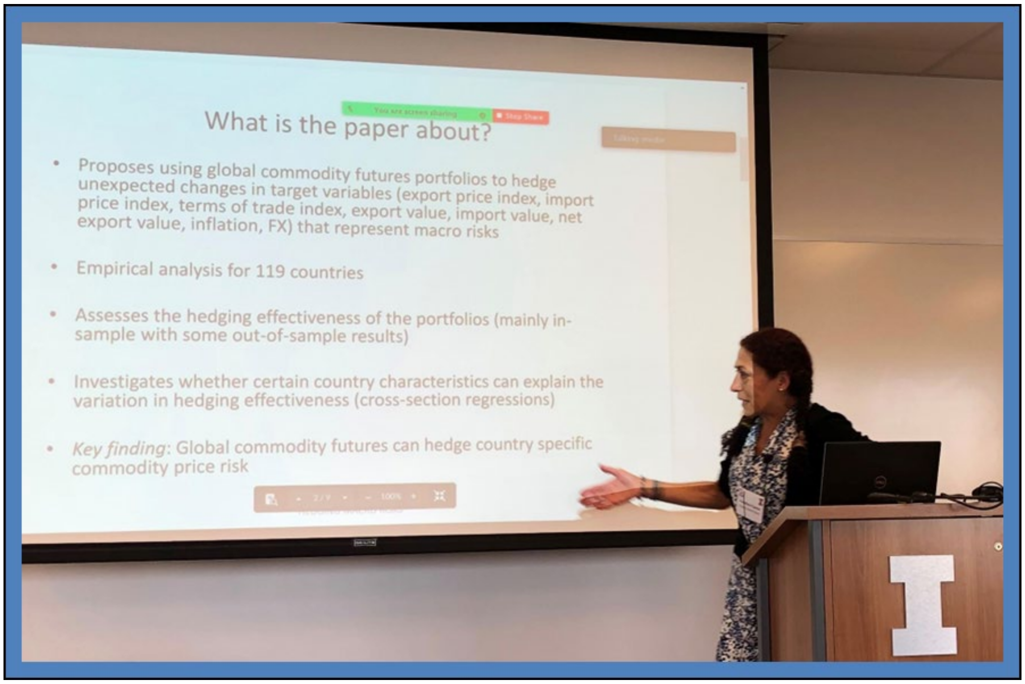
This digest article was contributed by Ana-Maria Fuertes, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.) and Associate Editor of the GCARD.

to sampling frequency and estimation window length) than the Pearson skewness and hence, it offers a more attractive portfolio cumulative return.



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

Using a double-sort portfolio analysis, the authors find that the positive return generated from buying more positively skewed commodity futures contracts is more pronounced precisely for those contracts with the highest (lowest) arbitrage risk/cost (liquidity) while the negative return generated from buying those negative skewed commodities is more pronounced for those contracts that are more overpriced.

The authors argue, under the directional-learning hypothesis by Kang and Park (2008), that investors with favorable predictions about the underlying futures contract will resort to the options market to buy more out-of-the-money (OTM) call options when the futures contract exhibits less liquidity and high idiosyncratic risk. When the futures contracts' liquidity is low, getting the best price is more challenging given a wider bid–ask spread market. Furthermore, trading activity via arbitrage, hedging, and speculation might be precarious for futures contracts with high idiosyncratic risk as intraday margin (collateral) calls with mark-to-market increased losses can force liquidation before convergence happens (Liu and Longstaff, 2004; Shleifer and Vishny, 1997). Investors will choose to purchase more OTM call options given all the associated risks above, driving RNSK to be more positive. Once the information is diffused to the underlying market, those assets will adjust their price to correct this belief.

Similarly, informed investors expecting negative movements in the futures market will resort to buying more OTM put options when the underlying assets are perceived to be overpriced. The present paper argues that there is a transfer of investors' risks (managing underlying inventory and hedging costs) to market-makers who consequentially require a premium on selling those OTM put options, yielding a more negative RNSK. Again, when information moves to the underlying market, the underlying price will react to correct the difference, generating a negative return. This is also compatible with the demand-based option pricing framework of Garleanu *et al*. (2009), leaving aside the short-selling constraint element.

Finally, in a cross-sectional analysis, the paper confirms that risk-neutral skewness is able systematically to price the futures contracts after controlling for a battery of extant commodity pricing factors.

Relevance of the Research Question

At a theoretical level, the significant relation between risk-neutral skewness and expected returns that the paper documents may instigate further research aimed at better understanding the price formation process in commodity futures markets. Traditional commodity pricing theories – the theory of storage of Kaldor (1939) and the hedging pressure hypothesis of Cootner (1960) – do not predict such relation.

A study of this nature on the relation between skewness and expected returns is relevant to academics and practitioners. At a practical level, the findings are potentially fruitful for commodity futures market participants as they suggest new ways of capturing risk premia through long-short portfolios formed according to a signal that is relatively unexploited in the commodities literature: risk-neutral skewness.

By contrast with the risk-neutral skewness, the Pearson skewness of commodity futures returns or realized skewness employed in Fernandez-Perez *et al*. (2018) is straightforward to estimate, but due to the properties of the returns, which are not necessarily realizations from an independent and identically distributed (IID) process, it can be sensitive to the choice of data frequency and estimation window length; for further discussion, see Neuberger (2012), Kim and White (2004), and Hansis *et al*. (2010). Through bootstrap simulation methods, Neuberger (2012) shows that realized skewness calculated from daily (monthly) data is not proportional to the realized skewness computed from monthly (yearly) data. Hansis *et al*. (2010) and Kim and White (2004) focus on the choice of estimation window length as the Pearson skewness requires; longer windows deliver more accurate Pearson skewness, but they may compromise the results by missing important short-term variation in the underlying return distribution. The aggregation property discussed by Neuberger (2012) implies that a low-frequency moment measure (*e.g.*, weekly RNSK) can be obtained in an unbiased way using high-frequency data (*e.g.*, daily options data).

Unlike the Pearson skewness, which is a backward-looking measure associated with the historical probability, the RNSK is a forward-looking measure associated with the risk-neutral probability – a probability of possible futures outcomes that have been adjusted for risk. The options market has been argued to carry valuable information for forecasting purposes as it reflects the market participants' expectations (see Bakshi *et al*., 1997; Bates, 1991; Black, 1975; Jackwerth and Rubinstein, 1996).

All in all, the present paper suggests that the RNSK of commodity futures returns represents a more informative skewness signal than the Pearson skewness for capturing risk premia and pricing purposes.

Data and Risk-Neutral Skewness Signal

The main data for the analysis are daily market observations for both futures and option contracts (price, trading volume, open interest, strike, time-to-maturity) from October 10, 2007 to March 1, 2016 from *Datastream* covering 22 commodity products within the agriculture, livestock, energy and metal sectors.

At each time *t*, for each commodity futures contract with a given expiration date *T*, the authors measure the risk-neutral skewness $RNSK_{t,T}$ signal of Kozhan *et al*. (2013) as

$$RNSK_{t,T} \equiv 3 \times \frac{V_{t,T}^{E} - V_{t,T}^{L}}{(V_{t,T}^{L})^{\frac{3}{2}}}$$

with

$$V_{t,T}^{L} = 2 \sum_{K_i \leq F_{t,T}} \frac{P_{t,T}(K_i)}{B_{t,T}K_i^2} \Delta I(K_i) + 2 \sum_{K_i > F_{t,T}} \frac{C_{t,T}(K_i)}{B_{t,T}K_i^2} \Delta I(K_i)$$

and

$$V_{t,T}^{E} = 2 \sum_{K_i \leq F_{t,T}} \frac{P_{t,T}(K_i)}{B_{t,T}K_iF_{t,T}} \Delta I(K_i) + 2 \sum_{K_i > F_{t,T}} \frac{C_{t,T}(K_i)}{B_{t,T}K_iF_{t,T}} \Delta I(K_i)$$

where $P_{t,T}(K_i)$ is the put option market price at time *t*, with multiple strike price levels K_i; similarly, $C_{t,T}(K_i)$ is the call option price; $F_{t,T}$ is the underlying futures price at time *t* with expiration date *T*; $B_{t,T}$ is the bond present value at time *t* with time-to-maturity *T-t*; $\Delta I(K_i)$ is the discrete increase among two adjacent strike prices. At the end of each sample week *t*, the commodity futures contracts are sorted according to their risk-neutral skewness measure *RNSK* and a fully collateralized long-short portfolio is formed by taking long positions in the top quintile with the highest RNSK and short positions in the quintile with the lowest RNSK; the constituent futures contracts are equally weighted. The portfolio is held for one week, when new RNSK signals are obtained and a new long-short portfolio is formed, and so forth.

Results

The fully-collateralized long-short RNSK portfolio generates an annualized 13.18% return with a Sharpe ratio of 1.39, which is significantly superior to the baseline Pearson skewness long-short portfolio yielding an annualized 1.63% return and Sharpe ratio 0.153 over the same period.

Next the authors regress the long-short RNSK returns on the long-only market portfolio, term structure, momentum and hedging pressure long-short portfolio returns that are the well-known proxies for commodity market backwardation and contango. In an additional test, the Pearson skewness based long-short portfolio returns are included as an additional factor. The RNSK portfolio alpha is a significant 12.56% per annum (traditional risk factors) and 12.62% p.a. (traditional risk factors and Pearson skewness) suggesting that the returns accrued by the long-short RNSK portfolio are not compensation for exposure to existing commodity risk factors nor the Pearson-skewness risk.

Furthermore, scrutiny of the ranked commodity futures contracts according to the RNSK signal suggests that the commodities in the top (most positive) RNSK quintile exhibit the smaller or most negative values of the traditional signals – term structure, hedging pressure and momentum – signalling contango. This suggests an opposite pricing pattern whereby the RNSK premium is more available in the contango phase.

Finally, different from the findings in the equities' literature, the RNSK signal in the commodity futures market has a relatively stable and longer pricing predictability. The long–short portfolio sorted based on averaging signals of the RNSK over the window (up to 30 days) can yield a significant 14.6% return after controlling for traditional commodity baseline factors. Moreover, the RNSK at week *t* is proved to be able to predict futures return up to *t*+10 weeks, yielding at least an alpha of 6% p.a.

Using idiosyncratic volatility, Amihud's liquidity, and the maximum (max) daily futures return the over past month as proxies for arbitrage risk/cost, liquidity risk and overpricing, respectively (see Chordia *et al*., 2020; Cao and Han, 2013; Amihud *et al*., 1997; and Bali *et al*., 2011), a double-sort portfolio analysis is conducted. The findings suggest that the positive RNSK and return nexus in the global commodity futures market (with short-selling) is associated with liquidity, idiosyncratic risk, and overpricing. Specifically, the portfolio with the highest arbitrage risk within the top RNSK quantile yields a significant 35 basis points (bps) per week. The spread return between the most arbitrage-risk portfolio and the portfolio with the least arbitrage risk is a significant 22 bps per week. The most positive RNSK portfolio outperformance is led by the contracts with the lowest liquidity. In particular, the portfolio with the lowest liquidity quantile within the top (highest) RNSK quantile generates 38 bps per week. Moreover, within the top RNSK quantile, the spread return between a portfolio with the highest liquidity and a portfolio with the lowest liquidity yields a significant return, −22.4 bps per week. Finally, the double-sort approach reveals that the portfolio with the largest max daily futures return yields -21.8 bps per week. The spread return between the highest max past month-portfolio and the lowest max past month-portfolio is -32.9 bps per week.

Last but not least, the authors test whether risk-neutral skewness can explain the cross-sectional return variation in the global futures market. There is a significant positive risk premium on average, which means that investors require compensation for being long futures contracts with more positive risk-neutral skewness.

Conclusions

This paper documents a significant positive relationship between risk-neutral skewness and returns in futures markets. Buying (selling) the commodities in the highest (lowest) risk-neutral skewness quintile simultaneously generates an annualized 13.18% return, which outperforms the return of the baseline Pearson skewness sorted long-short portfolio of Fernandez-Perez *et al*. (2018) with a 1.63% return over the same period. The risk-neutral skewness sorted long-short portfolio offers excess returns that are not compensation for traditional commodity risks, and is not encompassed by the Pearson skewness portfolio.

All in all, the positive relation documented in this paper between commodity futures risk-neutral skewness and returns are largely consistent with the demand-based option pricing theory of Garleanu *et al*. (2009). When the futures contracts become relatively illiquid and less attractive to arbitrage (speculation) activity, informed investors will purchase more OTM call options to maximize their profits. As that information is distributed to the underlying market, the futures price will increase to correct those beliefs implied from the options market. When the futures contracts are believed to be overpriced, to exploit the benefit of the potential price drop, informed investors will turn to the options market to obtain more OTM put options rather than sell futures contracts to avoid potential risk. After the information moves to the underlying market, the commodity futures price will drop accordingly.

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Keywords

Commodity futures, asset pricing, skewness, risk-neutral, risk factors.

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One Hundred Years of Rare Disaster Concerns and Commodity Prices

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This paper shows that rare disaster concern, defined as the news-implied volatility, performs very well at predicting the return of index commodity futures throughout the whole nearly century period of 1926 to 2016. This result holds after controlling for the current business cycle conditions, the macroeconomic variables, and the Volatility Index (VIX). We also find that rare disaster concern performs very well at predicting index commodity futures returns out-of-sample. The results remain robust while considering different macroeconomic conditions such as recession (expansion), contango (backwardation), or increased (decreased) inflation.

Introduction

For decades, a substantial literature has proposed rare disaster models as an important rational foundation for understanding various longstanding asset pricing anomalies such as the equity premium puzzle, the volatility puzzle, the forward premium puzzle, and the stock return predictability (*e.g.*, Rietz, 1988; Barro, 2006; Gabaix, 2012; Gourio, 2012; Wachter, 2013). Naturally, risk averse investors require a compensation for the extreme loss they may incur during the unlikely but extremely harmful states of the economy. As such, a high likelihood of rare disasters implies a high risk premium in forward-looking financial markets. This suggests that rare disaster concerns should predict asset returns. Whereas various studies (*e.g.*, Berkman *et al.*, 2009; Manela and Moreira, 2017) have built a link between rare disaster concerns and asset pricing quantities,[1] few studies, if any, provide empirical evidence that rare disaster concerns can predict commodity returns.

Why the Paper's Research Questions are Important

It is not surprising that there should exist a resounding connection between rare disaster concerns and commodity prices because such concerns affect consumption behaviors, production decisions, fiscal and monetary policies, and global trade. Through affecting agent behaviors and macroeconomic policies, rare disaster concerns provide people with incentives to adjust their behavior through which the demand and supply of commodities will be impacted, and therefore so will commodity prices. However, to date, the literature on the relationship between rare disaster concerns and subsequent index commodity future returns is very scarce and provides few empirical results. Especially, so far, no paper has investigated the ability of rare disaster concerns to predict subsequent index commodity futures returns in the long run.

In this paper, we fill this gap by providing a new finding that the perceived rare disaster risks play a prominent role in predicting commodity futures index returns using nearly one hundred years of data from 1926 to 2016.

This digest article was written by Qunzi Zhang, Ph.D., Professor in Finance at the School of Economics, Shandong University, China.

Professor Qunzi Zhang of Shandong University, China, lecturing during her Massive Open Online Course (MOOC) course on "Corporate Finance."

Data

In this paper, the monthly commodity futures index excess return data are directly downloaded from Levine *et al.* (2018)'s website.[2] Together with rare disaster data, which is obtained from Manela and Moreira (2017)'s website, the data spans from July 1926 to March 2016. We use the excess return of an equal-weight commodities portfolio as our main proxy for the commodity index excess return.

In this paper, we use six specific types of disaster measures of Manela and Moreira (2017): government, financial intermediation, natural disaster, stock market, war, and unclassified uncertainties, respectively. These disaster measures have a forward-looking advantage because they are constructed based on the combination of news and option implied volatility. Hence, they are ideal empirical proxies for the rare disaster concerns, *i.e.*, the forward-looking measure of disaster risk.

Methodology

Our rare disaster concerns are constructed using six underlying disaster proxies of Manela and Moreira (2017). An advantage of these measures is that they are constructed in an *ex-ante* way and capture perceived rare disaster risks. Another advantage is that these measures capture rare disaster risk from a multiple-dimensions perspective such as wars, economic disasters, and natural disasters. Naturally, investors are generally risk averse to these different types of rare disasters. We employ a simple principal component analysis (PCA) to harness disaggregated information dispersed in various rare disaster risks. The PCA method allows us to eliminate noise and separate out the representative component from the six measures of *ex-ante* rare disaster proxies. We simply apply a PCA procedure on the six disaster measures in squared form following Manela and Moreira (2017). For a given month, we use the standardized PCAs as the principal component representation of the six rare disaster measures. Using the standardized measure allows the principal components for the six disaster measures to be comparable.

Results

Our empirical analysis reveals that rare disaster concerns are able to significantly predict index commodity futures returns from 1926 to 2016. The forecasting power of rare disaster concerns is beyond and above the predictive ability contained in popular economic predictors such as economic variables and business cycle conditions. Additionally, we evaluate the out-of-sample performance of the rare disaster concern as a predictor for the index commodity futures return. For this purpose, we perform out-of-sample one-month ahead forecasts with several predictors, including the rare disaster concern index, business cycle variables, 14 economic variables proposed by Goyal and Welch (2008), and the VIX. We find strong evidence that the predictive power of the rare disaster concerns dominate that of the other predictors. Additionally, we show that an investor who forms her strategy based on timing rare disaster concerns does not only make positive investment profits but also enjoys significant economic gains. All these results confirm that the rare disaster concern is an important predictor of subsequent index commodity futures returns.

Following Levine *et al.* (2018), we employ three particular state variables to represent macro states for investigating commodity predictability. The first represents whether the commodity futures market as a whole was in backwardation or contango. The aggregate backwardation or contango is defined as the equal-weighted average level of backwardation or contango for all the commodities in the market. The second state variable is represented by the National Bureau of Economic Research (NBER) expansion and recession periods. The third state variable is unexpected inflation, as measured by the one-year change in one-year inflation. The results imply that rare disaster concerns generate better predictability in periods of Recession, Backwardation and "Inflation Up."

Conclusion

In this paper, we investigate the ability of rare disaster concerns to predict index commodity futures returns. We find that rare disaster concerns are by far the best predictor of monthly index commodity futures returns. The magnitude of its predictive effect on subsequent index commodity futures return is sizable. This result not only holds in a long sample period from 1926 to 2016, and is even better in recent sample periods (1955-2016 and 1985-2016). Also, the result is robust to the alternative sample periods or controls that we consider.

The predictability of rare disaster concerns is also economically significant: an investor implementing a mean-variance strategy based on commodity index return forecasts would obtain a higher Sharpe Ratio if she predicts the future commodity returns with the current disaster measure. The annualized returns are equal to 15.094%, with an annualized Sharpe Ratio and a certainty equivalent equal to 0.312 and 3.499%, respectively.

Endnotes

1 Manela and Moreira (2017) find that the aggregate rare disaster index (NVIX) has in-sample predictive ability for U.S. stock returns at long horizons.

2 Levine *et al.* (2018) provide the arithmetic commodity futures excess return across different commodities including futures available prior to 1960 (the start of most academic studies) and those that are currently incorporated in the S&P Goldman Sachs Commodity Index (GSCI). The complete list of these futures are aluminum, Brent crude oil, cattle, cocoa, coffee, copper, corn, cotton, feeder cattle, gas oil, gold, heating oil, hogs, Kansas wheat, lard, lead, natural gas, nickel, oats, pork, short ribs, silver, soybeans, soybean meal, soybean oil, sugar, gasoline, wheat, WTI (West Texas intermediate) crude oil, and zinc.

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Keywords

Commodity return predictability, rare disaster concern, News Implied Volatility (NVIX).

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The Crop with No Futures: Explaining the Absence of Derivatives Trading in the Rice Market[1]

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This research explores the reasons behind the low financial development (materialized by the use of derivatives trading) of the rice market, unique within the realm of large commodity markets. Through a comparison with crops with highly liquid futures markets (coffee, sugar and wheat), this article argues that the low financial development of rice is not due to one impeding factor but the accumulation of many instead. Of these, the most prominent are the disincentives for the participation of financially sophisticated actors, and the politicization of rice. I argue that both factors find their root in the geographical organization of the market, which is highly concentrated in developing economies.

Introduction

Derivative finance finds its roots in the rice bills traded in the streets of 17th century Osaka before expanding to Tokyo and the Southeast Asian rice markets under colonial rule. These markets arguably served as models for the rise of futures contracts for agricultural crops in Chicago at the end of the 1870s. However, while commodity exchanges continued growing in the 20th century, listing contracts for all sorts of agricultural crops, the rice market never managed to rebuild its futures trading that had been disrupted by WWII. While futures for other grains or soft commodities grow ever more liquid, sparking debates on the impact of this financialization, rice – the largest value agricultural market (FAO, 2019) – remains stagnant in its state of financial underdevelopment (see Figure 1 below). A small contract in Chicago meant to hedge the rice from the southern states and a few failures at establishing an international contract has led the financial industry to assume that rice simply does not fit into the mechanisms of futures trading. This article aims to go beyond that postulate by answering the following research question: *what explains the fact that financial development characterizes most food markets but has remained marginal in the rice market?*

In this article, *financial development* is defined as the measure and process of the increasing ability to trade (price) risk. It is the product of two variables: the financial sophistication of the market structure, that is, the availability of financial instruments to trade this risk; and the financial sophistication of market actors, that is, their individual technical ability to trade risk (Hardie, 2012; Rajan, 2006). The financial development of a commodity market is therefore mostly manifested in the liquidity of futures contracts and over-the-counter (OTC) derivatives for that commodity. The research question, therefore, implies researching the lack of liquid derivative instruments for rice.

This digest article was written by Sulian Lizé, Ph.D., Research Economist, LMC International

Relevance of the Research Question

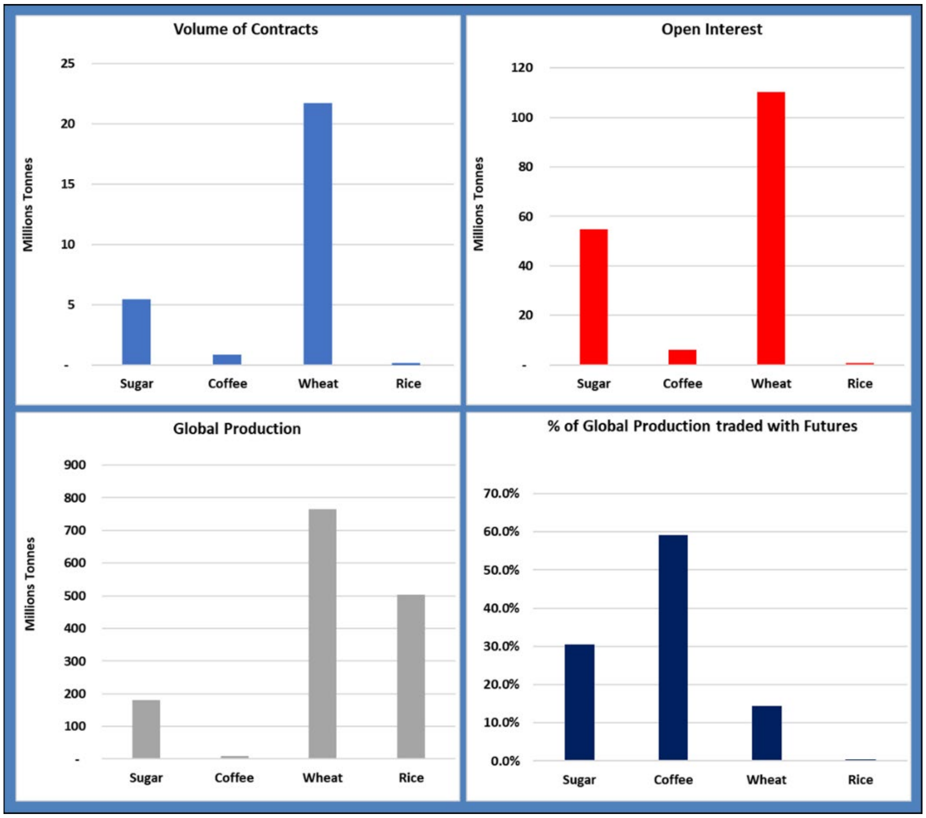
The present research has relevance for both practitioners and academics alike. Firstly, the research question has animated debates within the rice industry for decades, but the prevailing secrecy in the market has limited its ability to collectively provide an answer. Academic research, therefore, can potentially diagnose the market dynamics that have led to financial underdevelopment. Although the research itself aimed to avoid the contentious topic of the pros and cons of futures trading for market participants to focus on an objective analysis of the research question, many industry stakeholders believe that the lack of futures trading weighs heavily on producers. For instance, the impossibility to sell forward is acknowledged as an important obstacle for growers to obtain bank loans. The absence of a publicly discovered price deriving from (deeply liquid) futures trading also enables information asymmetry that disadvantages farmers when negotiating prices. This issue becomes even more relevant once the importance of the rice market is acknowledged: rice is the food staple of half of the world's population and is often believed to be the biggest employing industry globally, with an estimated 1 billion households depending on it for their livelihood (Diouf, 2003).

Secondly, rice can serve as a case study to enhance the understanding of the mechanisms involved in the financial development of commodities. The research presents a valuable contribution to the academic theory on the topic. For instance, the research advances the debate about which major factors contribute to the success or failure of futures contracts. The study of rice also allows building an understanding of financial development specific to the context of developing countries, for which the existing literature remains narrow. By answering the research question, this article is also able to provide a new theory of financial markets development that awards importance to the geographical chronology of the process.

Data and Methodology

The research primarily uses a comparative study between the case of rice and three financially developed crop markets: coffee, wheat and sugar. Since the research question is derived from the observation of the fundamental anomaly of the rice market regarding financial development, the research inevitably had to be articulated around a comparative method. The strategy was to identify hypotheses for what could cause the anomalies and singularities of the market development in rice. When the factors hypothesized to prevent financial development were confirmed to be features of the rice market, they were then explored within the compared market to analyze whether they were indeed hindering variables. If these were featured in other markets, it meant that they could not be standalone reasons for the lack of financial development of rice, although I explored their potential to be at least limiting factors. The research analyzes extensively both the empirical reasons for the failure of past futures contracts for rice and the theoretical ability for the rice market to develop financially.

Figure 1
The Volumes Traded for Selected Futures Contracts[2] on the 30th of April 2021 vs. 2019 Global Production[3]



As I hypothesized that the geography of the rice market, its lack of integration and preponderance in developing countries is key to its lack of financial development, the analysis needed to be grounded in a set of geographical case studies: the USA, Thailand and Vietnam as main areas of research, while the case of Japan allowed exploring more specific problems such as politicization. While the case of the USA illustrated the difficulty of rice to develop futures contracts even in the context of a financially highly developed economy, the cases of Thailand and Vietnam allowed for the study of the relationship between economic development and the financial development of a commodity.

The main body of the research is qualitative and based on the interviews of 46 market stakeholders during 41 interviews, carried out between July 2017 and November 2019. All the participants were involved or formerly involved in commodity markets, whether in the physical supply chain, in the finance industry or as research analysts. These interviews allowed for the collection of a vast amount of data from a large number of market actors that were either key stakeholders in the process of financial development, or representative of their respective interest groups. The interview process also allowed the anonymous disclosure of information that would not exist in written documents or be found in the academic literature as the rice industry is a secretive one. This also implies that the common knowledge of the market is highly fragmented between participants, and this research aimed at gathering and reconciling the informational knowledge of the industry.

Key Findings

The research challenges the common argument of the existing literature that a single factor[4] is enough to disrupt the financial development of a commodity market (Gray, 1966; Carlton, 1984; Sandor, 1973; Silber, 1981). Instead, based on the experience of the compared markets, it argues that the believed impeding factors are variables that only limit such financial development. In the case of rice, however, the accumulation of impeding factors to the establishment of futures contracts prevented the financial development of the crop.

Before detailing which factors have disrupted financial development, it is important to state that the analysis of the failure of past futures contracts for rice has revealed that they were often primarily the result of *ad hoc* issues such as mistakes in the design of the contract or mismanagement of the exchange hosting the contract. They, therefore, left the rice market with an unsophisticated market structure but did not prove the impossibility to see rice develop financially. Instead, it is the analysis of the market organization that allowed us to resolve the research issue.

The overall research paper, which this article summarizes, finds that rice market actors have a low propensity to participate in derivative trading, which deprives newly created futures contracts of the liquidity they need to grow and attract speculators. It is however important to notice that this low propensity to trade risk is due to reasons varying between actors. The first reason is the low financial sophistication of many physical market actors, including farmers. That issue is not unique to the rice market, but it is compensated in other industries by the advanced sophistication of intermediaries such as brokers and millers, which is not common in rice. The question remains as to why sophisticated actors, who could play a key role in the building of a futures market, are reluctant to do so. A first group is made of producers, such as some of the ones located in Louisiana, with the resources and knowledge to use derivatives but with a risk profile counter-incentivizing them to do so. The storable nature of rice means that they can keep the crop on-farm long after the harvest, waiting for a rally in prices instead of being price takers at harvest time. By doing so, they hedge physically, removing the need for a financial hedge. Secondly, they perceive their crop risk to be greater than their price risk and fear that by locking in prices early in the crop season, they expose themselves to further crop risk.

The second group is made of larger participants down the supply chain such as millers, traders and exporters, as well as farming cooperatives. These actors intentionally avoid participating in the building of derivative markets due to the potential erosion of their market power resulting from futures contracts. Such power can be the result of the profile of the supply chain, but its most important driver is the opacity of the rice market. These actors can go beyond the simple fact of not participating and actively sabotage futures contracts by lobbying governments to suppress derivative exchanges. All traders and importers are not reluctant to use futures trading, but the minority of those wishing to trade risk find themselves too few and therefore deprived of a counterpart to trade risk with. This implies that sophisticated actors of the rice market have less ability to promote the development of futures trading than to disrupt it.

The issue of a lack of potential participants in derivatives trading from the physical market brings us to the other major argument of this article: that the geography of the rice market is unconducive to its financial development. Unlike compared markets where developed nations are involved in international trade as either producers or consumers, rice remains a grain traded mostly within and between countries of the Global South (see Table 1). The comprehensive version of this article argues that the compared crops have developed financially because they had terminal markets based in the West or Eastern Asia, but that rice cannot go through the same development at the local level in developing countries. The commonality of small-scale farming and small trading entities in the Global South, for instance, reduces the number of financially sophisticated actors. The weakness of contract law in some developing countries can also be an obstacle to financial development as it can prevent the extension of OTC markets that create a link between the least sophisticated actors and futures markets. Drawing on the literature on the lack of agricultural data in developing countries (Perloff and Rausser, 1983; Barrett and Mutambatsere, 2008; Deichmann, Goyal, and Mishra, 2016), I also argue that this opacity creates a high degree of information asymmetry favoring larger traders and cooperatives. This is the source of the market power that these "unwilling financially sophisticated actors" are looking to protect.

Table 1
The Top 10 Producing, Consuming, Exporting and Importing Countries of Rice (in 1000's of metric tonnes)

	Producer		Consumer		Exporter		Importer	
1	China	*142,274*	China	*143,553*	India	*11,202*	China	*3,170*
2	India	*115,805*	India	*101,271*	Thailand	*10,095*	Philippines	*1,747*
3	Indonesia	*38,516*	Indonesia	*36,433*	Viet Nam	*4,727*	Benin	*1,727*
4	Bangladesh	*36,274*	Bangladesh	*35,367*	Pakistan	*4,059*	Iran	*1,444*
5	Viet Nam	*28,961*	Vietnam	*21,317*	USA	*3,552*	Côte d'Ivoire	*1,394*
6	Thailand	*20,811*	Philippines	*13,883*	Myanmar	*2,471*	Saudi Arabia	*1,272*
7	Myanmar	*17,873*	Thailand	*11,700*	China	*2,011*	Senegal	*1,119*
8	Philippines	*12,708*	Myanmar	*10,283*	Brazil	*1,049*	Iraq	*1,081*
9	Brazil	*7,702*	Japan	*8,450*	Uruguay	*931*	South Africa	*1,039*
10	Pakistan	*7,358*	Brazil	*7,433*	Italy	*716*	Indonesia	*1,001*

Another argument already existed in the literature but lacked substantial research: that the politicization of the market can impede financial development (Pochara, 2012; McKenzie, 2012; Hamilton, 2012; Carter, 2007). The thesis, upon which this article is based, argues that politicization is not unique to rice, but the nature of this politicization *is*. Indeed, the rice market, due to its double role as a staple food for consumers and a livelihood for producers within the same political space, is exceptionally politically salient. The political salience of the crop is another product of the prominence of the Global South in its geography as food expenses represent a larger share of household expenses in developing countries, while high levels of employment in agriculture imply that farmers hold collectively more political power (Gulati and Narayanan, 2003; Shigetomi, 2011; Clarete, Adriano, and Esteban, 2013). In the compared markets, political interventions have taken place at the international level with the effect of reducing volatility in the long run. In rice, it has more often taken place at the national level as rice policies can affect election results, creating high levels of political uncertainty (instead of stability) which has become the main source of risk in this market. The difficulty, if not impossibility, in modeling this political risk has deprived derivatives markets for rice from the participation of speculators. In addition, the growing amount of rice being traded internationally means that political shocks are increasingly transmitted between national rice markets.

Finally, the overall article confirms another assumption of the literature (Roche, 1992; Latham, 1998): that the fragmented nature of the market into many varieties prevents the creation of benchmarks. I argue that it can be more accurate to talk about rice markets than a single rice market. However, I argue that the financial development of these separate segments of the rice market is not theoretically impossible. As a result, the fragmentation of the global rice market is not a standalone explanation for the absence of futures contracts.

Implications and Conclusion

The case of rice carries a lot of lessons for the study of commodity finance. The first one is that financial development cannot be seen as in any way inevitable, whether in a developed economy or even more in a developing one. Instead, the building of derivatives markets is a slow process heavily influenced by domestic conditions; it needs a set of favorable conditions to take root. The increase in the sophistication of market actors is a long-term process, while the sophistication of the market structure can take several attempts before being successful.

Secondly, the financial development of commodities is a process exogenous to developing economies. The literature already argues that developing and transition economies are not conducive to the development of derivatives markets (Fernandez, 2003; Shamsher and Taufiq, 2008; Kuzman, Ercegovac, and Momčilović, 2018). While this argument is supported by the case of rice, coffee and sugar show that financial development can still take place in the domestic markets of developing countries. However, it does so through an expansion of the financial development of global markets, initiated in the Global North, into the domestic markets of developing countries.

Finally, the case of rice confirms the argument in Hardie (2012) that the financial sophistication of an actor does not correlate with this agent's likeliness to pursue the financialization of the market structure. It correlates with their exposure to price risk and negatively correlates to the threat that futures trading represents to their market power instead. If a sophisticated actor is not supportive of financial development, then its ability to sabotage also becomes key to the success prospects of a contract. Additionally, the presence of willing sophisticated actors in a commodity market is not sufficient to launch a futures contract. Their number is also critical to assemble enough trading counterparts to generate liquidity. To make a derivatives transaction succeed, there must be two willing actors. To make a derivatives transaction fail, one is enough.

Endnotes

1 This research digest article is based on the author's 2021 doctoral thesis in International Development at the University of Edinburgh. As such, the article has been written in the author's personal capacity. The views and opinions expressed herein do not necessarily reflect the positions of the author's current organizations.

2 Major futures contracts for each crop have been compiled and expressed in Metric Tonnes, depending on the contract size. These contracts are the ICE Sugar No. 5, No. 11 and No. 16 for sugar; ICE Coffee C and Robusta contracts for coffee; CME Chicago, Kansas City and Black Sea Wheat as well as Euronext Milling Wheat for wheat, and CME Rough Rice contract for rice.

3 Production data from the U.S. Department of Agriculture; futures data from Barchart.

4 These include lack of volatility, the size of the cash market, the lack of homogeneity or storability of the crop and prices not being freely determined.

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Long-Run Reversal in Commodity Returns: Insights from Seven Centuries of Evidence

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This study examines the long-term reversal effect in commodity spot markets using seven centuries of data. The research is the longest study of the long-term reversal effect covering 52 agricultural, industrial and energy markets from 1265 to 2017 employing U.K.- and U.S.-based commodity prices. Returns over the previous one-to-three years negatively predict subsequent performance in the cross-section of returns. The long-run reversal effect is strong and robust after surviving a variety of robustness checks. The effect cannot be explained by statistical biases, extreme events, or macroeconomic risks. The study reveals that the long-run reversal effect is driven by supply-and-demand adjustments in physical commodities through time.

Introduction

This paper examines one of the most documented anomalies in financial markets, which is the long-run reversal effect. The phenomenon known as the long-run reversal originates from De Bondt and Thaler (1985), which is the tendency for prices with high (low) returns to underperform (outperform) in the future. This effect has been studied in various asset classes including stocks, bonds, stock indexes, and currencies (Blackburn and Cakici, 2017; Khang and King, 2004; Balvers *et al*., 2000; Ahmed *et al*., 2018; Zaremba and Umutlu, 2018; Chan, 2013; Lubnau and Todorova, 2015). Furthermore, this phenomenon has also been studied in commodity spot and futures markets in recent decades (Andersson, 2007; Miffre and Rallis, 2007; Bianchi *et al*., 2015; Chaves and Viswanathan, 2016; Levine *et al*., 2018; Yang *et al*., 2018). This study extends the literature because it evaluates the long-run reversal effect on annual commodity spot prices using a data sample of more than seven centuries. The research is unique as it is the longest analysis of the long-run reversal effect to date in any asset class or investment type. The paper answers three questions, namely: (1) is the reversal effect observable in commodity spot prices? (2) what are its sources? and (3) what drives its variation through time?

The long-term nature of this study allows researchers to determine whether the long-run reversal effect is a modern aberration from data-snooping methods or whether this pattern in prices genuinely exists over long periods of time. Furthermore, the long sample period allows researchers to evaluate whether the long-run reversal effect has diminished over time due to the effects of market efficiency, investor learning, or other factors.

This digest article was written by Robert Bianchi, Ph.D., Professor of Finance, Griffith University, Australia.

The study shows a strong and significant long-run reversal effect in commodity returns across all seven centuries of data. Commodity returns over the past one-to-three years negatively predict future performance in the cross-section. A quintile spread portfolio of long (short) commodities with the highest (lowest) return during the past three years reports a mean annual return of -13.07% with a corresponding *t*-statistic of -18.81. The researchers emphasize that investors are unable to "short" a portfolio of physical commodities across seven centuries; however, these calculations are designed to identify the presence of the long-run reversal phenomenon in commodity markets. The key finding is the long-run reversal effect is very strong and statistically significant in commodity spot returns.

Data

The dataset employed in the study comprises of 52 commodity spot prices from the Global Financial Data (GFD) database, consisting of 753 annual observations from 1265 to 2017. A large majority of commodity prices originates from England, and then the study employs United States (U.S.) commodity prices when they are available. The sample of commodities consists of 29 agricultural, 17 industrial markets, and 6 energy markets. Monthly or daily data were unavailable for this long sample period; thus, the study employs the last closing price of every market for each year. All commodity prices and returns are expressed in U.S. dollars. The GBP/USD exchange rate data commences in 1660, and the authors chose to use this conversion rate for data prior to this period in time.

One potential data limitation that may affect the study is survivorship bias. This study mitigates this effect by including commodities that were traded and utilized in the past (for example, coal gas). The study employs various tests including cross-sectional regressions and portfolio sorts; however, the overall findings and conclusions remain the same. As a further check, the study examines inflation-adjusted commodity prices using both U.K. and U.S. consumer price indexes and the findings are qualitatively similar. The study does not employ futures markets in the main analysis due to the unavailability of daily or monthly data during this multi-century time period.

Methodology

Two primary frameworks are employed to estimate the long-term reversal effect, namely, cross-sectional regressions and portfolio single sorts. First, cross-sectional regressions are estimated with the total returns of commodities in current/future years as the dependent variable and total returns of commodities in the past one-year to six-years as the independent variables. Second, portfolio sorts are constructed with single sorts on past returns to verify the key findings. The portfolio sort methodology ranks all commodities on their past cumulative one-, two-, or three-year returns and constructs equal-weighted quintile portfolios. Then, spread portfolios are constructed to estimate the difference in returns between the highest and lowest quintile portfolio returns. The researchers acknowledge that for practical purposes, a short portfolio of perishable physical commodities (such as eggs or milk) is unrealistic; however, the portfolio-sort methodology provides a picture of the return patterns in these commodity markets over time.

Key Results

The cross-sectional regressions report statistically significant negative slope coefficients, which signify that past long-run returns negatively predict future performance. Put another way, high (low) returns in the past one-to-six years are related to low (high) performance in the subsequent one to four years. These patterns of returns hold for both raw and risk-adjusted returns. The *t*-statistics are significant and very large in many regression specifications.

The analysis of the portfolio single sorts show that commodities with the highest past returns significantly underperform the commodities with the lowest past returns on both a raw and risk-adjusted basis. The High-Low portfolio formed on past one-year returns report an average annual return of -8.55% (-8.89) on a raw and risk-adjusted basis with the associated *t*-statistics of -18.81 (-18.86), respectively. A more significant result is the High-Low portfolio formed on past three-year return reports an average annual excess return of -13.07% (-13.14%) on a raw (risk-adjusted) basis with corresponding *t*-statistics of -18.81 (-18.86), respectively. The results of the portfolio sorts demonstrate a strong, significant and robust long-run reversal effect.

The main findings show that commodities with high (low) returns during the past one-to-three years tend to under (out)perform in the future, which supports the presence of the long-run reversal effect. The robustness of the results are checked by calculating the sub-period analysis of the long-term reversal effect across each of the seven centuries in the data. The findings show that the long-term reversal effect is strong and significant in all seven centuries in the entire data sample.

Potential Sources of the Long-Run Reversal Effect

With the long-run reversal effect established in commodities, the next step is to understand the source of this effect and why we can observe this phenomenon in commodity spot markets. The finance and economics literature has developed a number of theories to explain the long-run reversal effect. This study considers five competing explanations that relate to commodity markets and the long-term data sample that is available for analysis. The researchers examine the possibility of (i) data snooping, (ii) data quality, (iii) exposure to macroeconomic risks, (iv) the effects from war, diseases, volcanic activity, and anomalous temperatures over the centuries, and finally, (v) supply/demand adjustments as possible sources to explain the phenomenon. Various regression analyses show that all of these explanations fail to explain the long-run reversal effect with the exception of supply-and-demand adjustments.

Supply-and-Demand Adjustments as the Source of the Long-Run Reversal

The study considers the time variation in demand, supply and inventories as the main driver of the long-run reversal effect in physical commodity prices. The hypothesis suggests that when prices increase above the cost of production, it is likely that producers experience higher profits and are more willing to increase their output of the respective commodity. This increase in the supply of a commodity is generally followed by commodity prices declining to a lower equilibrium price. Conversely, when prices decrease below the cost of production, commodity producers face losses and are willing to reduce or cease production. A period of reduced supply is generally followed by price increases.

Four analyses are performed to explain how supply-and-demand adjustments drive the long-run reversal effect in commodities. First, a return decomposition was performed using the approach from Conrad and Kaul (1998). This decomposition shows that a large proportion of the reversal profits stem from the autocovariance in individual commodity returns. This finding suggests that the mean reversion of individual commodity prices is the source of the long-run reversal effect and supports the supply/demand adjustment hypothesis.

The second analysis examines the supply elasticity of commodities. The long-run reversal effect is expected to be more (less) observed in commodities with elastic (inelastic) supply as producers have the capacity to more easily increase or decrease output. Agricultural commodities are expected to exhibit a stronger elasticity in comparison to non-agricultural markets as the long-term reversal effect was notably stronger in agricultural markets. To quantify this effect, the researchers calculate the speed of reversion by estimating a first-order autoregressive model. The findings show that the speed of reversion (*i.e.,* elasticity) is strongest in agricultural markets in comparison to the remainder of the commodity market universe.

The third analysis considers whether economic forces and technological advances over seven centuries have developed to overcome imbalances in the demand and supply of commodities through time. Over centuries, transportation, storage, import and export systems have improved to alleviate commodity shortages or surpluses, and thus, more easily adapt to demand or supply adjustments. If this hypothesis holds, one can expect to see the behavior of price reversion to decline over time from the Middle Ages to the modern times of today. The researchers employ an AR(1) model to calculate a rolling 100-year regression coefficient for each commodity. The researchers find this regression coefficient is unstable through time; however, it decreases in absolute terms over time. Put simply, demand-and-supply imbalances have moderated from the commencement to the end of the seven century sample period. This finding provides further support for the notion of the supply-and-demand adjustment hypothesis. Technical advances and trade improvements have resulted in the AR(1) regression coefficient decreasing over time which suggests that modern trade practices in commodity markets have reduced supply-and-demand imbalances, thereby resulting in a weaker reversion effect through time.

The fourth analysis compares the reversal effect in both physical spot commodity markets and futures markets. The researchers consider whether the source of the long-run reversal effect originates from the physical spot markets or in the futures derivative markets. To disentangle this effect, a sorting analysis is performed which reveals that the long-run reversal is stronger in physical spot markets than in futures contracts. Furthermore, the reversal effect in spot returns subsumes the same behavior in futures markets; however, the reversal effect in futures markets does not subsume the effect in physical markets. This finding suggests the long-run reversal effect originates from commodity spot markets, and therefore, this further supports the supply/demand adjustment hypothesis in physical commodity prices.

Conclusion

The study examined the long-run reversal effect in commodities over seven centuries, which is the longest study of its kind. The paper analyzed the annual returns of 52 commodity spot markets for the period of 1265-2017. The paper found a strong long-run reversal effect, which was statistically significant using both cross-sectional regressions and portfolio single sort analyses. The research finds that supply-and-demand adjustments through time explain the source in the behavior of the long-run reversal effect. This research contributes to our current knowledge and understanding of implementing contrarian strategies in commodity markets.

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Long-run reversal, commodity markets, early commodity prices, long-term historical returns, mean reversion, trading strategies.

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Carbon Cap-and-Trade: We See a Compelling Opportunity

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We see attractive investment opportunities in California's cap-and-trade carbon emissions market.

- *To combat climate change, policymakers are increasingly adopting "cap-and-trade" programs, which typically issue a declining number of greenhouse gas (GHG) emission allowances each year, capping the pollution businesses can emit.*
- *Carbon allowance supply will, in our view, shrink faster than covered entities can move to green power technologies, supporting allowance prices.*
- *California represents one of the most attractive carbon markets, with mechanisms to prevent emission prices from falling too low or rising too high.*
- *We believe that as California Carbon Allowance (CCA) demand eclipses an ebbing supply, more investors will enter the market, boosting CCA demand and price – benefiting those who invested early.*

As the international community races to combat climate change, policymakers are increasingly adopting a range of market-based incentives to reduce carbon emissions. Key among these are cap-and-trade programs. Cap-and-trade systems limit the total amount of carbon that can be emitted (cap) and allow the market to determine the price where the demand to emit matches the supply of allowances (trade). In essence, cap-and-trade programs use market forces to put a price on carbon, and this price on carbon creates a cost for companies and incentivizes them to reduce emissions.

How Does Cap-and-Trade Work?

A cap-and-trade system typically issues a declining number of emissions allowances each year – capping greenhouse gas (GHG) emissions. Covered entities – primarily companies that generate electricity, supply transportation fuels and natural gas, or operate large industrial facilities – acquire emission allowances. They do this in different ways, but typically it is some combination of receiving allowances directly from the program administrator or buying allowances in an auction, or buying allowances in the secondary or futures market. Covered entities then surrender carbon allowances commensurate with the amount of carbon they emit each year. It is similar to how individuals and companies pay taxes, but instead of declaring income and paying in a given currency, they declare carbon emissions and pay with emission allowances.

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Cap-and-trade allowances tend to be oversupplied in the program's early years and undersupplied later because the supply of allowances typically declines steadily over time. As the supply of allowances declines, the cost to reduce emissions typically increases and the market must provide greater incentives to balance demand with shrinking supply. Initially, a region can often reduce its carbon footprint by switching from coal to natural gas for power generation – a straight-forward, relatively low-cost move that cuts emissions in half. It's the proverbial low-hanging fruit for reducing emissions. However, additional savings – such as switching from natural gas to renewables power – tend to be more expensive and require greater time to implement. Outside the power sector, solutions to decarbonize tend to be much harder to come by. As covered entities struggle to find cost-effective ways to reduce emissions, many are expected to opt to keep emitting and purchase more allowances. This continued demand coupled with steadily falling supply is expected to increase the price for allowances and the rising market-based price gives participants an incentive to find the most cost-effective way to reduce emissions.

With supply shrinking faster than demand and the price of emission allowances below where we believe technology can be deployed to reduce emissions, we view emission allowances as an attractive investment opportunity across cap-and trade programs. Still, there are meaningful differences across programs, which we believe makes owning certain allowances more attractive than others.

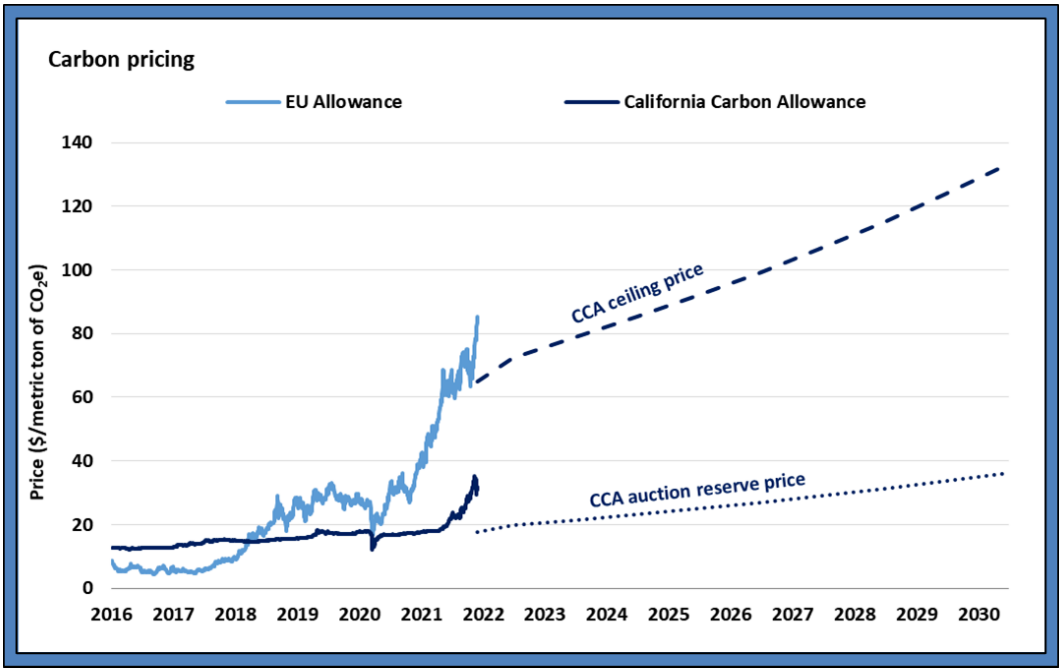
California Carbon Allowances

In our view, California represents one of the most attractive carbon markets. Launched in 2013, the California Air Resources Board (CARB) designed its cap-and-trade program with the benefit of having observed how supply-demand dynamics evolved in other markets (primarily the European market, which launched in 2005) and impacted prices. California's program addresses key concerns of a cap-and-trade program: that emissions prices are volatile, falling *too low* in economic downturns, melting incentives to reduce emissions, and rising *too high* in better economies, unreasonably burdening manufacturers and other major power consumers, potentially prompting them to leave the state.

Price floor. To address the risk of falling allowance prices, California has introduced an auction reserve price, placing a quasi-price floor under its auction of emission allowances. Thus, if bids do not meet at least the auction reserve price, the supply of allowances would be curtailed, supporting the trading price. This floor price rises yearly at a rate equal to the consumer price index (CPI) plus 5% (see Figure 1 on the next page). The escalating price can be viewed as an acknowledgement that in the beginning of a cap-and-trade program there are easy ways to decarbonize, and as time goes on and the low-hanging fruit has been picked, the market will likely need to provide greater incentives to reduce emissions.

Price ceiling. To limit how expensive California carbon allowances (CCAs) can become for compliance entities, California instituted a ceiling price for CCAs (see again Figure 1 on the next page). And at the ceiling price, supply becomes infinite. This ceiling price – currently about 2-3x the current price of CCAs – essentially caps the cost that companies, and the economy overall, can incur in pursuing these decarbonization objectives. In addition to outright limiting prices at the ceiling, CARB also implemented speed bumps for prices on the way to the ceiling. At prices fixed at 50% and 75% of the distance between the floor and the ceiling price, CARB would supply compliance entities with a limited amount of additional allowances outside the typical auction process.

Figure 1



Note: Auction Reserve Price and Ceiling reflect inflation swap pricing.

Sources: PIMCO, Bloomberg, and California Air Resources Board as of 30 November 2021.

ESG Considerations of CCA Investing

California carbon allowances may have a natural fit in environmental, social and governance (ESG) portfolio allocations. CCA investors help provide the liquidity and efficient price discovery essential to a well-functioning CCA market. The revenues that are generated by auctioning off CCAs are invested in various ESG-positive projects such as renewable energy, public transportation, recycling, and affordable housing. Thus, by purchasing physical CCAs, investors are helping to fund various projects that help to decarbonize the California economy and also give companies that emit a greater incentive to reduce their emissions.

Two CCA Valuation Methods

Given the unique floor price mechanism of CCAs, we can apply two different valuation frameworks. The first method values the auction reserve price (*i.e.*, approximate price floor) and compares it to current market prices, while the second takes the more traditional route of applying a supply-demand forecast to CCAs.

Valuation Based on Auction Reserve Price Mechanism

The auction reserve price represents a longer-term lower bound since auction supply drops to zero below this price. As such, we view the auction reserve price as a reasonable assumption of the *minimum* value of CCAs in the long run. Given that the current auction reserve price is known and that it escalates at a rate of CPI+5% every year, we can estimate a future value of the auction reserve price using inflation swap rates. Today's auction reserve price is $17.71 and using inflation swaps we would expect the 2030 reserve price to be about $36. We can then discount the 2030 auction reserve price back to today using current interest rates plus some additional spread to compensate for policy and liquidity risk. If we use a spread of 150 basis points (bps) over Treasury rates (1.55% to 2030), we get a discounted floor value of approximately $29. This means that if you could buy CCAs at $29 and then sold them at the floor in 2030, you would get a return of Treasuries plus 150 bps, or roughly 3%. Naturally, determining the intrinsic value of the price floor likely falls short as a true estimate of how much CCAs are worth.

To get a better fair value estimate, one should also account for the optionality of owning CCAs. After all, there is a chance that prices go much higher than the floor, possibly to the ceiling. What is that option worth? Well, that's debatable, but current implied volatility for a 1-year option is about 40%-50%. Longer-term options don't trade, but let's haircut that implied volatility to 30% and look at what an at-the-money $36 call maturing in 2030 would be worth. That option is worth about $8. This means that the fair value of a CCA using the forward floor and an estimate of the option premium should be roughly $37. In other words, without taking a fundamental view on where CCA prices should go, today a CCA should be worth almost the same value as the 2030 forward floor.

To put this in context, the current CCA price is around $31. This price provides an implied return roughly in line with Treasuries, with further upside should emissions not fall as fast as supply. To be clear, even once CCAs reach $37, we believe they can still be an attractive investment – at that entry point investors should earn a fair rate of return for the risk they take. In our view, today's price reflects the undeveloped state of this new market.

Valuation Based on Supply-Demand Expectations for CCAs

Ultimately, supply-demand dynamics are expected to drive carbon prices. Absent prices being at the ceiling or a change to the program, carbon allowance supply will drop by nearly 40% between now and 2030. Actual emissions, *i.e.*, demand for allowances, can be thought of as a function of GDP growth, population, market share of electric vehicles, renewables' share of power generation, and other variables. Looking at future supply relative to our demand projections, we see supply falling below demand in the next year. It will be challenging to decarbonize the economy at the pace supply falls without providing meaningful financial incentives for companies to make the necessary investments in clean(er) technologies. For this reason, we think investors may benefit by entering the market during the early years when supply is still plentiful.

While each cap-and-trade program is unique, it may be worthwhile to look at price developments in other, more established, jurisdictions, where the reduction in supply is more advanced and where prices could better indicate when alternative technologies become competitive.

For example, in Europe, emission allowances for an equivalent metric ton of carbon trade above $80, more than double the price of CCAs, without causing major harm to regulated entities. While prices in different regions are likely not directly comparable, in our view this does offer some validation that the price range California has anticipated, with a ceiling price of $72 in 2022, rising to $130 by 2030, is within reason.

Our Outlook for the California Carbon Allowance Market

The CCA market covers emissions across 85% of the California economy. There are currently in excess of 300 million metric tons of carbon allowances, making it one of the largest emissions trading systems in the world (Center for Climate and Energy Solutions). We believe that as the CCA demand eclipses an ebbing supply, more investors will enter the market, further boosting CCA demand and price – benefiting those who invested early. This cycle will continue until companies emit less carbon and demand for allowances eases. Until this happens, the price of carbon should continue to rise. As a society, we believe we must reduce carbon emissions in order to ensure a future as bright as possible for future generations. Involvement in the cap-and-trade market helps achieve that goal by setting the price where companies will be compelled to change their behavior and make investments to reduce greenhouse gas emissions.

Endnote

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Resources and Diplomacy: Commodity Signposts to a Post-War Economic Order

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Introduction

With the outbreak of major conventional warfare on the European continent for the first time in over 80 years, a new economic and political reality has engulfed Europe, its populations, policy makers and larger economic actors, regionally as well as internationally.

From the first explosions of the Russian invasion of Ukraine in the early morning of February 24th this year, achieving a peaceful resolution to conflict while punishing Russia by all means possible short of direct military involvement emerged as the objectives of Ukraine's western allies. Despite Russia's role as the heavily armed protagonist in the war, and although non-combatants, western countries and the NATO Alliance were however far from passive observers.

The West responded with steadily increasing armament supplies to the defenders combined with an aggressive policy of economic and political sanctions against the invader and its allies. These latter sanctions on Russia, in combination with the collateral destruction in supply of energy and food from Ukraine, caused unprecedented commodity market turbulence and initially led to large upward price movements on major exchanges.

However, while the achievement of a peaceful resolution to the conflict proved as elusive as Russia's attempt to score a rapid "Blitzkrieg" style victory, the medium- and longer-term implications for the European continent's economy and markets, as well as its future political and defense arrangements, will be profound.

The situation required a radical re-ordering of resource allocation, with concomitant shocks to corporate, public and personal finances that this will inevitably entail.

Blindfolded to Risk, Blinkered in Conflict

In the final week of February 2022, suddenly, a European foreign policy approach to Russia based on nuance, mutual economic interest and sometimes covert relations at the highest levels was quickly blown to pieces. Foreign and defense policies, often crafted to appeal to voters with more pacifist leanings, while at the same time tolerating those of nationalist inclinations – *e.g.*, quiet admiration for Vladimir Putin's Kremlin – were swept away in a stroke. The new reality of strategic vulnerability and heightened military threat would suddenly require greater focus on – and heavier allocation of resources to – the defense and security, at acceptable cost, of basic energy supplies.

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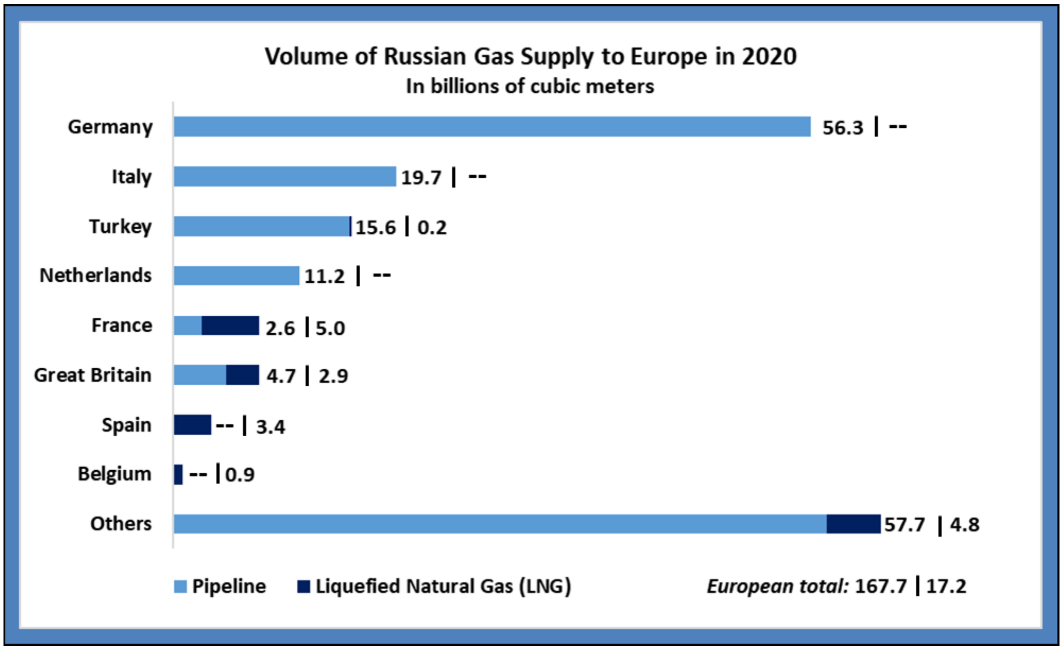
In this latter need, the miscalculation of those countries, which prioritized policies including sustainable energy sourcing and the elimination of nuclear power sources in favor of gas, has been laid bare. For Germany as well as others, an energy mix prioritizing cost reduction as well as greener, non-nuclear power at the expense of supply security and diversification represented a vulnerability which was underestimated.

Figure 1
Dependence on Russian Gas by Major European Economies



Sources: Statista and BP.

The early years of Angela Merkel's 16-year chancellorship, which began in 2005, had been an era of steadily building commercial ties and growing economic collaboration with Russia, culminating in the inauguration of the first of the Nord Stream 1 network of gas pipelines between the two countries in 2011. Even in later years as bilateral relations soured, a consensus at the top in German government and business believed the country could weather the political crises sufficiently to keep bilateral trade on an even keel, despite increasingly belligerent Russian actions towards its former Soviet neighbors.

But with the invasion this winter of another European country only 600 miles from Germany, everything changed. The western alliance strove to coordinate its response with sanctions, which included the elimination as far as possible, of Russian gas supplies from its imports. In Germany's case this would mean finding a replacement source for over half of all gas consumed in the country, presenting an immediate dilemma.

Clash with Climate Emergency Goals

In the previous decade, German energy policy was seemingly hooked on the dream of becoming a huge low-cost gas market at the heart of Europe, providing cheap energy to households and industry while also acting as a trading hub at the crossroads of Europe.

With the war in Ukraine it became clear that hard choices would have to be made and some politically uncomfortable back-pedaling with regard to using fossil and even nuclear fuels seemed inevitable. Although Russian gas has continued to flow westwards in the first weeks of the war and hard currency has been paid to Russia in exchange, in the new reality this can scarcely be expected to continue into the future at the same pace.

Germany may put on hold its decision to start decommissioning its remaining nuclear supply sources later this year as well as the aim of phasing out totally its largest single energy source, coal by 2038; and Norway, a large exporter of gas, is certain to play a much greater role in supplying much of the west European market going forward. The Netherlands, once a huge European gas producer, but now scaling back rapidly in the face of environmental concerns, may need to temporarily reactivate the exploitation of the huge reserve of the controversial offshore Groningen field, a large portion of which is already scheduled to be taken off stream later this year, due to strong evidence of dangerous seismic disturbances caused by sustained drilling activity.

In sum, strategic self-sufficiency, whether at the national, continental or defensive alliance level will of necessity be allocated much higher priority and will inevitably command a much greater call on economic resources than at any time for many decades.

Background to a New Geo-Commodity Order

The decade of the 2020s, still in its infancy, has already been one of major shocks for humanity. The belated realization by governments that there is no alternative to sacrifice in order to stabilize the pace of climate change at tolerable levels for the planet's survival was transformative; and on the public health front, the SARS-CoV-2 ("COVID 19") pandemic drastically changed attitudes to public health emergencies at government, transnational and public levels.

To these two catastrophic phenomena can now be added a third seismic shift requiring equally swift policy action: the imperative of ensuring security of defense and strategic resource availability in the presence of totalitarian, nuclear-armed regimes with neo-imperialist agendas.

The remainder of the article deals with the policy dilemma between controlling the impact of climate volatility while dealing with severe commodity market dislocations – whether war or pandemic related. While war has put an acute additional stress on resources and has led to unparalleled price volatility, the multi-year impacts of accelerating climate change and the market's response to its effects are likely to be of more lasting effect.

Commodity prices were already rising broadly well before the invasion of Ukraine and not only because of the impact of lingering pandemic supply chain issues. In addition to rising energy costs, emergent and then increasingly severe drought conditions in both North and South America stressed markets for several agricultural and soft commodity products, including soybeans, coffee, and canola as well as the staple grain crops, wheat and corn, the most impacted by the war.

Severe weather in Asia and Australia also caused dislocations, while the continuing effects of trade wars, and regional conflicts in Africa impacted markets for iron ore, aluminum, coal and specialist strategic materials. Cobalt, graphite, nickel, palladium and titanium among others have also been in the spotlight in recent months.

The next section reviews major ongoing examples of climate-impacted agricultural markets with its main focus on the Americas and North Africa. Facing multi-year droughts, multiple sources of input cost inflation and surging demand, imbalances building for many months in a range of crops are expected to lead to higher price levels and greater volatility.

The second section below surveys the landscape for strategic non-energy minerals, with a focus on Sub-Saharan Africa and the competition for influence and supply security which has already seen western actors face off against China in its earlier phase. Previously regarded as a region of minor strategic importance, and largely ignored during the Trump Administration, several countries in Africa are now set to become major economic and political battlegrounds as a new era of resource competition gathers pace, with its genesis in Eastern Europe's military conflict.

The final section returns to the issue of the clash between climate and military imperatives and asks the question: if "something has to give," then what is it most likely to be? Will it be energy and food security, price stability, or defense of national borders in a world of aggressive authoritarian superpowers? Or will it be the stabilization of planetary climate trends at humanly acceptable levels?

The debate will evolve according to events, and much will depend not only on which foreign policy choices are made but equally on how successfully governments manage their macroeconomic responses. As Ukraine's daily tragedy is inevitably displaced from the headlines, the world economy will continue to be faced with the new reality of much higher prices for many staples, both food and energy – as well as the shock to demand levels through constrained living. Fighting the threat of stagflation looks increasingly set to be a primary focus of policy.

1. War in Ukraine: The End of the Beginning

Zooming in closer to look at two trouble spots very distant from each other – southern Brazil's agricultural powerhouse running from the Mato Grosso to Rio Grande do Sul states, and the U.S. Plains states together with the Canadian Prairies, the impact of drought conditions is already presenting a multi-year crisis for crops.

In South America, a drought which began in late 2021 in the northern Argentina/Paraguay region has slowly moved northwards, impacting the soybean crop and leading to surging prices as production estimates continue to be slashed. This year more than ever, exports from the U.S. crop will have to compensate if there is not to be an even greater shortage, and any weather disruptions during planting and harvest seasons will be critical.

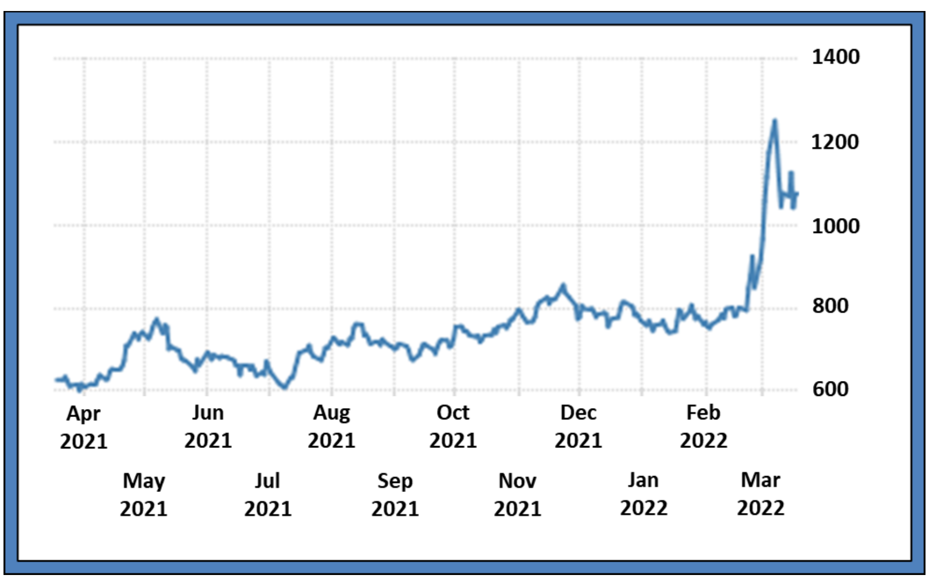
Meteorologically, weather conditions in South America are being attributed to a recurrence of the La Niña weather pattern, bringing unusually sustained heat and drought conditions to the region.

In coffee, Arabica certified stocks have been on the decline since late last year, with drought stressed trees in Brazil and crop size further impacted by the "off year" reduced production in 2021-22 which together brought price levels to over $2.50/lb by February of 2022. Analysts have estimated a multi-year crop impairment with trees unable to recover sufficiently to resume their full potential this year, leaving the consumer at risk of having to bear coffee costs close to double the average level of the previous few years.

Wheat's near-vertical price ascent in the immediate wake of the Ukraine invasion has its most obvious source in the lost production and exports resulting from the conflict, with combined Russian and Ukrainian output typically accounting for over 25% of global exports. However, the price of wheat was already close to 14-year highs at the end of 2021, even before the outbreak of hostilities.

As early as the fall of 2021, drought was emerging in the U.S. Southern Plains, impacting winter wheat crops. (The hard winter wheat variety which those regions mostly produce is the same as those which accounts for the bulk of Ukrainian wheat crops.) Meanwhile, to the north, available Canadian wheat stocks had also been dropping sharply, which together with drought conditions in the Dakotas and Minnesota brought prices towards multi-year highs even before war exploded in Eastern Europe.

Figure 2
Chart of Chicago Wheat Futures Prices
U.S. Cents per Bushel



Source: Trading Economics.

In North America, as elsewhere, the increasing cost of fertilizer has also been a cause of stress, with U.S. farmers facing increased costs of between 200-300% per acre to plant core crops such as corn, soybeans or cotton. Input costs of nitrates, phosphates and potash had already risen ahead of the war in Ukraine due to higher energy costs and interruption of supplies from China, and can only be expected to rise further in a higher energy cost environment.

With Russia's invasion of Ukraine, upward price movement switched into a higher gear. Globally, Russia is the third largest producer of wheat after China and India with an output of 75.5 million metric tons and some $7.7bn worth exported in the 2021-22 crop year.

For the current season, Russia and Ukraine combined produced 108.5 million metric tons of wheat, and exports which account for 29% of the global market. Their corn production is 57 million metric tons combined with exports accounting for 19% of the global market.

Although less often in the spotlight, proportionately the most impacted is the sunflower oil market, where together Ukraine and Russia produce over 12 million metric tons of sunflower oil accounting for 78% of the global export market. The knock-on effect on the vegetable oil markets, *e.g.*, soybean oil, could be powerful, although end-user reconfiguration blunts the immediate effect of demand switching.

Figure 3
Major Crop Production & Exports 2021/22 Marketing Year

	Wheat		Corn		Sunflower Oil	
Production	**TMT**	**% World Total**	**TMT**	**% World**	**TMT**	**% World**
World	776,420	-	1,205,350	-	22,066	-
Russia	**75,500**	**10%**	**15,225**	**1%**	**5,844**	**26%**
Ukraine	**33,000**	**4%**	**41,900**	**3%**	**7,289**	**33%**
Exports						
World	206,690		203,670		13,350	
Russia + Ukraine	59,000	29%	38,000	19%	10,450	78%

Abbreviation: TMT stands for a Thousand Metric Tons.

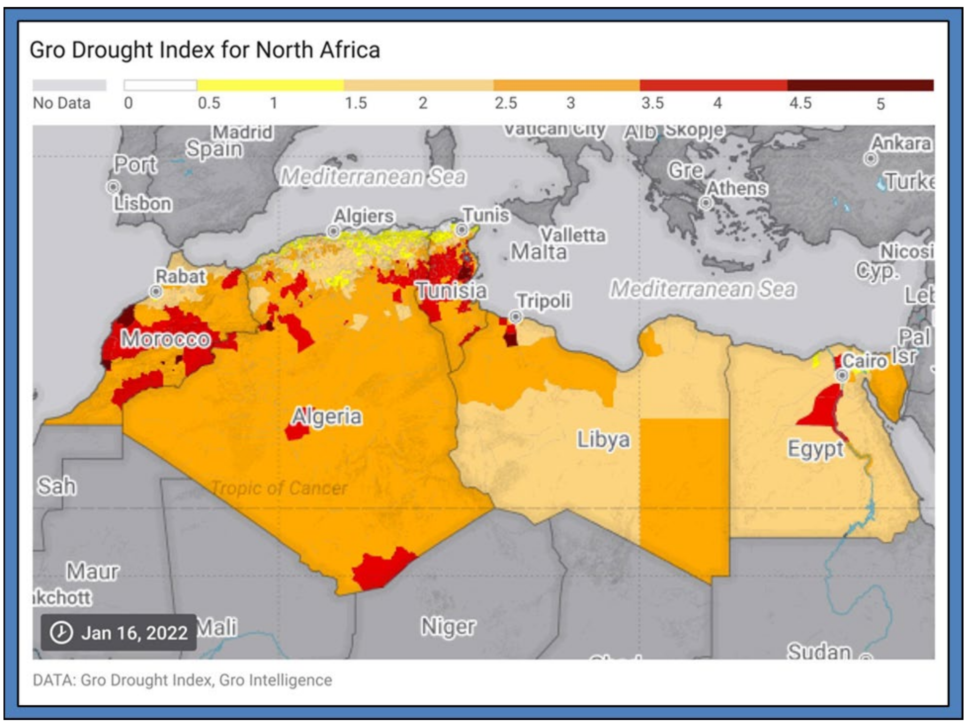
Source: U.S. Department of Agriculture (USDA).

An important aspect to the situation beyond security of physical supply is the price level which the world's developing nations can afford to pay. The world's largest wheat importers include Egypt, the largest, and Algeria, as well as Turkey, normally among Ukraine's biggest customers and typically dependent on smooth flowing shipping lanes through the Black Sea. Far from participating in anti-Russian embargos, these relatively poorer importers may struggle to pay wartime prices close to double last year's and so may be forced to seek subsidies or emergency supply from multinational organizations.

Algeria, traditionally tied to exporters from France, the European Union's (EU's) largest wheat producer, switched several years ago from the former colonial power and turned to Russia for supplies. With adequate stock for most of this year's needs, French domestic wheat producers are well positioned to supply Europe for now, while Algeria is in a far less comfortable position, also seeking supplies on the open market at a time of rising prices.

North Africa's most populous countries also face devastating drought conditions of their own, compounding the crisis. The map below illustrates the affected regions with orange representing regions with "severe" drought and red indicating "extreme" conditions.

Figure 4
Northern African Drought Conditions, January 2022



Source: Gro Intelligence.

A further aspect which could have major influence on the outcome of the current conflict and its supply-demand consequences is the role of China. Indeed, while not a party to the conflict in Ukraine, for China the evolving situation may present opportunity as well as risk. Relatively self-sufficient in a normal year, last year Russia's wheat exports to China were a tiny 12,300 tons, out of a global Russian total of 26m. This year however, imports displaced from Russian exporters subject to sanctions could become a significant source of supply.

China's total domestic wheat production rose in the 2021-22 crop year, according to the USDA, to a record 137 million tons, despite a catastrophic flood-impacted winter wheat crop. This weather shock was the mirror image of the similar stress to North American winter wheat crops, for whom the impact of droughts has been discussed above.

Shortly after the outbreak of the Ukraine war, Beijing struck a deal with Russia, committing to buy all its wheat exports and granting access to its deep-sea ports, even in preference to traditional suppliers. The additional supplies will also help to fill any gaps from last year, when China was forced to mix wheat with relatively pricey corn to meet animal feedstock needs, depleting stocks.

2. Axis of Angst: Strategic Mineral Resource Vulnerabilities

Beyond the energy markets, dominant in world headlines, non-energy mineral markets have also seen surging demand in recent years related not only to their strategic and military uses but also their carbon control properties. In many of the strategic minerals which have risen in price, either Russia or China is the dominant Eurasian producer/supplier, with Southern and Central Africa in several cases featuring prominently in reserves, and frequently in output too.

For example, Russia is near the top of the global league in production of both titanium and cobalt, key inputs in aircraft manufacture, although cobalt, along with graphite are also used in lithium-ion batteries for electric cars. The world's largest cobalt producer is the Democratic Republic of Congo (DRC). Meanwhile, platinum and palladium, where Russia is in the top two worldwide producers, are vital in automobile emission control systems. South Africa dominates in world platinum production and competes for first place with Russia in palladium.

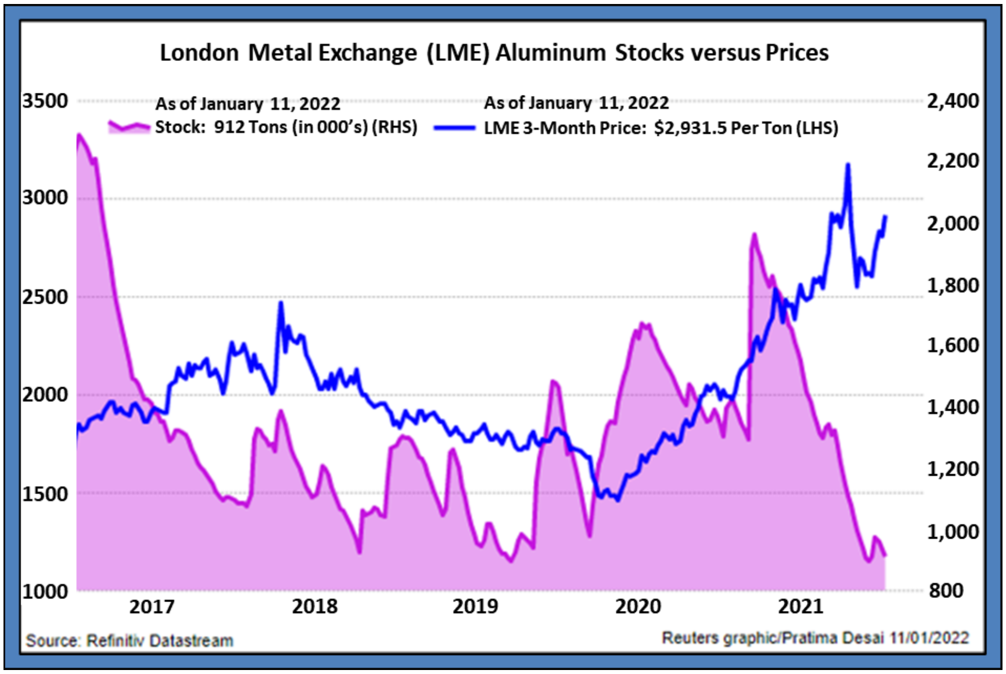
Taking a step back to the 1980s, with the Cold War into its final decade and Ronald Reagan in the White House, the U.S. and many of its allies embarked on programs of strategic minerals stockpiling, at a time when China's role was negligible and the primary threat was, as it is today, from Russia. At that time, Russia and the West courted African states seen as strategically important in mineral production.

Forty years on, Russia is once again the principal adversary, China now represents a major force and African sources for several critical minerals are more crucial than ever in ensuring the superpowers' strategic security of supply. In the past two decades, China has raced on to the scene, often with state-backed investments in mineral producing nations, including Guinea, the DRC and Mozambique as well as cultivating close economic relations with South Africa.

Today's situation is complicated by a China whose role in enforcement of the West's sanctions is uncertain while African nations today are in position to play the role of supporter or spoiler depending on their loyalties. Unlike the grains markets, where production is concentrated in the Northern Hemisphere plus South America and Australia, for mineral commodities, Africa is the serious swing supplier. It forms the third vertex in a new strategic triangle of production, trade and consumption with Russia/China facing the West at its other two points.

Turning first to the base and industrial metals, in common with their agricultural counterparts, several were already in full-blown bull markets prior to the Ukraine invasion. In aluminum, produced from bauxite/alumina, Russia is the world's third largest producer after China and India. Bauxite itself comes from an array of different countries, with Guinea, Australia and Brazil the top three in terms of reserves globally.

Figure 5
Aluminum Prices and Stocks, 2017-2021



Source: Refinitiv Datastream.

World number one Guinea has already been subject to instability in September 2021, with a *coup d'état* against an incumbent president Conde who was accused of corruption related to billion dollar deals with China in exploiting the country's bauxite mining reserves. Presciently, an aggravating factor in that coup was a spate of bread price riots linked to souring grain import costs from both Russian and North American suppliers.

In iron ore, Russia and Ukraine are the world's third and fifth largest producers respectively, with Brazil and Australia in the lead, while for nickel, which is largely used in stainless steel, Russia holds the number three place. However, the largest refined nickel producer in the world, Norilsk, is domiciled in Russia. More importantly, Norilsk controls Siberian mines supplying about 17% high-purity nickel used in New Electric Vehicle (NEV) batteries, which can only be sourced in commercially viable quantities from a few other locations globally.

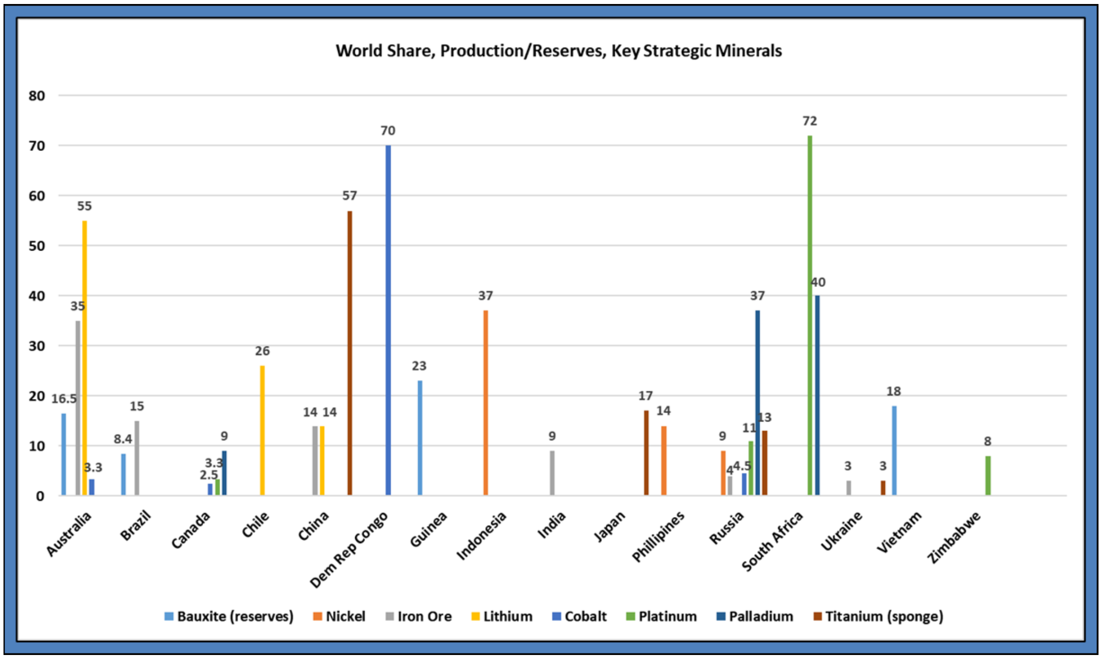
On March 8 this year, with prices of most metals moving up, nickel traded on the London Metal Exchange suddenly exploded fivefold in price in one session, touching $100,000/ton. While the initial rally was war related, a massive short position held by a fabled Chinese trader being forcibly unwound, caused total chaos and forced the exchange into an unprecedented cancellation of deals and a halt to trading.

While Europe and North America generally have secure alternatives, if not domestic sources of supply in these industrial metals, for the specialist strategic metals, the picture is quite different. In platinum and palladium, both of critical importance in automobile emissions control catalyst manufacture, South Africa is the dominant world producer with Russia in second position. For palladium, however, the roles are reversed with Russia historically the world's number one producer and South Africa historically in second position. According to estimated 2021 data, though, South Africa overtook Russia as the number one palladium producer, as shown in the figure on the next page. Palladium is broadly accepted as the preferred element for catalytic converters in gasoline vehicles, while platinum is more widely used in diesel engines.

In other strategic minerals, when it comes to titanium, where its high-performance alloys are a critical component in aircraft manufacture, we find Russia and Ukraine in third and fifth positions worldwide, with China the leading producer and no major source of western production. Similarly, in cobalt, the Democratic Republic of Congo is by far the world's largest source of reserves and production, with Russia in number two position and western production not in the same league. Cobalt is a key ingredient in Lithium-ion batteries and other energy storage systems and is becoming prized in recent decades for use in mobile phones as well as a range of nonstrategic uses, *e.g.*, ceramics manufacture.

Lithium production itself is dominated by China, although the biggest world reserves are found in South America and Australia. Again, important for batteries, lithium's use in NEV production has surged, and today the largest lithium trading market in the world is in Shanghai, where prices have soared in recent years. In terms of strategic as well as climate mitigation policy, the West has been overtaken, if not outflanked by China in its sourcing of lithium in recent years, to the extent that industry is now ringing the alarm bells. ''China owns basically 70-80% of the supply chain for new electric vehicles, lithium-ion batteries and therefore energy storage,'' said Stuart Crow, chair of Lake Resources, a major Australian-listed lithium producer. "There simply isn't going to be enough lithium on the face of the planet,'' he concluded.

Figure 6
Top Global Producers of Selected Industrial and Strategic Metals



Source: U.S. Geological Survey.

Fast Forward on Climate Action or Backpedaling to the Future?

On March 8, 2021, after relatively brief debate, the U.S. and the U.K. announced the suspension of all oil imports from Russia, marking beyond doubt a clear departure from the scale of many of the previously enacted sanctions – some of which had appeared more symbolic than serious in their likely impact on Russia's access to vital foreign exchange flows. While the U.S. has relatively low levels of foreign energy dependence - some 7% of oil imports are currently from Russia - and in European terms, the U.K. still has access to its offshore resources, the decision by core EU leaders to support the energy import ban was a much greater step.

In the case of the U.K., and the Netherlands – environmental risks notwithstanding – reactivation of offshore resources which until recently were uneconomic (at pre-2022 prices) and in the process of being decommissioned, the option to reactivate or re-phase closure schedules exists. Furthermore, the French economy, as we have seen, has significantly less dependence on Russian oil and gas than its EU neighbors to the east and the government has announced further nuclear capacity construction.

Nevertheless, the French stance towards Russia (demonstrated by majority state-owned TotalEnergies, a major player in Russian oil and gas) on boycotting oil business and disinvesting from Russian partnerships in the early weeks of the conflict was far less resolute and more nuanced than that of counterparts Shell and *bp*. Total only announced a freeze rather than a disinvestment, which gave the appearance of holding back on more drastic action.

However, it was the reversal of course by Germany in joining in the sanctions, as was its decision to rapidly enact legislation allowing foreign weapons sales, which would set the direction for Europe on energy imports going forward.

Clearly there were let-outs and loopholes for sanctioner and sanctioned alike. The U.K. for example said that their import control measures would come into force "by the end of the year" – compared with the Biden Administration's aim of ending all Russian oil purchases within 45 days. Others pointed out that oil sales could be rerouted to China, and Europe could buy from those displaced former Chinese suppliers, effectively just bumping Russian oil down the chain of transactions, in a kind of back-door "laundering" of sanctioned Russian exports with very little net effect.

Nevertheless, in combination with crippling financial sanctions on the use of foreign exchange reserves and the SWIFT overseas interbank payment protocol, the measures taken were in a totally different league from anything taken before.

Towards a Green Cold War

However, policymakers now face the challenge of how two very different policy imperatives can be reconciled – radically overhauling the energy economy to urgently combat climate change while at the same time sharply increasing defense spending and ensuring strategic self-sufficiency in power – in what seems increasingly likely to become a lengthy new Cold War environment. In a world of limited resources, with western economies already debt-laden and reeling financially from two long years of pandemic, hard choices will need to be made.

Furthermore, throughout 2020-21, as supply chains became severely impacted, freight prices soared and costs of a wide range of imported commodities began to rise sharply. Despite the optimistic pronouncements of lawmakers and central bankers that the impact of dislocations on essential commodity supplies would subside in a matter of months as pandemic-related bottlenecks cleared, instead, with the outbreak of war in Europe in early 2022, prices of key food and energy items accelerated rapidly.

Yet, only a few short months before the outbreak of war in Ukraine, and despite a world still in mid-struggle against yet another lethal wave of the COVID-19 pandemic, at the COP26 climate summit in Glasgow, in November 2021, an unprecedented consensus of governments had given their backing to an urgent and accelerated policy of carbon-reduction measures entailing rapid reconfiguration of their energy supplies and major investments in alternative sources of fuel. At the same time, they issued a raft of pledges to combat the effects of climate change in the developing world and compensate the victims of drought, storms and floods in those regions most impacted.

What then, are the options now for western governments, given a resettling of priorities back towards the domestic from the geopolitical?

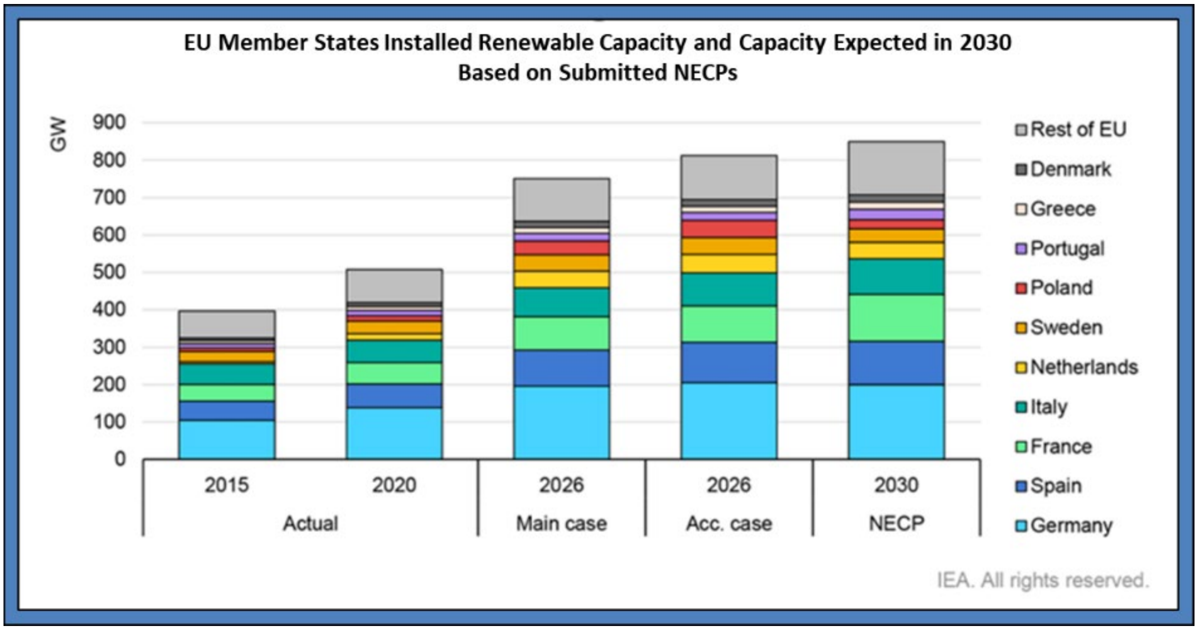
There is a risk that quick fix solutions are more readily adopted in times of pain than in times of peace. While some have contended that the solution lies in revitalized offshore exploration, more pipelines (such as North America's controversial Keystone Pipeline) and wider use of fracking are the best approach to securing future supplies: at the other end of the spectrum, the solution is seen as an acceleration of the pace of development of renewables: wind, solar, and wave, as well as hydrogen and nuclear sources of generation.

All this comes against a backdrop of pressures on household and industry budgets, which governments have tried to plug with *ad hoc* measures initially. The U.K. introduced an energy price cap, France gave a one-time cash subsidy to users, while Italian Prime Minister and former European Central Bank Chief Mario Draghi urged a joint EU approach. Following an EU summit at Versailles in early March, Draghi stressed the amounts already spent by national treasuries on energy cost relief – in the Italian case €16bn and counting – and pronounced: "A convincing fiscal response will be needed, fiscal policies … which cannot come from national budgets … it must be a European response."

In the longer term, it has been suggested that a radical upward repricing of carbon emissions credits is the solution to achieving climate goals in times of rising prices, by reducing their supply and driving up price, forcing industry into an accelerated pace of change. Few would believe that would be a sensible or even practical policy to implement in the spring of 2022 when cost control and supply security are paramount, but over the long term, a reinforced system such as the EU Emissions Trading System's (ETS') carbon emissions trading regime could be an important part of the way forward.

In her address to the European Parliament days after the outbreak of war, EU President Ursula von der Leyen set the tone for Europe's future policy imperatives. ''We must no longer be reliant on Kremlin gas,'' she declared. ''We need to redouble our efforts … to put Europe's energy security on a stronger footing … In the long run it is our switch to renewables and hydrogen that will make us truly independent … Every kilowatt of solar, wind, hydropower, or biomass, reduces our dependence on Russian sources … It is a strategic investment.''

Figure 7



Abbreviations: Acc. Case = accelerated case; NECPs = National Energy and Climate Plans; and GW = gigawatts.

Source: International Energy Agency analysis based on NECPs.

But in the same address the EU President admitted that short-term measures to take up the slack from lost Russian energy would focus on immediately increasing supplies from Norway and stretching capacity from other European suppliers, involving the construction of new gas terminals and installations to distribute the energy to industrial and domestic users.

And so the debate will run – align long-term energy mix choices with climate change ambitions, or prioritize short-term security of supply? Whichever the outcomes on the battlefield and at the negotiating table (or screen), the implication is that the energy mix will not only be quite different from before, but also quite a lot costlier.

In a peacetime scenario, standards of living are paramount, and the maintenance of employment as well as affordable energy may increasingly press on governments – especially those with elections in the offing – to stay the pre-war course. The tide of compassion for the victims and survivors of war may slowly ebb as the reality of lower living standards for the European middle class hits home. In France, where presidential elections were held in April, Marine Le Pen, the second-round challenger to the incumbent president Macron, stated on the campaign trail, ''Yes, we support Ukraine … but at what cost?''

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Author Biography

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Colin Waugh has spent much of his career in investment management, research and trading. He was a Partner, Portfolio Manager and Head of Research in the New York firm of Galtere Ltd, a $2.5bn commodity-based global macro fund, until 2009 when he joined Lombard Street Research (LSR) as an Associate Director for Commodities Research in LSR's Global Strategy

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A regular China visitor and event speaker over the past decade, he also maintains an active interest in digital applications in banking and financial sector reform and digital solutions for developing market financial inclusion. He holds a Certificate in Future Commerce from the Massachusetts Institute of Technology and is also a Director of Dublin-based Vitro Software, a global medical technology company.

Waugh has also worked extensively in Africa on development and migrant-related humanitarian projects and has published two non-fiction books about African political leaders: "Paul Kagame and Rwanda" (2004) and "Charles Taylor and Liberia" (2011).

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

What Drives Gold Prices?

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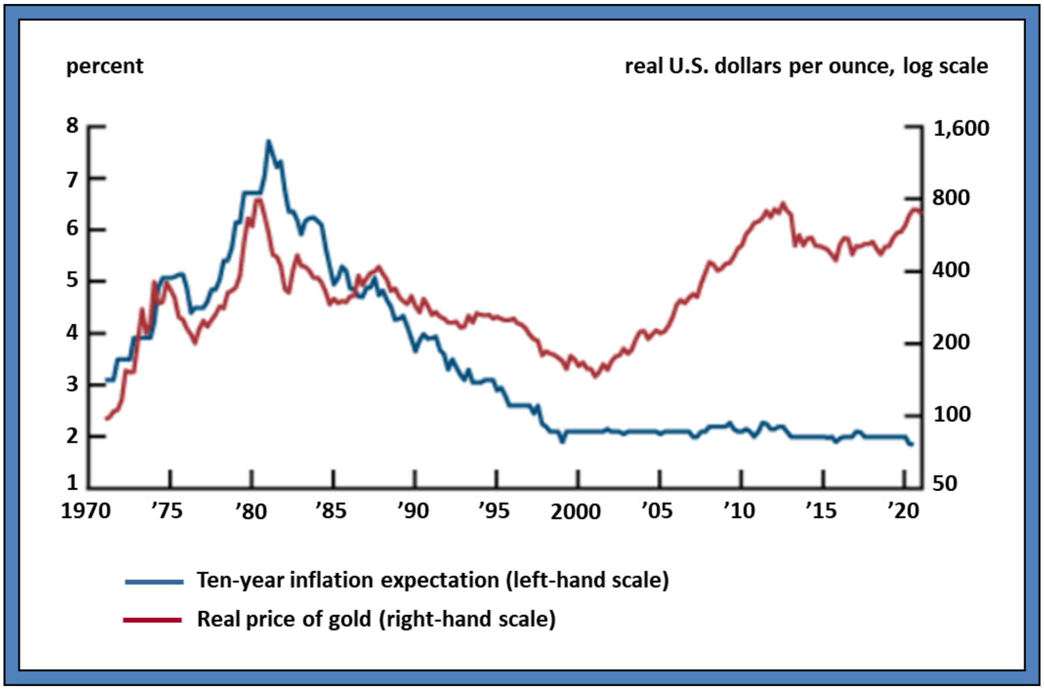
A half century after gold ceased to play a significant formal role in the international monetary system, it still captures a great deal of attention in the financial press and the popular imagination. Yet there has been very little scrutiny of the primary factors determining the price of gold since its dollar price was first allowed to vary freely in 1971.[1] In this article, we attempt to fill in that gap by highlighting three considerations that are commonly cited as drivers of gold prices: inflationary expectations, real interest rates, and pessimism about future macroeconomic conditions.

Our empirical results in this article are organized around three claims—namely, that gold is a hedge against inflation, gold is sensitive to expected long-term real interest rates, and gold is regarded as protective against "bad economic times."

Gold is a hedge against inflation. A rise in inflation or inflationary expectations increases investors' interest in purchasing gold and, therefore, drives up its price; in contrast, disinflation or a drop in inflationary expectations does the opposite. We will measure the "inflation hedge" motive for holding gold with *PTR*—which is the mnemonic for the survey-based ten-year inflation expectation that is provided by the Board of Governors of the Federal Reserve System; *PTR* has in recent years coincided with the ten-year inflation projection of the Survey of Professional Forecasters (SPF) conducted by the Federal Reserve Bank of Philadelphia.[2] The notion that gold can be identified with an inflation protection motive is of course connected with the fact that, in contrast to fiat money, gold is in nearly fixed supply. But this property of gold is shared by many other commodities. The special status accorded gold may be a relic of the gold standard era, or it may even reflect a belief on the part of a subset of investors that there is a positive probability that the world will at some point return to a gold standard. Figure 1 on the next page shows how the real price of gold and the long-term inflation expectation have evolved over time. The measure of the real gold price is the London PM fixing price for gold (from the London Bullion Market Association) in U.S. dollars per ounce deflated by the U.S. Consumer Price Index, or CPI (from the U.S. Bureau of Labor Statistics), plotted on a log scale; and the measure of expected inflation over the next ten years is *PTR*. From 1971 to around 2000, the real gold price and the long-term inflation expectation tend to move together. A sharp uptick in inflation expectations during the period 1971–80 coincides with a dramatic run-up in gold prices. Gold prices fell dramatically during the Volcker disinflation of 1980–83.[3] Over the period 1983–2000, the steady downward march of expected long-term inflation following the Volcker disinflation period coincides with the decrease in the real gold price. Since 2000, however, the long-term inflation expectation has deviated relatively little from 2%, whereas the real gold price has increased more than fivefold. The role of expected inflation in this later period seems to have given way to that of the real interest rate—our second key driver of the gold price—which we discuss next.

Figure 1
Real Price of Gold and Ten-Year Inflation Expectation, 1971:Q1–2021:Q1

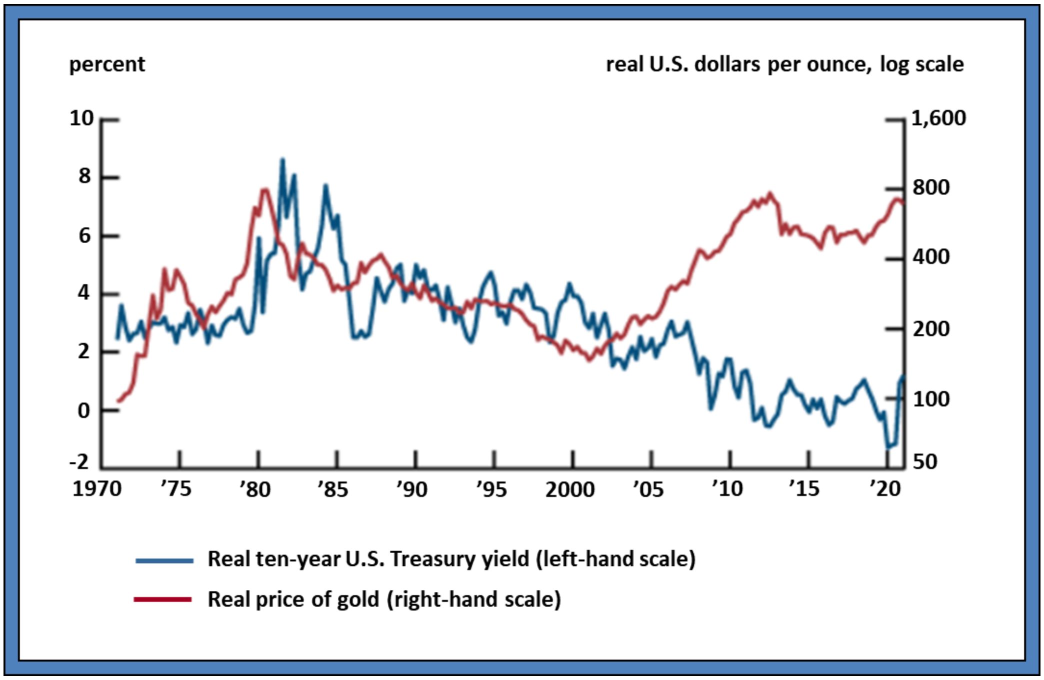


Notes: See the text for details on the measures of the ten-year inflation expectation and real gold price. All data are quarterly.

Sources: Authors' calculations based on data from the London Bullion Market Association and Board of Governors of the Federal Reserve System.

Gold is sensitive to expected long-term real interest rates. Given that gold is a long-duration durable asset with a relatively stable dividend yield, its price is expected to have a strong inverse relationship with the long-term real interest rate. A rise in expected real rates, all else being equal, should drive down the price of gold.[4] Figure 2 on the next page shows the real gold price (the U.S. dollar price per ounce deflated by the CPI, once again on a log scale), along with the real ten-year U.S. Treasury yield (the nominal yield on ten-year Treasury securities minus *PTR*). The predicted negative co-movement of the real interest rate and the real gold price does not show up in these data before 2001.[5] By contrast, between 2001 and 2012, the long-term real interest rate fell some 400 basis points, accompanied by an over fivefold rise in the real gold price.

Figure 2
Real Price of Gold and Real Ten-Year U.S. Treasury Yield, 1971:Q1–2021:Q1

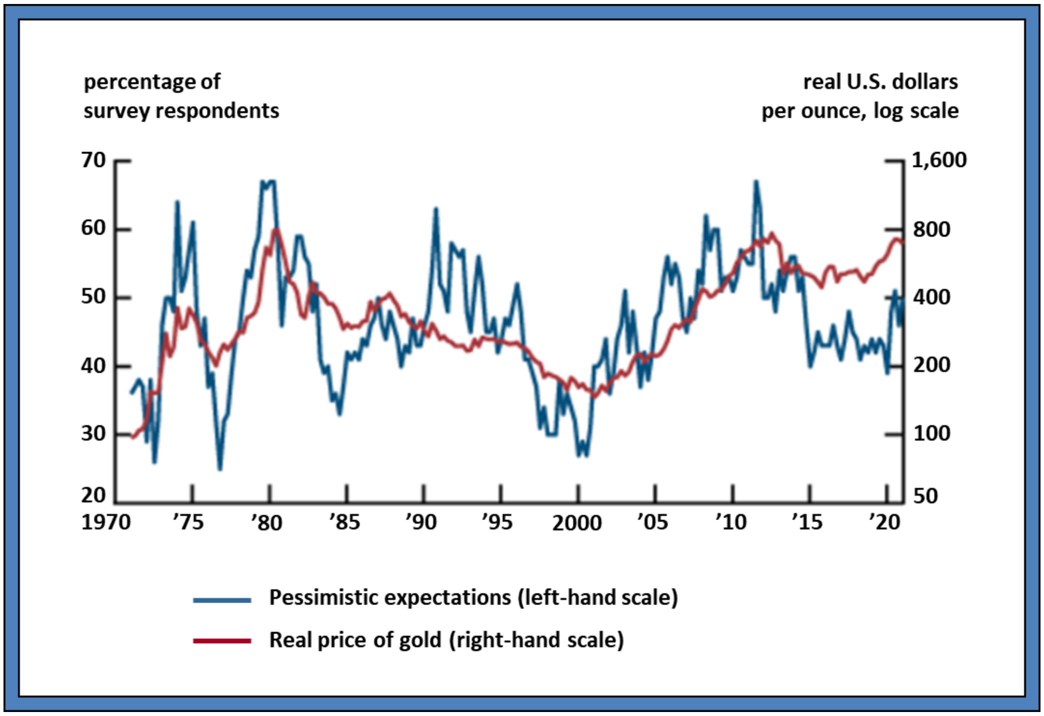


Notes: See the text for details on the measures of the real ten-year U.S. Treasury yield and real gold price. All data are quarterly.

Sources: Authors' calculations based on data from the London Bullion Market Association and Board of Governors of the Federal Reserve System.

Gold is regarded as protective against "bad economic times." We test for this factor's importance by using the *Surveys of Consumers* conducted by the University of Michigan (Michigan survey); one of the key survey questions is the following: "Looking ahead, which would you say is more likely—that in the country as a whole we'll have continuous good times during the next 5 years or so, or that we will have periods of widespread unemployment or depression, or what?"[6] We use as our measure the fraction of pessimistic responses to this question, and refer to it as "pessimistic expectations" in our analysis. Figure 3 on the next page shows the log real gold price along with the fraction of respondents to the Michigan survey who expect the next five years to be characterized by mostly bad times; there is considerable positive correlation between these two variables over our sample period.

Figure 3
Real Price of Gold and Pessimistic Expectations for the U.S. Macroeconomy, 1971:Q1–2021:Q1



Notes: See the text for details on the survey measure of pessimistic expectations and the measure of real gold price. All data are quarterly.

Sources: Authors' calculations based on data from the London Bullion Market Association and University of Michigan, *Surveys of Consumers*.

Multiple Regressions

Comparing Figures 1–3 reveals that the key factors driving gold price variation often move together. For example, the rather steady rise in pessimistic expectations (Figure 3) between 2001 and 2012 matches a persistently falling real interest rate over the same period (Figure 2). To disentangle the roles of the various factors over time, we perform multiple regressions.[7] Our regressions provide a simple econometric evaluation of the contribution of our three key factors to the time-series variation in the real gold price over the period 1971–2021. In addition, we show that one additional factor proxied by real world or U.S. gross domestic product (GDP) plays an important role in accounting for the long-run trend in gold prices.

We begin with regressions that explain the association between the average annual log level of real gold prices and four variables, also at the average annual level: 1) the real U.S. dollar value of world GDP provided by the World Bank, 2) the expected ten-year real interest rate computed as the nominal ten-year U.S. Treasury yield minus the Federal Reserve Board's *PTR*, 3) *PTR* itself, and 4) the fraction of the Michigan survey's participants expecting largely bad economic times over the next five years (*i.e.*, the pessimistic expectations variable). These regressions highlight the sources of longer-term variation in the level of real gold prices over the past half century (see Figure 4). Although we find this exercise to be the most revealing about the basic historical movements of gold prices, the sample is not large and, more importantly, the degree of persistence in the error term is substantial, as indicated by the relatively low Durbin–Watson statistic of 0.98.[8] The second regression exercise (whose results are reported in Figure 5 on the next page) uses essentially the same variables; but instead of looking at levels, it looks at the relationship between the log *change* in the real gold price and *news* about the explanatory variables using quarterly data. Finally, we conduct a limited investigation using daily data (whose regression results are reported later in the paper in Figure 6). The precise variables discussed here are not available at the daily frequency. However, we can investigate the roles of expected real rates and expected inflation using daily data on Treasury Inflation-Protected Securities (TIPS) and break-even inflation rates[9] relative to nominal Treasury yields. In these three exercises, as in all regressions on nonexperimental data, it is important to repeat the usual caveat that the statistical analysis reveals correlations in the data but does not in itself establish causality. The extent to which such regressions go beyond mere association depends on the "reasonableness" of the coefficients (see note 7) and, in short, the ability to "tell the story" that goes with the regressions.

Figure 4
Factors Influencing Annual Real Gold Prices, 1971-2019

	Log (real gold price)
Log (real world GDP)	1.125* (0.105)
Ten-year Treasury yield – *PTR*	–0.131* (0.022)
PTR	0.365* (0.033)
Pessimistic expectations	0.012* (0.004)
Constant	–35.588* (3.329)
R-squared	0.87
Durbin–Watson statistic	0.98

*Significant at the 1% level.

Notes: Standard errors are in parentheses. The standard errors have been corrected for serial correlation using the Newey–West method. See the text for details on the real gold price, real world gross domestic product (GDP), real ten-year Treasury yield, *PTR* (a measure of the ten-year inflation expectation), and pessimistic expectations (based on University of Michigan survey results).

Sources: Authors' calculations based on data from the London Bullion Market Association, World Bank, Board of Governors of the Federal Reserve System, and University of Michigan, *Surveys of Consumers*.

Figure 4 shows the annual regression results. The real-world GDP measure, which comes in highly significantly, reflects the fact that the demand for the services of gold and the demand for other goods increase together, approximately one-for-one in percentage terms. The estimated coefficient on the ten-year Treasury yield minus *PTR* indicates that a percentage point rise in the long-term real interest rate lowers the real gold price by 13.1%. *PTR* has an additional effect over and above its presence as a component of the real rate—and indeed this is far stronger quantitatively. Given the long-term real interest rate, an extra percentage point of ten-year expected inflation raises the real gold price by a hefty 37%—well in line with the long-held "inflation hedge" view. Finally, evaluated at the mean of 0.46, a one standard deviation increase in the fraction of pessimistic survey respondents (8.1 percentage points) raises the gold price by 9.7%.

Figure 5
Factors Influencing Changes in Quarterly Real Gold Prices, 1971:Q1-2021:Q1

	Δ Log (real gold price)
Innovations in log real U.S. GDP	0.395 (0.625)
Innovations in (ten-year Treasury yield – *PTR*)	–0.034* (0.011)
Innovations in *PTR*	0.010 (0.044)
Innovations in pessimistic expectations	0.005* (0.001)
Constant	0.010 (0.006)
R-squared	0.12
Durbin–Watson statistic	1.91

*Significant at the 1% level.

Notes: Standard errors are in parentheses. See the text for details on the real gold price, as well as the VAR (vector autoregression) innovations in log real U.S. gross domestic product (GDP), real ten-year Treasury yield, *PTR* (a measure of the ten-year inflation expectation), and pessimistic expectations (based on University of Michigan survey results).

Sources: Authors' calculations based on data from the London Bullion Market Association, U.S. Bureau of Economic Analysis, Board of Governors of the Federal Reserve System, and University of Michigan, *Surveys of Consumers.*

For Figure 5, we shift our focus to quarterly data. Here the conceptual experiment is to ask how *news* about the explanatory variables is reflected in contemporaneous changes in the log real gold price. In addition to the markedly reduced concern about serially correlated errors, this has somewhat more of a causal feel than the levels regression in Figure 4, although the coherent story told by the levels regression gives it more economic credibility than it would have on its purely econometric merits alone. For the exercise whose results are reported in Figure 5, we replace the world output series with real U.S. GDP, in logs, given that our world GDP series is only available annually. The news variables are constructed by running four predictive regressions—collectively called a vector autoregression (VAR)—on the explanatory variables; the *innovations* from this VAR constitute the news (or surprise) component of the key explanatory variables.[10] A 1% innovation in log real U.S. GDP is associated with a rise in the real gold price of 0.4%, substantially lower than the 1.1% value in the first row in Figure 4, although in Figure 5 the coefficient is very imprecisely estimated (indeed not statistically significant). A 1 percentage point innovation in the expected ten-year real interest rate (the nominal yield on ten-year Treasury securities minus *PTR*) is associated with a 3.4% reduction in real gold prices. In striking contrast with the result in Figure 4, after accounting for the real interest rate, innovations in *PTR* play no significant role in the gold price. The coefficient on innovations in the pessimistic expectations variable appears small, but this is deceptive because of the large units in which the pessimistic expectations variable is measured, as well as the large variation in this variable over time. A 10-percentage point innovation in the fraction of survey participants who expect the next five years to constitute mostly bad times raises the real gold price by 5%. Because the pessimistic expectations variable repeatedly reaches lows of about 30% and highs of 60%, over the entire sample it drives substantial fluctuations in the real gold price.

Finally, we do a limited exercise using daily data and report the results in Figure 6 on the next page. Because the CPI is published only monthly, the dependent variable is the daily change in the *nominal* gold price. This is less problematic than it may at first appear because if we could observe daily changes in the overall price index, they would be at least two orders of magnitude less than the corresponding changes in the highly volatile nominal gold price. Of the independent variables we study in this article, only measures of the real yield on long-term Treasury securities and expected long-term inflation—in this case taken from the TIPS market—are available at a daily frequency. However, we regard this as useful for two reasons. First, the regression is run on the daily differences in the log nominal gold price; innovations in real GDP or pessimistic views on the next five years are likely to be essentially constant at this frequency. Second, the roles of expected real interest rates and inflation have been our most central theme (as evidenced by the coefficients in Figures 4 and 5), and we have the data to obtain at least some evidence on these at the daily frequency. Since the variables are in differences, which are quite noisy, the R-squared, which measures the fraction of the variance of the dependent variable that is explained by the regression, is only 0.012. Yet, there are valuable lessons in this exercise. First, the negative effect of the real interest rate on the gold price—the proposition that comes most directly from economic theory—is once again confirmed. Hence, it has been shown to hold in annual levels, quarterly innovations, and daily differences. Second, the observation that the inflation effect is quantitatively much larger than the real interest rate effect holds here, as was the case in the levels regression of Figure 4, though contrary to the innovations regression of Figure 5.

Figure 6
Factors Influencing Changes in Daily Nominal Gold Prices, January 7, 2003–February 12, 2021

	Δ Log (nominal gold price)
Δ TIPS yield	–0.011* (0.004)
Δ Break-even inflation rate	–0.027* (0.005)
Constant	–1.71E-05 (2E-04)
R-squared	0.012
Durbin–Watson statistic	2.11

*Significant at the 1% level.

Notes: Standard errors are in parentheses. TIPS means Treasury Inflation-Protected Securities. See the text for details on the break-even inflation rate.

Sources: Authors' calculations based on data from the London Bullion Market Association and Board of Governors of the Federal Reserve System.

Conclusion

We have investigated several hypotheses about the determinants of gold prices—in annual levels data, quarterly data in innovations form, and daily data in differences. The negative effect of real interest rates on gold prices predicted by theory holds in all three contexts. Two of the three specifications (the quarterly innovations specification being the exception) support the notion that gold is an inflation hedge and that this effect is quantitatively larger than the real interest rate effect. The two specifications that can be used to evaluate the proposition that gold prices also reflect protection against bad economic times are highly supportive of it. In the early part of the sample, variation in inflation or inflationary expectations was the single most important consideration for the real price of gold. From 2001 on, however, long-term real interest rates and pessimism about future economic activity appear as the dominant factors. While disinflation since 2001 might have been expected to result in low gold prices, any effect of low inflation was more than compensated for by unprecedentedly low long-term real interest rates and by pessimism about future economic activity.

Endnotes

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1 The Bretton Woods system—which pegged the U.S. dollar price of gold and, for the most part, fixed ratios between gold and the other main currencies—collapsed in stages because of inherent contradictions in the design of the system. In 1971, the U.S. Gold Window was closed and the fixed price of gold vis-à-vis the dollar ended. We thus begin our sample in 1971. For a full explanation, see Bordo (2017).

2 *PTR* is from the Federal Reserve Board's FRB/U.S. model's database; see note 4 of Roberts (2018).

3 Further details on the U.S. disinflation period of the early 1980s associated with former Federal Reserve Chair Paul Volcker are in Bordo and Orphanides (2013).

4 This idea manifests itself in at least two ways. First, for the owner of a gold mine to be indifferent between keeping gold in the ground on the one hand and mining it and investing the proceeds in financial assets on the other, the price must be expected to rise at the rate of interest. Given an appropriate terminal condition, the higher the expected real interest rate, the lower the initial price would have to be. A second approach would be to imagine that gold provides some service flow (*e.g.*, its value as jewelry). The present value of that "dividend stream" depends inversely on the real interest rate.

5 This is in contradiction with Barsky and Summers (1988), who found a strong negative correlation between the real gold price and their measure of the real interest rate, particularly over the period 1973–82; rather than using survey-based inflation expectations, they used a statistical model of inflation that was more sensitive to current inflation and thus provided a quite different series for expected long-term inflation.

6 The full Michigan survey questionnaire is available here: https://data.sca.isr.umich.edu/fetchdoc.php?docid=24776 (as of July 16, 2022.)

7 Multiple regressions are statistical exercises estimating the effects of several independent variables on a dependent variable. Each regression coefficient represents the mean change in the dependent variable for a one-unit change in the independent variable while holding constant the other independent variables.

8 The Durbin–Watson statistic—which measures the degree of persistence or serial correlation in the residuals (differences between the observed values and the values predicted by the regression model)—takes on a value close to 2 in the ideal case where the residuals are serially uncorrelated. A value close to zero indicates that the errors are so persistent that the regression is "spurious" (uninterpretable and effectively meaningless). The Durbin–Watson statistic of 0.98 in the current regression exceeds the level at which the regression would be regarded as spurious but raises some questions about how well specified the regression is—an issue largely addressed by the innovations formulation in Figure 5. In addition, the standard errors of the coefficients in Figure 4 have been corrected for serial correlation as indicated in that figure.

9 The TIPS yield, as noted on the Federal Reserve Board's website, https://www.federalreserve.gov/data/tips-yield-curve-and-inflation-compensation.htm, is a real rate. The break-even inflation rate is the one that would in principle make a risk-neutral investor indifferent between holding a nominal Treasury security and a TIPS of the same duration. It is often regarded as a measure of inflationary expectations at the relevant horizon.

10 A VAR is a statistical model used to capture the dynamic relationship between two or more time-series variables; in a VAR, each variable is a linear function of past lags of itself and past lags of the other variable(s). In a VAR context, an innovation is the difference between the observed value of a variable at a particular point in time and the optimal forecast of that value based on information available before that point in time.

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Assessment of Cryptocurrency Risk for Institutional Investors

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Introduction

Since the circulation of the original Bitcoin white paper in 2008, the value of all cryptocurrencies has risen to exceed one percent of all traded wealth. In recent months there have been large variations in the values of major cryptocurrencies like Bitcoin and Ethereum, in addition to frequent massive shifts in the values of lesser known cryptos. The institutional landscape continues to evolve rapidly with firms like Goldman Sachs and Fidelity setting up trading facilities, while other organizations like HSBC have steadfastly advised clients to keep away from crypto. A useful overview of the current state of play appears in Horne (2021). Irrespective of intrinsic or extrinsic value, we expect that such items will be present in institutional investor portfolios from time to time.

As such it is necessary to have methods in place to assess the risk of holding cryptocurrencies and the incremental impact of crypto holdings on overall institutional portfolios. The main portion of our proposal focuses on key building blocks for understanding the risk of cryptocurrencies and *what magnitude of return expectations would justify those risks for a typical investor*. Our process involves both historical and forward-looking information, as well as several nuances in the statistical estimation of a covariance matrix (within crypto and between crypto and other assets).

An additional feature is a means to incorporate "tail risk" as might arise from geopolitical events (being outlawed or severely regulated) and operational risks (*e.g.,* theft, loss of private keys) based on use of mixture distributions and the method of Cornish and Fisher (1938). This relevance of tail risk is motivated by real world events such as the aggressive regulation of crypto activities by China and other countries, and the persistent occurrence of large hacks (*e.g.,* Poly Networks in August 2021) wherein losses of a half billion dollars or more are almost ordinary.

While the emergence of cryptocurrencies has led to numerous working papers within the academic community, we draw attention to Alexander and Imeraj (2019), which addressed the empirical volatility of major cryptos as being on the order of 80% annualized. Schwenkler and Zheng (2020) identify pairwise covariance structures in the behavior of cryptocurrencies, which they ascribe to news coverage. The classic work of Hotelling (1929) also offers a relevant foundation given that a major purported benefit of cryptocurrencies is their built-in limitation of a finite supply (at least for each individual cryptocurrency).

Analytical Method for Market Risk

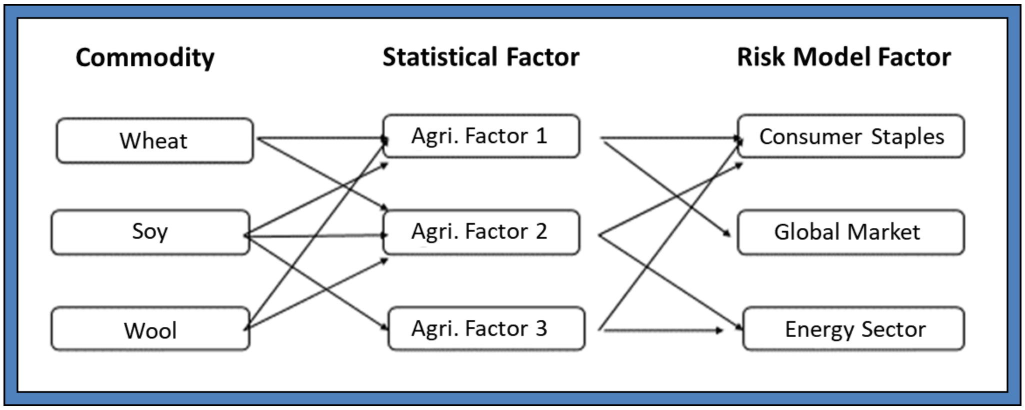
Our coverage of cryptocurrencies is closely related to the methods we routinely use for commodities and fiat currencies of frontier market countries. For fiat currencies, we create groups of currencies based on geographic proximity, trade relations, and cultural similarity. A similar grouping concept is used for cryptos. The grouping scheme allows us to build principal component factor exposures for crypto currencies, which are then mapped onto existing risk model factors for non-crypto assets.

The first step is to use a principal component analysis (PCA) of one or more groups of crypto assets to estimate statistical factors that are common drivers of observed returns. These factors may be difficult to identify and may change over time. PCA is a traditional way to deal with such situations which generates factors based on the covariance matrix of the asset returns themselves. In the usual manner of a statistical risk model, we keep the statistical factors which contribute the most to variance and dismiss smaller ones as representing noise. A useful model for drawing the line between PCA factors and noise is presented in Laloux *et al.* (2000).

Once the statistical factors for a sample period have been identified, the second step maps the statistical factors onto existing factors in other models to determine the correlations between a crypto asset and traditional assets. A general discussion of factor modeling methods is in diBartolomeo (2014).

To keep the model parsimonious and to try to avoid overfitting, the number of identified factors onto which each statistical factor is mapped should be limited. One does not know the nature of statistical factors: hence one does not know which risk model factors are most likely to be relevant to it. To select among traditional risk model factors in a systematic fashion, a cross validated LASSO regression is used. This procedure automatically drops factors which do not add to the explanatory power of the model for cryptocurrencies, while simultaneously shrinking remaining risk factor loadings towards zero to combat overfitting. An illustration of the same process applied to commodities is presented in Figure 1 on the next page.

Figure 1
A Conceptual Diagram Illustrating the Stages of Our Modeling Process



Preliminary results show that PCA in this case picks up a crypto "market" factor which loads positively on all the major cryptocurrencies. Subsequent statistical factors tend to reflect the movement of cryptocurrencies around this market factor. These statistical factors can then be mapped onto our risk model with the LASSO regression. Some unique challenges are presented in this case by the very short history of most cryptocurrencies. One simple approach is to take Bitcoin as an indication of the crypto market and use traditional regressions to estimate "beta" to Bitcoin as a metric of risk for small cryptos that cannot be included in the original PCA cohort.

Table 1

	Statistical Factor 1	Statistical Factor 2	Statistical Factor 3
Bitcoin	0.33	-0.01	0.40
Ethereum	0.44	0.10	0.39
XRP	0.46	0.32	-0.78
Cardano	0.53	0.35	0.24
Binance Coin	0.44	-0.87	-0.15

An example result for five cryptocurrency loadings on statistical factors for a single time period is presented in Table 1.

Besides defining the cohort set, the statistical process for cryptocurrency must account for several uncommon features. The first is the very large departure from our usual independent and identically distributed (IID) return assumptions. Cryptocurrencies have exhibited high degrees of skew, kurtosis, and serial correlation in their returns. These behaviors may arise from speculative interest from retail investors, the erratic nature of interest from major financial institutions, or fear of cryptocurrencies being severely hampered by regulation (as seen in China).

With respect to non-IID behavior we employ four analytical nuances to improve the transformation from purely historical observation to forward-looking risk forecasts. The first is the use of "root mean square" (RMS) rather than standard deviation as the measure of dispersion of factor returns. We are treating factor return time series as if markets are relatively efficient so mean returns to a factor should be close to zero, rather than whatever time series mean is observed. For example, a return time series that goes up 10% per month every month for two years (as was roughly observed with Internet stocks in the late 1990s) would have a standard deviation of zero but a significant value for root mean square.

The second technique is the idea of "range based" volatility measures, also replacing the usual definition of standard deviation of returns. One way to think about the volatility of an asset is to consider the percentage distance between the highest and lowest prices observed during a particular period (*e.g.,* day, month, year). If the high and low prices are close together, the asset has low volatility. If the high and low prices are far apart, the asset is volatile. Several papers starting with Parkinson (1980) have shown that if returns are IID, there is a direct algebraic transformation between traditional return volatility and range-based measures. A very simplified range based measure of volatility would just be (high - low)/(high + low). For example, if we observe that a cryptocurrency had a low price of $1000 and a high price of $3000 over the past month, we get a volatility of *50% per month*.

The third proposed input to *ex-ante* currency risk estimation is the availability of a "carry trade" wherein bank deposits denominated in a particular currency offer higher interest rates than in major currencies. As cryptocurrency deposit accounts do not carry any form of government deposit insurance, the risk of counterparty failure is substantial. As of the writing of this article, retail "Bitcoin savings accounts" are available with yields over 8% annually, as compared to close to zero for ordinary bank accounts in the U.S.

Our final key input is the concept of "convenience yield." The anonymity and ease of global transactions has material economic value to certain market participants (criminals, tax evaders, investors in countries with capital controls). While this effect is hard to quantify directly there is a long history of low or negative interest rates in countries with strong banking secrecy laws. In the 1980s Swiss banks routinely offered negative interest rates on deposit accounts while U.S. banks were offering a rate of around 5% (the maximum allowable under Federal Reserve Regulation Q until 1986).

At the current time the combination of convenience yield and interest premium is probably around 12-13% which implies a volatility equivalent (*i.e.,* inclusive of higher moments) of 70-80% annually for major cryptos. For a derivation of this relationship see diBartolomeo (2020), which is an extension of Litzenberger and Rubinstein (1976) and Wilcox (2000 & 2003). There is also a thinly traded Bitcoin Volatility Index (BVOL) whose value has ranged from a low of around 19% to a high of 188% annualized. As of this writing, the BVOL value was 79.3%.

Modeling Event Risk

In addition to large scale thefts and the possibility of being outlawed in some countries, there have been many cases of lost computer files, passwords known only to a decedent, and other means creating situations where cryptocurrencies are inaccessible to the rightful owners. There have been successes by law enforcement or quasi self-regulation in recovering significant amount of stolen crypto as in the

Colonial Pipeline case and the recent seizure of purportedly stolen crypto valued at $3.6 billion by the U.S. Department of Justice. Perversely this trend may decrease the acceptability of cryptocurrencies among participants seeking anonymity decreasing the "convenience yield" premium in crypto valuation into question. On the other hand, the East Caribbean Currency Union is the first central bank to issue a blockchain based, central bank digital currency (CBDC), and other countries are exploring or have launched pilots. In addition, El Salvador has recently recognized Bitcoin as legal tender.

To provide a framework for modeling such event risks, we propose a simple two state model. In one state, there is an event risk incident with probability P, and an expected return (loss) L with standard deviation S0. In the other state, there is no operational risk incident with probability (1-P), but there is market risk with expected return E and volatility S. We combine the two states into a single distribution using a "mixture of normal distributions" process. See Robertson and Fryer (1969). The resultant combined distribution will have four moments with negative skew and positive excess kurtosis. We use the aforementioned method of Cornish and Fisher to convert to the closest fit normal distribution.

As an example, we can assume our "regular state" has .999 probability per day with a daily volatility of 5% and an expected arithmetic return of .1% per trading day. The "incident" state has a probability of .001 per day. We assume that in the event of an incident, the expected loss is 80% with a standard error of 3%. Including both market risk and "event" risk we get a combined equivalent daily volatility of 9.08%. Annualizing under IID assumptions we get 144% per annum. It should be noted that if we cut the incident probability to .0001, we get a volatility of 5.07% per trading day, just a tiny bit higher than with a zero probability of an incident.

Stablecoins

A sidelight to the cryptocurrency discussion is the matter of "stablecoins" like Tether where a coin issuer functions like an 18th century bank issuing its own currency. Commercial banks in Hong Kong and Scotland still routinely issue their own "bank notes." To stabilize the value of cryptocurrencies at a relatively fixed value in U.S.$ (like a pegged currency), the "custodian" holds financial reserves that purportedly assure that the stablecoins have a claim on assets that can be converted to conventional currency.

However, experts including Gary Gorton of Yale have questioned the validity of the collateral in these structures (Coy, 2021). Lacking complete confidence in the collateral, we can treat this concern as we would counterparty risk in an over-the-counter (OTC) derivative acting in reliance on a clearing organization for sound collateral management, or a recognized credit rating for the counterparty.

Liquidity as the Risk Mitigation Method

On an annualized basis, the return volatility of cryptocurrencies looks enormous (80% for the majors, far higher for many of the less known). Investors are depending on high liquidity to allow them to exit an asset quickly to limit losses. Under typical IID assumptions, 80% per annum is about 5% per trading day, so a three standard deviation event is a 15% loss per trading day. Even if we "fatten the tails" consistent with a t-5 distribution, we end up around a 20% loss.

However, it should be noted that liquidity is not infinite for any asset. On October 19, 1987, the U.S. stock market lost $1 trillion in capitalization (a roughly 22% decline) when the New York Stock Exchange (NYSE) Designated Order Turnaround (DOT) execution system got overwhelmed. This massive decline was the result of only *$15 billion in trading volume*. While the core blockchain capacity for Ethereum was significantly upgraded in 2021, crypto transactions done on "Decentralized Finance" peer-to-peer networks are highly vulnerable to disruption which could lead to extreme cases of "jump diffusion" in prices.

Conclusions

Our proposed analytical process for crypto risk is closely related to our current practices for commodities and frontier currencies. This process makes for relatively simple integration with risk models for other asset classes.

The assessment of volatility and market risk is highly dependent on a nuanced understanding of the extent of non-IID returns with unstable means. If we include operational risk, the resultant volatility estimates are extremely sensitive to the probability of an "incident." Even seemingly low probabilities like 1 in 1000 create a profound increase in volatility equivalence and related risk metrics (*e.g.,* Value at Risk).

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Dr. Thomas Blackburn has worked in the finance industry since 2014, after receiving his Ph.D. in Physics in 2013. After an internship at Northfield Information Services, he worked at BNY Mellon and then State Street from 2015-2019. He has since returned to a Northfield as a senior risk analyst.

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Dan diBartolomeo is the founder and president of Northfield. He is a board member of several industry professional associations. diBartolomeo spent several years as a Visiting Professor at Brunel University. In 2018 he became co-editor of the *Journal of Asset Management.*

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William Zieff is a Director at Northfield Information Services. He has extensive experience in quantitative investing. Prior to Northfield, Zieff held senior roles at Wells Fargo, Putnam Investments, and Grantham, Mayo, Van Otterloo. He has taught Master's and undergraduate degree quantitative finance at major universities. Zieff holds a degree in Economics and Mathematics A.B. from Brown University and an M.B.A. from Harvard Business School.

The Problem of Widespread "Basis" and "Flat Price" Risk in Agricultural Commodity Markets

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Stable's research covers the widespread issue of "basis" and "flat price" risk within the agricultural commodities sector. This article defines the term "basis" to describe the difference between a cash market price and the corresponding futures market price with "flat price" risk defined as the risk where the market operator is exposed to the full spot price of a commodity. The article drills into the level of coverage that liquid futures contracts offer in the agricultural commodity markets and highlights the shortcomings in the sector. Overall, Stable finds that only 16% of global agricultural commodity markets are covered by liquid futures markets. This provides a significant issue for risk management in the sector with widespread "basis" and "flat price" risk occurring. A case study on the organic corn market highlights the challenges of price risk management in a relatively new product within the market where no exchange-traded contract exists. This is in contrast with the conventional corn market, which has some of the most established futures contracts in the agricultural commodities sector. Another case study examines the recent price volatility in beef, which was caused by plant closures during the COVID-19 pandemic. The move in prices has disrupted the once tightly knit relationship between the Chicago Mercantile Exchange (CME) live cattle futures and the price of beef, leaving industry participants without a suitable hedging tool for their price exposure. Stable concludes that the market is in need of a modern, targeted solution for the age-old problem of "basis" and "flat price" risk within the agricultural commodities sector. Stable is working hard to find a lasting solution to this issue for the industry.

Introduction

The definition of the term "basis" in academic literature can vary widely across asset classes. In the commodities sector, the term is commonly understood as the difference between a cash-market price and the corresponding futures market price. The risk of basis can be caused by unforeseen fluctuations in the cash-market price versus the futures price and is therefore an inherent challenge within risk management strategies. In addition, within the agricultural commodities space a number of markets operate without any form of liquid futures markets. This leads to another type of price risk, which is described as "flat price" risk. In this article, we highlight the definition of "basis" risk within the agricultural commodity sector and identify markets where "flat price" risk is most prevalent. We then highlight two markets where arguably both "basis" risk and "flat price" risk exists: organic corn and cattle & beef.

The views expressed in the *GCARD* are those of the individual authors.

Defining “Basis” Risk in Agricultural Commodities

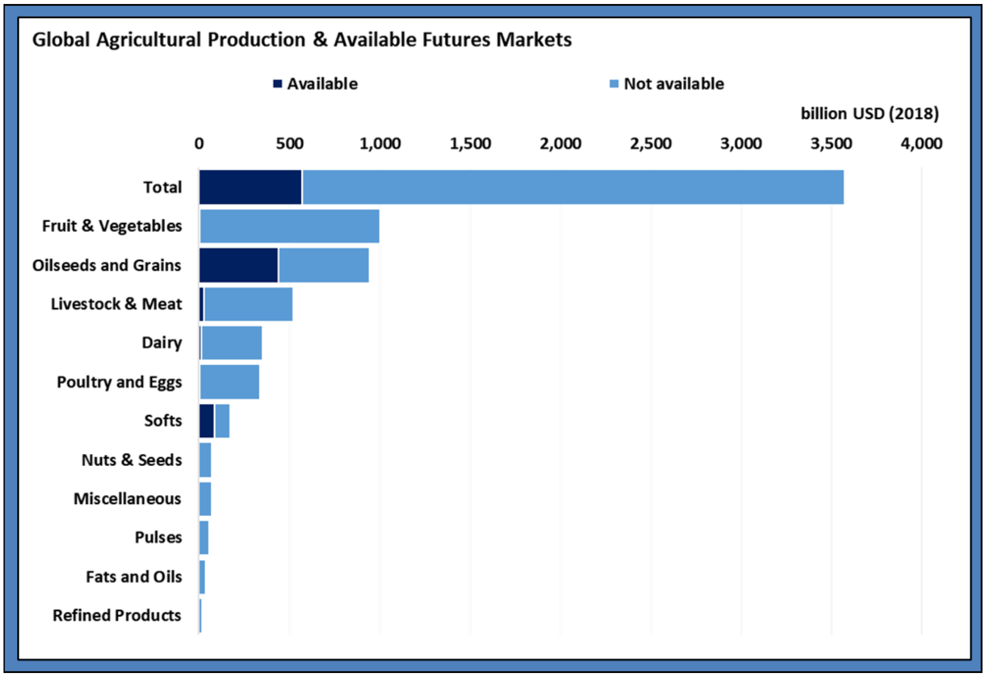
We can make a distinction between at least four types of “basis” risk occurring commonly in agricultural commodity markets. These center around four primary differences between the cash price and the futures price: specification, time, location and price movement. The first of these is “product quality basis risk,” which occurs when there are differences in grade, quality, or other specifications from the standardized futures contract specification. The second of these is “calendar basis risk,” which arises when the delivery date of a local cash trade differs from the expiration of the futures market contract. “Location basis risk” occurs when the underlying asset’s point of sale differs from the futures market delivery point, resulting in a difference in logistics costs. Lastly, “price basis risk” occurs when a cash price does not move in conjunction with the corresponding futures market price, which can occur when there is a difference in information flow or price reporting frequency.

Managing the exposure to these types of “basis” risk is particularly challenging in agricultural markets. There is high variability among product specifications; and due to many producing and consuming regions having restricted access to global flows, a significant portion of agricultural commodity trading happens on a local basis. These factors mean that many agricultural commodities can have exposure to one, or even all four, of the listed types of basis risk. This can cause a significant level of volatility in the basis values and create difficulty hedging these products on liquid futures exchanges.

Outside of Futures Markets

The definition of “basis” risk includes those markets that have relevant liquid futures markets available for hedging purposes. Liquid futures exchange contracts, however, are not available in all commodity markets. According to Stable’s research, currently only 16% of the value of global agricultural production is covered by operational futures contracts. This is calculated by matching relevant products and futures markets based on product specification, factoring in traded volumes. This means that there are a wide number of agricultural markets where there are no futures market hedging options available to market participants. The risk when exposed to the absolute price of a commodity is described as “flat price” risk. As per Stable’s research, the greater part of the world’s agricultural commodity markets is fully exposed to price volatility, and therefore “flat price” risk is widespread.

Figure 1
Global Agricultural Production & Futures Markets Scope for Hedging



Sources: Stable Research, Food and Agriculture Organization (FAO) of the United Nations, and Bloomberg.

In terms of futures contract coverage by sector, the oilseeds and grains markets have the highest coverage with 46% of the global value of production covered by futures contracts. This is closely followed by the softs sector, which is made up of sugar, cotton, cocoa and coffee, with over half of the production value covered by liquid futures contracts. Outside of these markets, however, in the meat and livestock, dairy and fresh produce markets, very little coverage exists in the form of futures contracts. These markets have obstacles such as a lack of product standardization and storage restrictions, which could make launching futures contracts challenging. Within these markets, the primary risk management tools available are bespoke, often costly and imperfect solutions, such as cross-hedging, over-the-counter products and long-term physical contracts.

Established Product, New Approach - The Case of Organic Corn

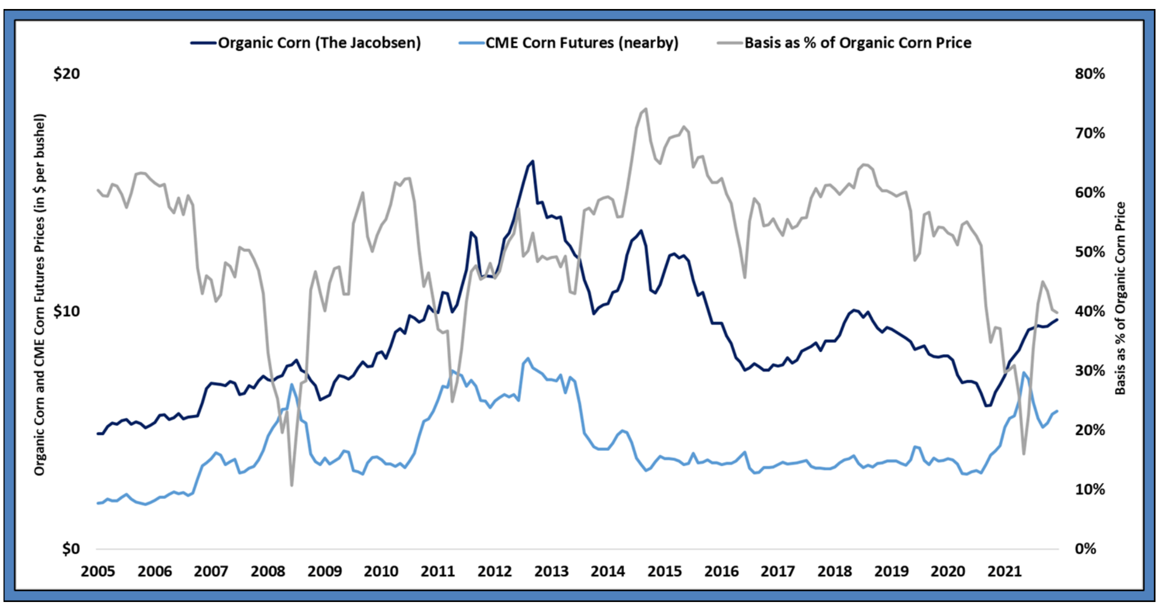
In some markets, despite there being a long history, new farming practices can emerge and lead to a significant level of both "basis" risk and "flat price" risk between physically identical products. After being domesticated over 7,000 years ago, corn has developed into one of the most important crops globally (Pruitt, 2016). Conventional corn markets are well-established and sophisticated with futures contracts in the U.S. originating in the 19th century (CFTC, 2022). Organic corn, on the other hand, is a relative newcomer. Although traditional farming practices—almost by definition—go way back, the organic space began emerging in the 1930's in response to synthetic fertilizer production after the First World War (Kuepper, 2010). Increasing organic demand through the sixties and seventies encouraged a more sophisticated marketplace with longer supply chains. And third-party organic certification arrived in 1973 (in California), primarily regulating against the use of synthetic fertilizers and pesticides (Lotter, 2003).

Despite organic and conventional corn being physically identical, they are to all intents and purposes completely separate markets. The main reasons for this are the criteria for certification, which, among other things, require a three-year transition period during which yields suffer without an organic premium to compensate (USDA, 2022). This produces an economic hurdle for farmers wanting to expand their organic area. Moreover, it is a disincentive to convert acreage back to conventional use. More recently, between 2008 and 2019, the U.S. organic corn area grew 7.5% annually to reach 319,953 acres harvested with the number of operations increasing by 89%, according to the United States Department of Agriculture's (USDA's) National Agricultural Statistics Service. The 2016-2019 period alone saw production expand by a further 50%.

Alternative Farming Practices, Conventional Hedging Tools

As the market develops over time, so too should concern over the lack of suitable price risk management tools. The nearest hedging option to those in the organic corn space are conventional corn prices, which the United States Federal Crop Insurance Corporation uses as a benchmark for coverage programs. Conventional futures (such as those offered by the CME Group) are occasionally traded by organic market participants, but the strategy is arguably ill-advised.

Figure 2
Organic Corn versus Conventional Corn Price Difference



Sources: The Jacobsen[1], the CME Group, and Stable Research.

The "basis" between the two corn market prices, or in this case the organic premium, can vary substantially. Recent years' price movements illustrate their separation and the "basis" risk inherent when cross-hedging with corn futures. The 2016-2020 period saw conventional prices flatline while imbalances in the organic sector resulted in price volatility. More recently, conventional corn prices spiked due to, among other things, strong Chinese demand, a poor Brazilian harvest and drought impacting major competing markets. While organic corn prices rose during this time, they did not jump nearly as much and were insulated from co-movements in other sectors. This resulted in the organic premium almost disappearing entirely in May 2021, which is significant considering organic corn prices were three times those of conventional corn a few years earlier.

Methods in the organic grain space may compound the above concerns. Organic corn farmers in the Midwest are usually wedded to a rotation, most often with hay, and rarely exceeding two years of corn in any four years (Brock *et al*., 2021). While it is true that conventional corn is often rotated, synthetic fertilizers offer more flexibility to react to market prices – as the perennial focus on the corn/soybean ratio might suggest. This is also evidenced by empirical work highlighting negative cross-price elasticities of conventional U.S. corn and soybean acreages in the short run (Kim and Moschini, 2018). Without the ability to hedge effectively, more rigidity in organic practices can increase risk at the farm level. It may also lengthen bullish or bearish price trends in organic markets. Compared to a more flexible and mean-reverting conventional space, such differences should provide caution for those considering a cross-hedge between these separate markets. They may look the same; they may taste the same; but in both price and practice they are not the same.

Butchering the Term “Basis”: The U.S. Cattle and Beef Markets

Although the traditional definition of “basis” is outlined in the first section of this article, there are examples when the term is used for the difference in price between two related products. In the case of the livestock and the meat industry, “basis” is used as a way to describe the relationship between the price of the animal and the price of the meat that it produces. While a futures contract exists for live cattle futures on the CME, no futures contract exists to directly manage price risk for the boxed beef cutout. With no clear-cut risk management tools available, market participants who are exposed to the price of beef could face significant levels of “basis” risk to the CME cattle futures, or perhaps pure “flat price” risk exposure to beef prices.

Typically, participants manage risk in a variety of ways from strategically timed procurement decisions (sometimes storing the product in a freezer until needed) to agreements between the buyer and seller to purchase set volumes at set prices over a period of time. In some cases, participants will deploy imperfect cross-hedging strategies using existing futures products that are sufficiently correlated to beef prices (CME Group, 2020).

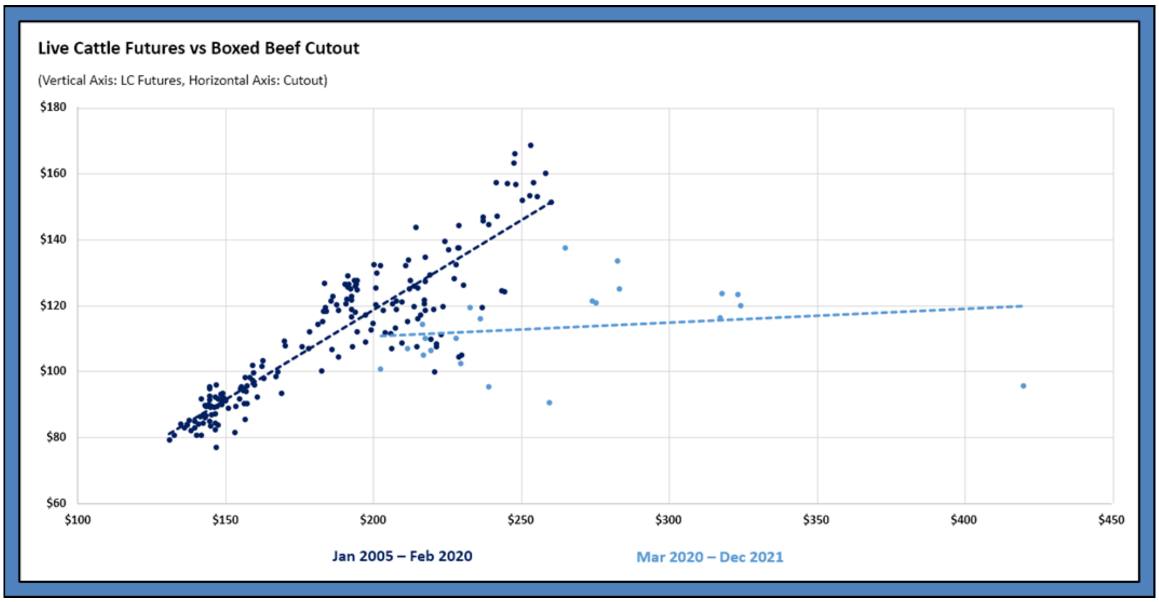
Over time, the literature around managing beef price risk with live cattle futures has shifted. While the argument originally suggested that using live cattle futures could be an effective hedging tool for hedging beef, recently consensus has switched to the contrary. Live cattle futures are now viewed as a relatively ineffective hedging tool for beef price risk, particularly when it comes to individual cuts of beef (Mattos *et al*., 2003). Despite this, there are those who still use live cattle futures to hedge the boxed beef cutout.

Pandemic Disruption Impacts the "Basis"

Recently, pandemic disruptions in the industry have rendered the use of live cattle futures as a beef price hedging tool even less effective. Fundamental disruptions in the market supply chain in the first half of 2020 caused the relationship between the beef and cattle price to breakdown.

Prior to March 2020, cattle and beef prices exhibited a reasonably correlated relationship that was periodically disrupted by short term, exogenous shocks. Indeed, the monthly correlation of live cattle futures and boxed beef cutout prices between January 2005 and February 2020 was over 90%. However, following the disruption of slaughter facilities during the pandemic, this relationship broke down. Between March 2020 and December 2021 the correlation fell to just 16%. Figure 3 shows the breakdown in this relationship.

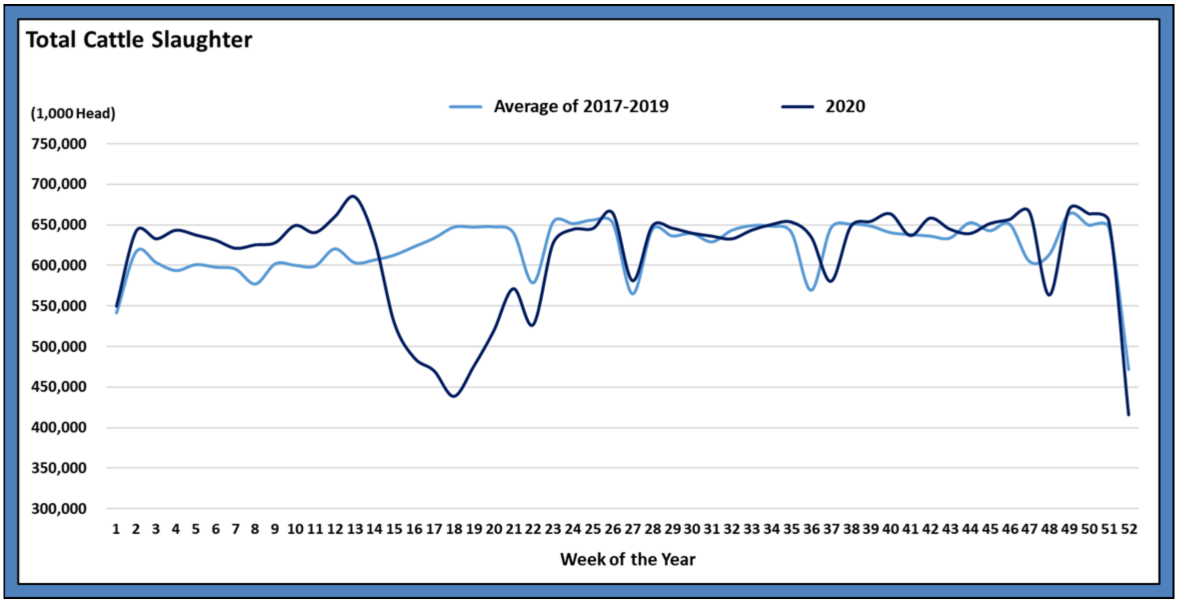
Figure 3
Live Cattle (LC) Futures versus Boxed Beef Cutout Prices (in $ per 100 pounds)



Sources: Stable Research, USDA, and the CME Group.

The breakdown in the relationship was fundamentally driven by disruptions in the meat packing and processing industry. Over the course of a few months in 2020, more than two dozen livestock processing plants closed due to issues related to COVID-19, for periods ranging from a few days to several weeks. In some cases, the closures were due to COVID-19 outbreaks among workers at the plants; in other cases, workers stopped going to work out of fear of catching the virus. This led to severely reduced capacity across many of the plants that remained open. Overall, processing capacity was reduced by more than a third from the end of March 2020 to the beginning of May 2020, when slaughter numbers hit their lowest levels. The USDA estimates that daily capacity at U.S. cattle and hog facilities declined as much as 45% at some points in May of 2020.

Figure 4
Total Cattle Slaughter: Same Period Comparison of 2020 versus Average of Previous Three Years



Sources: Stable Research and USDA.

The decline in slaughter capacity created a backlog of animals that would take months to work through. This was a particular challenge for livestock producers, who scrambled to slow the weight gain of animals already in the pipeline for slaughter. This capacity reduction created an oversupply of animals available for slaughter, driving the price of fed cattle down. The reduction in processing capacity not only impacted slaughter levels, but also reduced beef production. This restricted the supply of available beef on the market to fulfill existing orders. As a result, there was an even greater shortage of beef available on the spot market, which helped drive up the negotiated boxed beef cutout price.

This temporary shock breakdown in supply and demand and consequent price correlation illustrates the fragile nature of the use of hedging models for fundamentally different products. The "basis" or even "flat price" risk during this period would have become almost impossible to manage. Indeed, the beef market serves as an excellent example of a market that has lacked adequate tools to manage price risk in the past.

A Modern Solution to an Ongoing Problem

As evidenced by the two markets highlighted in this article, both "basis" risk and "flat price" risk are widespread throughout the agricultural commodities markets. The historic institutions of futures markets have stood for a long period to serve a number of markets with hedging solutions, and yet only serve just over 15% of agricultural commodities. This results in businesses in these markets relying on often imperfect solutions to preserve their crucial bottom line. This can mean relying on and hoping that historical correlations will hold true to future correlations, which can be destructive when these assumptions break down. As we have seen with both organic corn and cattle and beef, this can happen, resulting in unmanaged price volatility, causing problems for businesses throughout the commodities supply chain.

In short, to solve the problems noted in this article's case studies, our firm has created a 21st century solution to help manage agricultural commodity price risk. Our advanced technology enables us to deliver liquidity into commodities where no futures markets exist. We do this by offering our clients option-based contracts, with settlement upon 3rd party indexes that are tightly correlated to their price risk exposure. We complement cutting-edge technology with specialized market expertise to provide timely and accurate hedging solutions that enable our clients to minimize basis or flat price risk.[2]

Endnotes

1 The Jacobsen is the leading provider of organic and non-Genetically Modified Organism (non-GMO) grain prices globally.

2 We invite readers to visit www.stableprice.com to learn more about the risk management solutions that we provide.

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Paola Luporini arrived at Stable in 2021 to lead the building out of Stable's global fundamental supply-and-demand (S&D) balance sheets: mapping the global agricultural commodity markets through data and building the infrastructure for a 21st century technology platform. Previously she worked as a senior analyst at S&P Global Platts, with prior experience as a trader at Italpreziosi in the metals markets and Raizen, covering the sugar markets, in Sao Paulo.

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Sam Horsfield joined Stable in 2021 to build out Stable's understanding of the global grains markets, writing content and managing the global grains S&D and trade flow analysis. Previously Horsfield worked at Tesco as a Commodity Analyst in the oilseeds markets following the completion of a M.Phil. in Economics at Cambridge University.

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Sakshi Mehta works in Stable's research team in London, supporting the building of global fundamental S&D balance sheets and leading Stable's market sizing project. She recently received her Master's degree in Economics and Strategy for Business from Imperial College Business School, U.K., and has previous experience working at Ernst & Young as a Financial Service Risk Management Analyst.

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Having joined Stable 3 years ago, Joe Brooker leads the research team with a focus on sourcing price discovery in opaque commodity markets and expanding Stable's global fundamental market analysis to support the growth of Stable's products. Booker has previously been a senior sugar analyst at S&P Global Platts having started out at ADM in their London sugar trading team. Between those roles, he covered the research of the African sugar markets at ED&F Man.

The JPMCC gratefully acknowledges that on November 18, 2021, the Head of Commercial Development at Stable USA, James Sullivan, participated in a joint webinar held with the CU Denver Center for International Business, on "Emerging Technology in Global Commodities."

Interview with Sharon (Hyman) Weintraub

Senior Vice President, Gas and Power Trading International, *bp*

Sharon Weintraub, Senior Vice President for Gas and Power Trading International, *bp*, presenting at the International Petroleum and Natural Gas Enterprises Conference (IPEC) in Zhoushan, China. Weintraub is also a member of the JPMCC's Industry Advisory Council.

We are delighted to interview Sharon (Hyman) Weintraub, the Senior Vice President for Gas and Power Trading International within *bp*'s Trading and Shipping arm in London. Weintraub's career spans commodity derivatives trading, risk management, and chief financial officer duties in positions across the globe, including in Chicago, Houston, London, and Singapore. She is also a member of the JPMCC's prestigious Industry Advisory Council.

In our January 2022 interview, Weintraub describes her 30+ year career along with her view on the significant changes in the industry that have occurred during her career in the energy markets. She then discusses her current role at *bp* as well as some of the initiatives of the JPMCC's Industry Advisory Council. The interview concludes with her advice for students and young professionals interested in a career in the commodities and/or energy markets.

How did you get involved in the energy industry and how has your career evolved?

Oh, to cut a long story short: I have been working in trading for over 30 years and joined *bp* 17 years ago. Shortly after college graduation I was working for Continental Bank in Chicago (now part of Bank of America) in an analyst position. I was very fortunate that the Head of the Interest Rate Derivatives trading desk identified what he thought was the personality and capabilities to be a successful trader. He wanted to extend the bench into the energy markets and offer risk management products to the bank's customers, particularly as the energy markets were deregulating. Well, I jumped at the opportunity and over 16 years, I traded energies, base and precious metals as well as interest rate derivatives. As the banking industry consolidated, I felt the pull to New York if I wanted to advance in my trading career. Personally, my husband and I wanted to remain in Chicago so that is when I decided to give *bp* and the physical energy markets a shot. At the banks, I had been a financial trader and this shift would grow my skillset and understanding of physical oil and gas markets. So, I joined *bp* in the Finance & Risk organization, consciously stepping away from trading and onto the CFO track. Four years after joining *bp* in Chicago, I took up an opportunity to move to London to serve as the business lead for a major systems transformation project for the global oil trading business. If I had seen the job description, I probably never would have applied for the role, let alone make the move, but the business CFO really supported me and encouraged me to take the leap. That role propelled me into various risk roles and ultimately to CFO roles and expatriate assignments in all of *bp*'s global trading hubs and to my current role in leading gas and power trading and origination outside the Americas. The best part about having spent over 30 years in trading is that every single day is different and that's what makes it exciting.

The major event impacting the energy markets over the last couple of years has been COVID-19. What other events or issues may be on the horizon?

It is a pivotal time to be in the energy industry. I liken it to the dot-com era and start of internet businesses and the digital revolution of late 1990s/early 2000s. Navigating the world's energy transition is energizing and challenging, and the pandemic has only accelerated the drive for this change. The growth in renewables will impact the traditional hydrocarbon businesses in a variety of ways. Of late, hydrocarbons haven't been receiving the capital investment of years past, however hydrocarbons will be needed for years to come. Natural gas will play an important role in the energy transition, for example, as a means for managing intermittency from renewables growth. The sun doesn't always shine and neither does the wind blow all the time, so having other feedstocks – like natural gas – to manage the flexible generation required is important. Additionally, unlike oil and gas which can be stored and moved around the globe, power is difficult to store. Growth in technologies such as large-scale batteries will also be required over the coming years. Separately, the growth in bioenergy is tremendous, also supporting a lower carbon footprint. Biogas and biofuels such as sustainable aviation fuel are growing quickly. Finally, companies are looking to future fuels such as hydrogen and ammonia. This will require the regulatory environment to evolve, infrastructure investments and clarity for businesses to make commercial decisions Finally, none of this can be achieved without a focus on data and digitization.

How has bp's ambition for net zero by 2050 impacted your role within the organization?

As announced in 2020, *bp* pivoted our corporate strategy and committed to net zero by 2050, moving from an international oil company to an integrated energy company. Our new strategy is built around three pillars: (a) resilient and focused hydrocarbons, (b) convenience & mobility, and (c) low carbon energy. Hydrocarbons will be core to our strategy for decades to come, but we're focusing our hydrocarbon business on oil and gas that is cheaper to produce, resilient to the rising cost of carbon, and in line with our guidance of reducing production by around 40% by 2030. On convenience and mobility - *bp* sells fuels and convenience retail with over 10 million customer touchpoints. We want to double this part of our business over the next decade by expanding into new markets, such as in India, redefining our convenience offer, and building the best electric vehicle (EV) charging business with well over 10,000 charging points in some of the world's busiest EV markets – such as in the U.K., Germany and China. We're also working with some of the world's most exciting companies – like Didi, VW, Daimler and BMW – to give consumers a fast, convenient and affordable charging experience. On low carbon electricity and energy, we want to substantially grow our renewables business by the end of this decade and have already made considerable progress. We've grown our low carbon energy pipeline from 4 Gigawatts (GW) in 2019 to 21GW today. We're also growing our pipeline in solar, generating jobs, delivering electrons from renewable power across 12 states in the U.S., and adding offshore and onshore wind projects to our portfolio.

As Senior Vice president of Gas and Power Trading International, my commercial business is core to our net zero strategy. Trading and shipping serve as an integrator across the entire company from production whether molecules or electrons, from our own equity or merchant projects through to the customer demand. So, my teams are active across the entire value chain. We are actively growing our power trading business including in the U.K., Europe and Asia Pacific as well as our global liquefied natural gas (LNG) business.

What more could be done to bring more young women into the industry?

When I started in trading, I was one of the only females in a sea of men and I have experienced some biases. Additionally, I couldn't see what I wanted to be due to a lack of senior female role models. At *bp*, I'm proud to say that the culture has evolved over the years, and it's been an intentional shift and we are continuing to drive for progress. As an organization, we encourage our staff, men and women, to find more agile, flexible ways of working, because we now have the technology to make careers and life a more balanced platform. For example, if someone can go home at 4pm, have dinner with their family, then get back online at 7pm for an hour, then why not? It works for the business; it works for the individual – it's a success on both fronts and we should do more of it. One of the benefits from the pandemic is a greater corporate acceptance for flexible working.

We also need to continue to work on creating a space where people can bring their whole self to work and contribute to their fullest. That's what an inclusive environment looks and feels like to me - it's collaborative, it's respectfully challenging, but it's also caring for our people and business and diversity is valued.

The JPMCC is fortunate to have you as a member of its Industry Advisory Council: what are some of the JPMCC initiatives that are most notable?

Through its courses and webinars, the JPMCC provides the tools and methodologies required to deepen a student's understanding of the energy industry. The courses available are led by industry experts with invaluable insight and information to share. The offerings span online courses to professional development. Regarding the JPMCC's co-sponsored webinars, I participated in a thought-provoking panel discussion sponsored by the JPMCC on the European natural gas markets. Separately, there was another panel which focused on highlighting the U.S. natural gas markets.

What advice can you give to students and young professionals who are interested in a career in the energy markets?

My advice for people who are interested in the energy industry, or any other field for that matter, is to take stretch projects and career risks. First, get the basics down and do the best you can in a role. Ultimately, you are responsible for your own development and career path so take the time for foundational courses either in-house or via the JPMCC. Perhaps do a variety of roles which deepen your commercial and operational understanding. In a trading organization, roles in market or credit risk, compliance, pipeline scheduling or cargo operations are commercially enabling and create a great base for trading or origination as well as for CFO and CEO tracks. Volunteer for stretch projects and consider international assignments if that is an option. Also, I found great mentors and sponsors over the years who helped to shape and guide my career. Finally, look for a culture where you can speak up, be heard and feel included.

Thank you, Sharon, for your insights during our January 2022 interview with you!

Endnote

For a comprehensive interview with Sharon Weintraub, one can listen to the "Talking Commodities" podcast, which was co-hosted by Dr. Tom Brady, Executive Director of the JPMCC and Stephen Butler, Chief Commercial Officer of ChAI.

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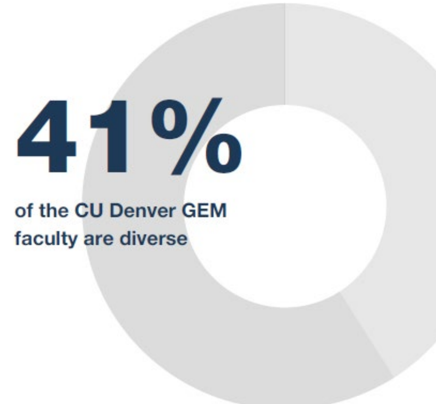

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EDITORIAL ADVISORY BOARD MEMBER NEWS

Commodities Trading USA 2022

Lance Titus (with microphone), Managing Director, Uniper, at a JPMCC Research Council meeting. To his right is JPMCC Research Council member, Rob Vigfusson, Ph.D., Principal Economist, Amazon.

Lance Titus of Uniper and Deanna Reitman of DLA Piper participated in the keynote panel, "Unlocking Carbon Trading Markets," on June 8, 2022 at Reuters' "Commodities Trading USA 2022" conference in Houston. Titus is not only an Editorial Advisory Board member of the *GCARD*, but also is a member of the both the Research Council and Advisory Council at the J.P. Morgan Center for Commodities (JPMCC). Reitman is a new Advisory Council member of the JPMCC.

The panel covered the following issues:

• the formation of carbon trading markets and how they can be utilized to identify low-cost solutions to reducing emissions;

• the criteria for quality carbon credits and how to verify third party data sets to ensure robust trade; and

• how carbon trading regulations will affect the commodities trading landscape through creating a viable solution to reducing emissions while remaining profitable.

Journal of Futures Markets

A paper on "The Negative Pricing of the May 2020 WTI Contract" will be published in a forthcoming 2023 issue of *The Energy Journal*. This article is by **Adrian Fernandez-Perez**, Ph.D., Acting Director of the Auckland Centre for Financial Research (New Zealand); **Ana-Maria Fuertes**, Ph.D., Professor in Finance and Econometrics at Bayes Business School, City, University of London (U.K.); and Joëlle Miffre, Ph.D., Professor of Finance, Audencia Business School (France). Dr. Fuertes is also an Associate Editor of the *GCARD*; and Dr. Fernandez-Perez is an Editorial Advisory Board member of the *GCARD*.

Ana-Maria Fuertes, Ph.D., of Bayes Business School (U.K.) and Professor Joëlle Miffre, Ph.D., of Audencia Business School (France), compared notes on their respective research presentations during the Commodity & Energy Markets Association (CEMA) conference in Chicago on June 21, 2022.

A digest version of their comprehensive paper was published in the Summer 2021 edition of the *GCARD*. The *GCARD* article is available here.

Commodity & Energy Market Association (CEMA) Conference

The University of Illinois (Urbana-Champaign) and Michel Robe, Ph.D., of UIUC, organized the 2022 Annual Meeting of the Commodity & Energy Markets Association (CEMA) in Chicago. Five JPMCC Research Council members participated in the conference, including Professors Michel Robe (UIUC), Ehud Ronn (University of Texas at Austin), Nikos Nomikos (Bayes Business School, U.K.), Colin Carter (University of California, Davis), and K. Geert Rouwenhorst (Yale University).

Three board members of the *GCARD* also participated in the conference: namely Professors **Ana-Maria Fuertes** (Bayes Business School, U.K.), **Isabel Figuerola-Ferretti Garrigues** (Universidad Pontificia de Comillas, Spain), and **Andrea Roncoroni** (ESSEC, France/Singapore). In addition, **Hilary Till**, the Contributing Editor of the *GCARD* and Solich Scholar at the JPMCC, also presented at the conference.

JPMCC Advisory Council

From Left-to-Right at the April 2022 JPMCC Industry Advisory Council meeting: **Robert Greer**, **Hilary Till**, **Jodie Gunzberg**, CFA, and **Tom Brady**, Ph.D.

JPMCC Advisory Council (Continued)

After the lifting of COVID-19 restrictions, JPMCC Industry Advisory Council members were grateful to be able to meet again in person at the University of Colorado Denver Business School on April 1, 2022. The following *GCARD* Editorial Advisory Board members attended the Advisory Council meeting: **Robert Greer** (Scholar in Residence, JPMCC), **Jodie Gunzberg**, CFA (TradeBlock), **Tom Brady**, Ph.D. (CoBank Executive Director of the JPMCC), and **Peter O'Neill** (Archer Daniels Midland Company), in addition to *GCARD* Contributing Editor, **Hilary Till**. Greer, Gunzberg, and Brady have each been featured in past *GCARD* interviews.

International Association for Quantitative Finance (IAQF)

From Left-to-Right at the 2022 IAQF/Northfield Award Dinner are **Hilary Till**, **Mark Keenan**, **Jodie Gunzberg**, CFA, **John Kowalik**, and **Ilia Bouchouev**, Ph.D.

Similarly, the IAQF/Northfield Financial Engineer of the Year Award Dinner at the Yale Club in New York City on May 17, 2022 provided an opportunity for the following *GCARD* Editorial Advisory Board members to meet in person: **Mark Keenan** (Engelhart Commodity Trading Partners), **Jodie Gunzberg**, CFA (TradeBlock), **John Kowalik** (UBS), **Ilia Bouchouev**, Ph.D. (Pentathlon Investments, LLC), and **Adila Mchich** (CME Group), along with the *GCARD*'s Contributing Editor, **Hilary Till**. Till is also a board member of the IAQF; and the IAQF is a professional society partner of the *GCARD*.

Updates from the GCARD's Contributing Editor

The following provides commodity research updates from the *GCARD*'s Contributing Editor, **Hilary Till**, in chronological order. On behalf of the JPMCC, she was cited in *Wired* (U.K.) magazine on making Big Data useful for commodities trading (based on an interview held in June of 2021.)

Till also presented on "OPEC Spare Capacity and Oil Prices" at "The Volatility of Crude Oil Prices, and the Mitigation of Oil Price Risk" Virtual Workshop, which was organized by Dr. **Jennifer Considine** on behalf of the King Abdullah Petroleum Studies and Research Center (KAPSARC), Saudi Arabia; the Oxford Institute for Energy Studies, U.K.; and the Centre for Energy, Petroleum and Mineral Law & Policy (CEPMLP), University of Dundee, U.K. Dr. Considine, in turn, is a Visiting Researcher at KAPSARC; Senior Research Fellow at CEPMLP; and an Editorial Advisory Board member of the *GCARD*. Till's presentation will be included in a forthcoming KAPSARC *Workshop Brief*. Dr. **Ilia Bouchouev** also presented at the virtual workshop. He is the Managing Partner of Pentathlon Investments, LLC; an Oxford Institute for Energy Studies (U.K.) Research Associate; an Adjunct Professor at New York University's Courant Institute of Mathematical Sciences; and an Editorial Advisory Board member of the *GCARD* as well.

In addition, Hilary Till also co-authored with **Joseph Eagleeye**, a chapter on "Big Data, Black Holes, and Tapping the Value of Future Price Data" for the forthcoming book, Research Agenda for Energy Politics (Cheltenham, U.K.: Edward Elgar Publishing Ltd). The book is co-edited by **Jennifer Considine**, Ph.D., Sylvain Cote, Ph.D., Douglas Cooke, and Geoffrey Wood, Ph.D. Eagleeye is a Principal with Premia Research LLC and is an Associate Editor of the *GCARD*.

Till most recently participated in an Executive Leader Roundtable, organized by the Professional Risk Manager's International Association (PRMIA), on "Food Security & the War in Ukraine." David Coleman, Managing Director, Risk Management, European Bank for Reconstruction and Development, provided an update on work in this area. Till is a Sustaining member of PRMIA's Chicago chapter steering committee; and in addition, she has written on food security issues on behalf of the EDHEC-Risk Institute (France/Singapore) where she has served as a Research Associate.

And in September 2022, Till's research work on commodity trading debacles and risk management was extensively cited in the *Journal of Commodity Markets*' paper, "Fourteen Large Commodity Trading Disasters: What Happened and What Can We Learn?".

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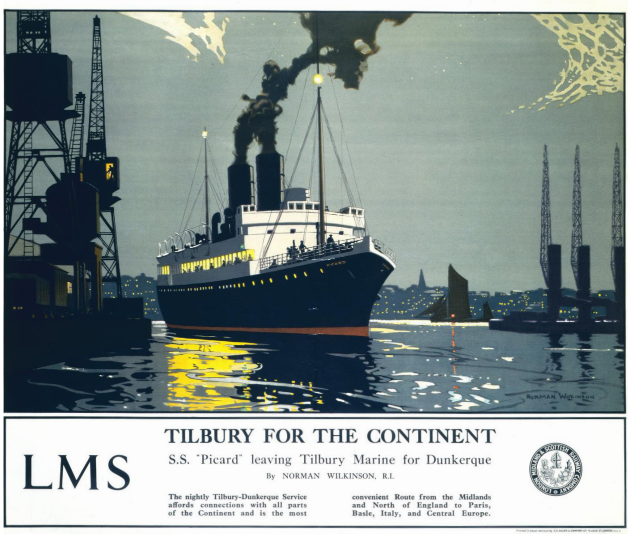
GLOBAL COMMODITIES
APPLIED RESEARCH DIGEST

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

The JPMCC is the first center of its kind focused on a broad range of commodities, including agriculture, energy, and mining. Established in 2012, this innovative center provides educational programs and supports research in commodities markets, regulation, trading, investing, and risk management. The CoBank Executive Director of the JPMCC is Dr. Thomas Brady, Ph.D.

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



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