PRIMARY COMMODITIES MARKET FORECASTING FOR COMPANY COMPETITIVENESS

by

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ABSTRACT

MILES SHEN. Primary Commodities Market Forecasting for Company Competitiveness. (Under the direction of DR. CRAIG DEPKEN II)

Primary commodities are the most essential inputs within the industrial production of goods and services. Business cycles and macroeconomic factors such as supply and demand contribute to primary commodity price behavior. The financialization of primary commodities has given rise to the futures price market, which allows rational expectations and speculative behavior to influence commodity prices. In applying industrial, financial, market structure, and economic relationships, a number of commodities price analysis and forecasting techniques can be utilized to predict future prices. Valuable to companies within the modern economic environment, forecasting and price analysis methodologies provide descriptive and statistical business intelligence, contextual to primary commodities and relevant industries. In applying primary commodities forecasting, firms inform decision-making processes, enhance strategic management capabilities, and improve competitiveness within their particular marketplaces.

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As the culmination of my academic career, I would like to express my deepest appreciation for my thesis supervisor, Henrik Johannsen Duus. This endeavor would not have been possible without his invaluable patience and guidance throughout this research process.

DEDICATION

I dedicate my thesis to my dear family and friends. Their belief in me and moral support is recognized and cherished.

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1. INTRODUCTION

The introduction to the topic of commodities forecasting begins with a brief background of the author and the motivation for the choice of the subject. Subsequently, the basis for this research is presented through the identification of the problem to be studied and the problem statement. The delimitations section provides the constraints and scope of the project. Choice of research methodology and supporting theory directly follow. Lastly, the general structure of this thesis is outlined.

1.1 Background and Motivation

The author of this research project is a double degree exchange student at Copenhagen Business School from the University of North Carolina at Charlotte. The researcher's academic background pertains to business analytics, economics, and finance. With the awareness that these fields can be connected in a plethora of distinctive ways, the interest to unify these topics by exploring data science techniques within the fields of economics and finance materialized as this research project.

The particular analytical practice chosen by the author is forecasting because of the relevance and utility it holds within the modern business landscape. Large sets of historical records have been collected over decades. Given this, data-driven methods presently used by modern businesses allow for the ability to generate descriptive information on past trends and predictions on the future. Companies can strengthen the accuracy of reporting and support decision making processes in business through the power of analytics and forecasting (Amazon Web Services, 2023).

Business analytics is a core component of the motivation for the research, yet the desire to shift the project from exclusively quantitative processes was present. Thus, the inquiry developed

into applications of forecasting for the purpose of planning and strategy within business. As a centerpiece of the investigation, strategic forecasting is selected because this method of research serves as a fusion of traditional forecasting and corporate strategy. Strategic forecasting approaches analysis from the macro and meso level, allowing for a view over the broader economic landscape. Solely, conventional forecasting for uses on the micro level of business are unable to achieve this vantage point (Duus, 2016). Through this perspective, an examination of economic systems and business cycle theory consistent with the aforementioned aim to apply forecasting methodologies to strategies for industry can be attained.

Commodities is established as the subject matter of this project because the foundations are rooted within the author's academic experience in economics and finance. The prominence of the primary commodities market and the necessity of natural resources within the macroeconomy is far reaching. No matter the level of economic development, the survivability of a society is wholly dependent on a secure supply of raw materials (Radetzki & Wårell, 2021).

The interrelated studies of business analytics (through forecasting) and economics (through business cycle theory) and finance (through commodities prices) combine to form the inspiration for this research. The decision to research this topic is initially based upon an intellectual curiosity to investigate applications of strategic forecasting and financial economic theory. The central motivation for the topic of this thesis emerges from the interest to understand commodities as a central aspect of the economy and its weight within the development of strategies in modern firms.

1.2 Problem Identification

The practice of exchanging natural resources has been comprehensively documented over history. Primary commodities are essential in the advancement of rising economies and the

stability of well-established economies. The relationship between raw materials and financial instruments has amplified the significance of commodities within economic markets to new heights (Radetzki & Wårell, 2021). There is extensive literature and historical records that account the evolution and varying value of commodities over time.

Forecasting and data analytics are fundamental within decision-making processes of the modern economy. Utilized in government, industry, and finance, these tools serve to estimate the future and explain uncertainty in the economic environment. With the ability to calculate probabilities of events and outcomes, the employment of forecasting techniques is very important to business planning (Holden et al., 1999).

The perception of primary commodities is broadened through a change in focus from conventional forecasting to strategic forecasting. However, a detailed inspection of distinctive forecasting techniques is necessary. This is required in order to account for and study the implications and effects of a variety of mentioned practices within strategic real-world environments. There are several directions for research within strategic forecasting. One such point of interest is strategic business cycle forecasting, which is a method of guidance for managers in industry to modify practices according to variations in the business cycle (Duus, 2016).

Business cycles are defined as a progression of a country's economy from a time of expansion to recession to growth again. The four main cycle phases can be categorized: expansion, peak, recession, and trough (Cambridge University Press, 2023). Primary commodities and their price movements can be linked to fluctuations in the business cycle. Commodities are exhausted for usage in secondary and even tertiary stages of industry for product creation (Radetzki & Wårell, 2021). All goods, to an extent, are subject to fundamental

economic principles and movements in economic activity, and in turn, primary commodities used in production and manufacturing in industrial stages are affected by business cycles.

Although literature and information exist for these distinct subjects, this investigation seeks to connect concepts into a cohesive organization. This project considers the preexisting documentation, theories, and analyses adjoining the topics of primary commodities and forecasting. The key purpose of this thesis is to devise a comprehensive examination by blending an academic enquiry into primary commodities markets with a study of real-world applications in the business environment.

1.3 Problem Statement

As the basis for academic research, the problem statement serves two purposes. First, it establishes a guide for the academic investigation, and second, it serves to communicate the subject matter of this research in a succinct and effective manner.

1.3.1 Main Research Question

This thesis intends to resolve the following main research question:

How can companies improve competitiveness through commodities forecasting?

1.3.2 Sub-Research Questions

The main research question can be expressed as the summation of the sub-research questions. The collective answers to these inquiries realized in subsequent sections of this thesis provide a multifaceted solution to the overarching problem statement. With this in mind, the sub-research questions are as follows:

1. *Which business cycle theories exist?*
2. *How has the primary commodities market developed over time?*
3. *What is the relationship between primary commodities and the business cycle?*

4. *What factors contribute to changes in commodity market price?*

5. *What techniques are companies utilizing to forecast and analyze commodity prices?*

6. *What are the benefits of different techniques?*

7. *How do companies implement forecasting results in decision-making processes?*

1.4 Delimitations

The delimitation section provides structure to the focus of the thesis. By specifying the scope of the research, related but excessive information and subject matter can be disregarded to identify evidence that clearly addresses the main research question as seamlessly as possible. The delimitation constricts research expectations and direction from the outset.

In order to conduct research that translates economic theories and methods of economic analysis to practicality in business, strategic forecasting is selected as the epicenter for the construction of this research. Three focus categories are identified from the greater research area: futures research, strategic warning, and strategic business cycle forecasting. Futures research examines the future using various analysis techniques such as the Delphi technique, scenario construction, scenario planning, and more. Strategic warning is fixed upon the management perspective and strives to strengthen the capacity for management systems to react to environmental uncertainty (Duus, 2016). Both futures research and strategic warning are excluded from this research because these areas do not align with the theoretical foundation, being business cycle theory.

1.5 Choice of Methodology

Through the specification of research methods, a logical organization and order for the thesis project process can be defined. By choosing the manner of data collection and interpretation, the conclusions drawn from the research are unequivocally affected. Developed

by Lewis Saunders (2019), the research onion model acts as the basis for research methodology in this work.

This thesis observes pragmatism as the choice of research philosophy. Positioned toward the real-world, the pragmatist paradigm is valued as a collection of tools used to address problems by means of functional solutions with the intent to inform future practice (Kaushik & Walsh, 2019). Hence, the foundation of this work to employ knowledge for the purpose of real-world applications is in accordance with the philosophy of pragmatism.

Additionally, an abductive research approach is followed due to its underlying support from the pragmatic philosophy. Abduction operates by shifting between theory and analysis throughout the research process (Saunders et al., 2019). Because of its adaptability, abduction fosters a research environment of inquisitiveness, reflection, and constant adjustment.

Relating to data collection, both secondary and primary data is collected and utilized to generate solutions that satisfy the main research question by answering several underlying sub-research questions posed in this work. The research design of this thesis follows a qualitative research design. The assembly of data is composed of secondary and primary data, where the secondary data is gathered through a literature review using academic and business databases and journals. The primary data is sourced from qualitative interviews within the field including firms with expertise in the use of commodities within the supply chain or forecasting methods specific to commodity prices and outlook.

1.6 Choice of Theory

The present thesis follows strategic forecasting and, more precisely, strategic business cycle forecasting as the direction for investigation of primary commodities. In choosing the theoretical

concepts, there are three major sections for literary review and research: business cycle theory, primary commodities, and price analysis and forecasting techniques.

The blend of interdisciplinary concepts formulates the theory chapter. The business cycle theory section establishes a brief historical summation of macroeconomic thought development over time and considers the academic reasonings from a range of many different schools of thought. The primary commodities section defines specific commodity sectors and characterizes cyclical behavior in commodity price movements. Finally, the forecasting section identifies specific practices commonly used in price analysis and business forecasting with the capacity for application in this topic area.

1.7 Thesis Structure

This thesis is structured in seven individual chapters in a logico-deductive fashion outlined as the linear-analytic approach by Saunders (2019). The below figure is a visual representation of the structure of this thesis.

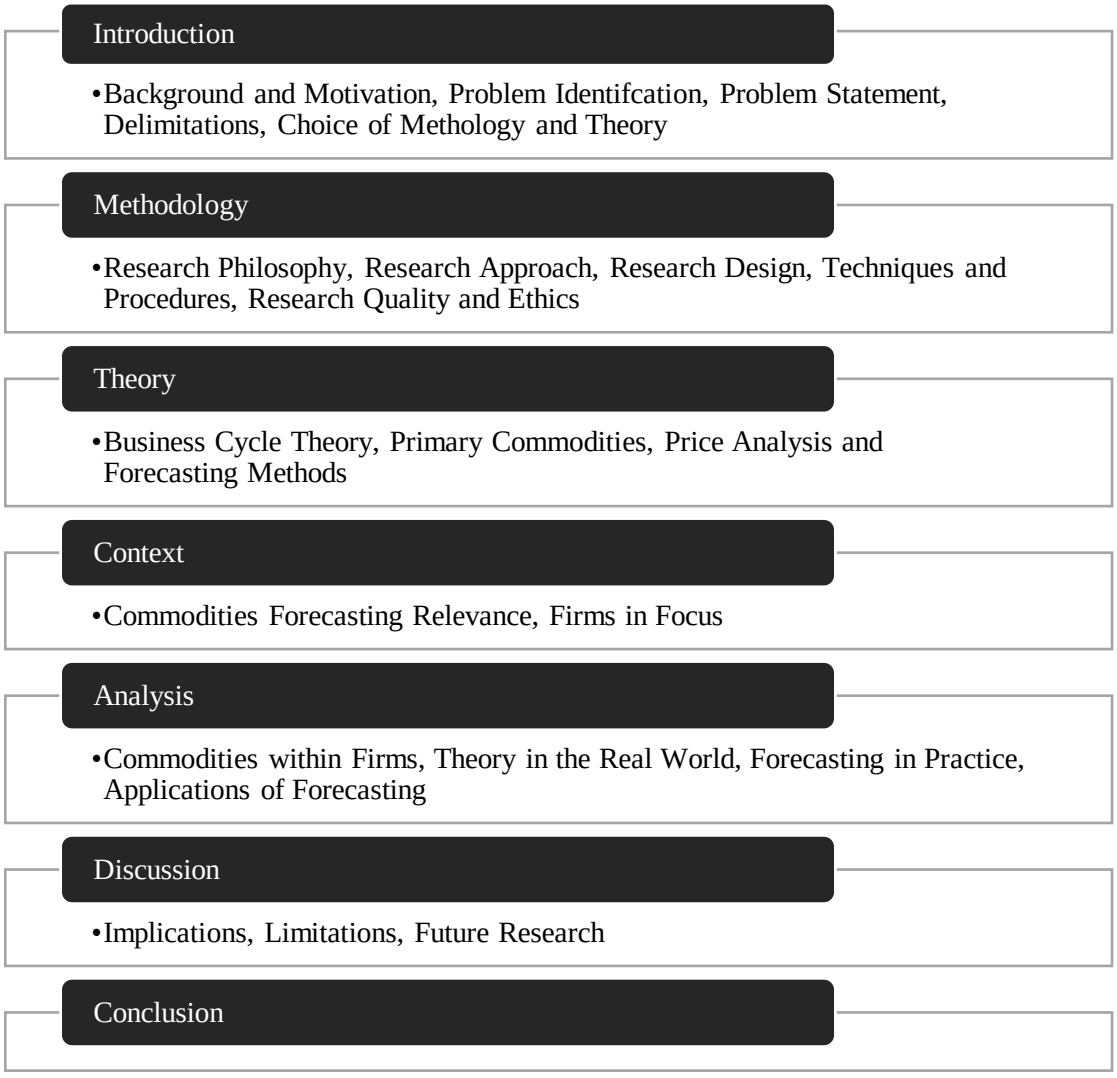

Figure 1: Thesis Structure.

Source: *Author Creation*

2. METHODOLOGY

The methodology section of this work specifies the systematic framework of research conduct in order to answer the main problem statement and sub-research questions. As the underlying foundation for this section, the research onion from Saunders et al (2019) is chosen. The structure of the research onion considers multiple phases in the methodological procedure, which are crucial to the manner of study and organization of this thesis. These aspects are depicted in figure 2 as the layers of Saunders' research onion. The rationalization and clarification of methodological choices based upon this model follow later.

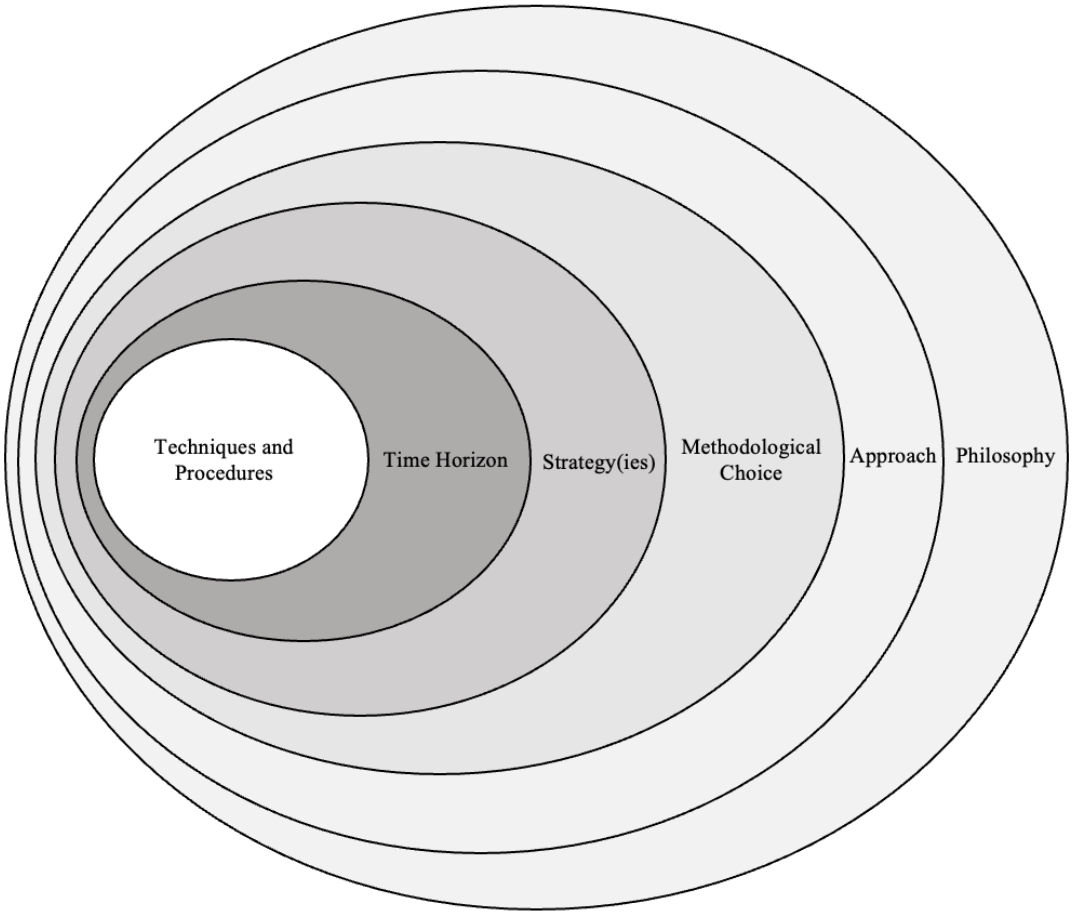

Figure 2: Research Onion.

Source: Adapted from *Saunders et al. (2019)*

2.1 Research Philosophy

The initial layer of the research onion is the research philosophy. The specification of research philosophy is an essential piece in the formation of methodology. Both implicit and explicit expectations support the foundation of research and have the ability to definitively impact the study. Regardless of a researcher's awareness of influential factors, the author's philosophical assumptions mold the investigative process and the theoretical presumptions drawn from collected and analyzed data (Bell et al., 2019).

There are three areas where assumptions reside: ontology, epistemology, and axiology. Ontological assumptions concern realities in nature, epistemological assumptions refer to knowledge and the presentation of knowledge, and axiological assumptions come from the researcher's personal values and ethics (Saunders et al., 2019). Sources of influence affecting the direction and conduct of research originate from several areas. Hence, the need to distinguish and classify research philosophy is apparent.

In continuation, Saunders describes five main research philosophies: positivism, critical realism, interpretivism, postmodernism, and pragmatism. Table 1 provides brief and distinctive descriptions of each philosophy consolidated from several works such as Bell et al (2019), Saunders et al (2019), and Creswell & Creswell (2018).

Table 1: Research Philosophies.

Source: *Author Creation.*

Research Philosophies	
Positivism	- Common in natural sciences - Emphasizes empirical methods and pure data
Critical Realism	- Applies explanatory methods and data to business - Reality is independent from the researcher's view
Interpretivism	- Divides human existence and physical observations - Highlights role of research subjectivity
Post Modernism	- Stresses power of language - Interest in alternative claims to mainstream views
Pragmatism	- Resolves subjectivity and objectivity - Values application of theory and findings to reality

Of the five research philosophies mentioned above, pragmatism is the most relevant philosophy for this study. As a paradigm, the pragmatist belief is positioned within the ontological assumption that reality is complex, and the practicality of ideas is important (Saunders et al., 2019). There is also allowance for the social construction of knowledge. While there is a single objective reality present, human experience shapes reality subjectively through perception and individual understanding (Kaushik & Walsh, 2019). The expectations of epistemology constitute acceptable knowledge through the pragmatic philosophy as significant, solution oriented, and actionable within the future (Saunders et al., 2019).

Pragmatism advocates utility. Choosing one particular phenomenon instead of another is solely based upon function and feasibility. Developed as a set of tools to address problems rather than a stationary position, the goal of pragmatism is to solve problems in the real world using the application of theories and abstract concepts (Kaushik & Walsh, 2019). Because this specific research project is driven by value creation and the aspiration to capture explanations of effective commodities forecasting processes, the researcher's axiological assumptions align with

pragmatism. Ultimately, the pragmatic philosophy acts as the base for this works' research methodology.

2.2 Research Approach

To develop theory for a research project, there are three main approaches considered: deduction, induction, and abduction. Deduction follows a linear progression from a plausible hypothesis to subsequent tests and eventual conclusions (Ketokivi & Mantere, 2010). Induction is the antithesis of deduction, beginning with observations and seeking to apply theories and postulate causes of the phenomena (Bell et al., 2019). Abduction blends both deductive and inductive reasoning. As an iterative approach, a back-and-forth process is invoked between theory and evidence throughout research conduct (Schwartz-Shea & Yanow, 2012).

An abductive inquiry overcomes many of the limitations present within deductive and inductive logics (Bell et al., 2019). Deduction is limited by following a path from hypothesized theory to conclusions and, as a result, is hindered by the inability to create new theoretical knowledge (Yu, 1994). On the contrary, induction is restricted by empirical data and results (Bell et al., 2019). Because the conversion to theory from generalized laws found in observations is limiting, shortcomings and even fallacies can arise from new findings and evolving circumstances (Yu, 1994). Balancing the computational and cognitive reasoning in theory building, abduction begins with a conundrum or phenomenon and seeks to identify conditions that provide the most explanatory power (Bell et al., 2019). The ebb and flow between theoretical ideas and literature of the abductive approach provides flexibility lacking from the other approaches.

From a philosophical core for research, the pragmatist perspective provides a compelling foundation for the continuous and reflective nature found in abduction (Saunders et al., 2019).

Abductive reasoning is exploratory and allows for the creation of new ideas and theories of the world. As a result, this thesis follows abduction as the main investigative research approach in order to establish the links between theory and evidence (Bell et al., 2019; Yu, 1994).

2.3 Methodological Choice

As the third layer of the research onion, methodological choice forms the type of research comprising quantitative, qualitative, or mixed methods (Saunders et al., 2019). Choice shapes the type of academic study, which in turn directs the particular procedures for use (Denzin & Lincoln, 2011). The first type of research inquiry is quantitative. Associated with numerical values, quantitative research methodologies study the relationships between variables in order to assess objective theories. Qualitative is the second category of methodological choice and is recognized with words. This method seeks to derive meaning and solutions of human and social problems from the interpretation of individuals or groups. Finally, mixed methods use aspects of both quantitative and qualitative methods (Creswell & Creswell, 2018).

A qualitative research design is selected. In answering the main research question, it is necessary to focus upon the human aspect of strategic decision making within the firm. This research is conducted over a single phase, and the different methods for data collection are iteratively performed synchronously. In accordance with qualitative research methods, the analysis is performed using triangulation, which is the use of multiple methods of data collection and data sources to bolster findings (Creswell & Creswell, 2018). The concurrent qualitative methods approach most accurately describes this works' methodological choice.

2.4 Research Strategy

Following the choice of methodology, the research strategy specifies the plan of action. To answer the main research question, research strategy acts as a nexus between the researcher's

underlying philosophy and means of data collection and analysis (Denzin & Lincoln, 2018). Considering research paradigm, approach, and choice, there are a multitude of research strategies available including experiment, survey, ethnography, case study, and more (Saunders et al., 2019). The case study strategy is most aligned with this research project.

A case study is defined as a comprehensive investigation seeking to explore a process, phenomenon, or topic in a real-world setting (Creswell & Creswell, 2018; Yin, 2018). The use of real-life context in a case study differentiates it from the other research strategies, but as a result, an understanding of the related context becomes crucial to the commenced research. Used for both inductive and deductive approaches, case studies can construct theories within exploratory research and verify hypotheses within explanatory research (Saunders et al., 2019). Because of the versatility in application to research approach, the use of the case study strategy under abduction is appropriate. Moreover, this research strategy exemplifies the philosophy of pragmatism and supports the researcher's motivation to contribute academic research through practicality.

Case study research can be segmented into several structures, but for the purpose of this methodology, a single embedded case study strategy is employed (Yu, 2018). This thesis observes the singular process of using theories and knowledge of the business cycle to forecast commodities prices in order to increase company competitiveness. In addition, data analysis is conducted by compiling sources of information and expertise across various groups within the commodities forecasting field.

2.5 Time Horizon

An important aspect when considering research is the periods in which a phenomenon is studied and observed. There are two perspectives regarding research project time horizons:

cross-sectional and longitudinal. Cross-sectional time horizons are described as snapshots within time and explain highly specific events or relationships between various factors related to a unique phenomenon. In contrast, longitudinal time horizons accompany research into changes and developments over longer periods of time and seek to broaden the scope of the study (Saunders et al., 2019).

For this specific work, aspects from both horizons are included. As a direct response to the problem statement, a cross-sectional focus in modern forecasting and perspectives in regards to primary commodities require an investigation into the presently used practices. However, a longitudinal component is also reasonable for this work because closer examination into the growth of business cycle theories and historical applications through forecasting provides substance and underpinning for the argumentation and findings to follow.

2.6 Techniques and Procedures

In deciding on techniques and procedures for a project, it is imperative to acknowledge the key aspects of the analysis. This research is considered a concurrent qualitative methods case study strategy. Developing from the use of both primary and secondary sources for research, qualitative data analysis is the center of this project.

2.6.1 Secondary Sources

Secondary sources for data were collected from previously conducted research or resources with appropriate information relevant to the present work. The existing data is originally obtained for other purposes, yet research projects in development can utilize these materials to reveal supplementary knowledge, explanations, and findings (Saunders et al., 2019). In organizing the theory section of this work, a review of existing literature was conducted in order to establish an expansive history of business cycle theory, a contextual structure for the

relationship between primary commodities and economic cycles, and an understanding of several business forecasting and price analysis techniques. A plethora of sources were gathered from online databases and archives including academic books, research articles, government websites, organizational reports, and more.

2.6.2 Qualitative Interviews

For the analysis portion of this study, qualitative interviews of industry participants and experts in primary commodities forecasting were conducted to acquire primary data. In seeking further clarification of the topics of business cycles and primary commodities forecasting, a semi-structured interview technique is used. The information gathered in the theory section is applied to construct broad themes to loosely frame and direct each conversation (Olson, 2016; Saunders et al., 2019).

Interviews conducted were prompted by an interview guide covering the topic of primary commodities, analytical techniques for forecasting, and the use of forecasting results for industry use. Conversations were largely informal and the guide was followed at the discretion of the interviewer (Interview Guide found in Appendix A).

Five participants from unique firms were interviewed for this research project. Selection criteria is based upon professional experience and commercial knowledge of primary commodities and analytical forecasting of natural resources within industry. Participants are gathered through unprompted contact on the employment-focused social media platform, LinkedIn, and by reference from the author's personal connections. Selected firms make business decisions within the realm of commodities or generate commodities specific forecasting data through analysis. A condensed list of interview participants follows (Interview Transcripts found in Appendix B).

Table 2: List of Industry Experts.

Source: *Author Creation*

Industry Experts					
Interview Number	Company	Country	Years of Experience	Role	Interview Medium
1	Mintec Limited	United Kingdom	6+	Forecast Analyst	Microsoft Teams
2	The Smart Cube	India	3+	Base Metals Analyst	Microsoft Teams
3	Premia Capital Management	United States	25+	Commodities Management Expert	Phone Call
4	NJR Group	United States	8+	Chief Executive Officer	In-Person
5	Lowes Home Improvement	United States	20+	Senior Finance Manager	Microsoft Teams

2.7 Research Quality and Ethics

In the assessment of business and management research quality, there are three principal criteria: reliability, replicability, and validity. Reliability refers to consistency of applied measures and concepts. Replicability, which is similar to reliability, concerns the methodological steps leading to a study's results and the capacity for reproduction (Bell et al., 2019). Finally, validity serves to identify the integrity of the conclusions drawn. Validity can be further segmented as measurement, internal, external, and ecological. Measurement validity confirms whether measures used within the study appropriately capture the phenomena in question (Saunders et al., 2019). Internal validity relates to causality of variables and seeks to identify relationships that could be caused by factors other than the target. External validity refers to generalizability and ability to apply the results outside of the context of the study. Ecological validity concerns pertinence within naturally occurring social settings and conditions (Bell et al., 2019).

In order to assess the quality of research and the criteria mentioned above, the process of validation is necessary. Validation determines the reliability, replicability, and validity of research through the authentication of research data, analysis, and interpretations. The validation technique performed in this thesis is triangulation. Aligned with multi-method studies, triangulation requires the usage of multiple sources of data and analysis (Saunders et al., 2019). Bolstering the confidence in the research, the particular technique enhances the robustness of the study by utilizing more than one means of measuring a concept (Bell et al., 2019). This thesis employs triangulation within the theory and analysis sections of this work by evaluating and compiling information from several academic sources and multiple firms or experts dealing in commodities forecasting in order to explain the phenomenon of primary commodities forecasting through the lens of business cycle theory.

The research organized and gathered within this thesis utilized internet-mediation. This includes the gathering of secondary data and conducting interviews with industry participants active through primary commodities forecasting. Online sources and virtual correspondence are the primary means for information. When engaging in internet-mediated research, there are many issues and ethical matters that must be addressed (Saunders et al., 2019). There are four areas of concern: harm to participants, lack of informed consent, invasion of privacy, and involvement of deception (Bell et al., 2019). To avoid these concerns and maintain proactive conduct, honest communication is established with participants. Responses, regardless of interviews or virtual correspondence, are prefaced by informed consent regarding their decision to participate or not. Any quotes or information present from participants within this work is preceded by the approval of the private source. Personal data is not present within the work. All information gathered is exclusively used for the purposes of this research project.

3. THEORY

A diverse number of theories and practices are considered for the development of this research project. It is important to distinguish these topics from one another, provide proper explanations, and emphasize key differences between the theoretical models and professional practices included within this master's thesis. The primary framework is strategic business cycle forecasting concentrated on primary commodities. Thus, the theory chapter is subdivided into three definite sections, business cycle theory, primary commodities, and price analysis and forecasting methodologies.

3.1 Business Cycle Theory

This section delivers an overview of the progression of business cycle theory. Thought and study into business cycles has been conducted for over a century, and a plethora of models and theories have been created to determine the causes of the phenomena (Zarnowitz, 1991). In a chronological timeline, this segment of theory covers early business cycle theories to various contemporary theories.

3.1.1 Early Business Cycle Theories

Ranging from the late 19th century well into the early 20th century, early economists theorized about the root of fluctuations in the economic conditions at the time (Knoop, 2010). Many of the first theories were simplistic, focusing on a single variable as the explanation for business cycles (Zarnowitz, 1991). While these initial models can be considered rudimentary when compared to contemporary works in macroeconomics, they serve as the building blocks that would be used to construct much more complex and comprehensive theories on business cycles (Knoop, 2010). While numerous early theories on the business cycle were developed, descriptions of some of the most impactful are provided below.

3.1.1.1 Early Agriculture Theory

Some of the very first theories on economic fluctuations stem from crop harvests and agriculture. Because the agriculture industry was considered noteworthy and influential in the late 19th century, the sunspot theory was conceived by economist, W. Stanly Jevons in the 1860s. He theorized that low sunspot activity from the surface of the sun negatively affected plant growth and agricultural output. Jevons made an effort to prove these effects by using periodic solar cycles as a mechanism for economic variability (Peart, 1991). Ultimately, this theory was discredited from scientific evidence that verified unalignment between the cycles of sunspot and economic activity. Although Jevons' hypothesis was invalidated, his work shed light on the importance of expectations (Knoop, 2010). Emphasizing the significance of agent reactions and behavior within the business cycle, it was postulated that investor and creditor responses to price fluctuations magnified the direct effect of demand (Peart, 1991). Heightened agent expectations lead to an increase in output, and lessened agent expectations lead to a decrease in output. Essentially, expectations were theorized as self-fulfilling.

The Cobweb theory was another influential business cycle theory originating from the role of agriculture in the economy. Several economists contributed to the theory in the early to mid-20th century. This theorem seeks to explain the impacts that supply and demand shocks can have on cyclical variability in price and output (Poitras, 2023). There are two primary assumptions important to note. The first is that goods are perishable and cannot be stored, and farmers must accept current prices. The second is that expectations are backwards facing, and farmers will plant in the spring based on prices in the fall. As an illustration of the Cobweb theorem, a temporary negative supply shock is considered between the sale and planting periods. Producers observe the perturbance before supply levels return to normal, and a chain of events occurs

where prices are shifted accordingly in order to compensate. Quantity is affected in turn, and producers will have to shift prices yet again in order to sell all goods and clear the market. An unstable back and forth market environment will persist, and although equilibrium will never be met completely, a condition of steady flux about an equilibrium will occur (Knoop, 2010). The initial Cobweb theorem and assumptions are challenged in modern economic environments where goods can be stored and backwards looking expectations are considered naïve and unplausible. Further research and study emphasize the importance of expectations, where rational expectation is established as an informed prediction of future events (Poitras, 2023).

3.1.1.2 Early Monetary Theory

Prior to the Great Depression, an international monetary system known as the gold standard was widely standardized. It acted as a requirement for countries to back the amount of circulating paper currency by a fixed amount of gold. Hence, a limit on the money supply of a country is solely dictated by the gold holdings of the country. Consequently, the direct fluctuation in a country's money supply is uniquely tied to trade. A country engaging in a trade deficit, or importing more than exporting, experiences gold outflows and reduces money supply. In contrast, a country with a trade surplus will be subject to a rise in gold and increased money supply (Knoop, 2010).

Because of the distinctive relationship between money supply and trade stemming from the gold standard, R. G. Hawtrey, an economist at the time, recognized bank rates as a central policy variable in directing business cycles (Glasner, 2014). Additionally, Hawtrey's monetary business cycle theory is endogenous or self-generating within an economy and does not consider exogenous or external shocks as a cause (Knoop, 2010). As a further explanation, a merchant's desired holdings of inventories would be highly sensitive to the cost of holding these inventories.

As a result, fluctuations in the carrying costs of inventories directly linked to bank rates prompt variations in income and spending. This subsequently impacts the desired inventories and sparks a cycle. Built upon this logic, a reduction in bank rates would cause an expansion of income and output, and an increase in bank rates would start a contraction of income and output (Glasner, 2014). In order to avert these cyclical fluctuations, Hawtrey proposed the adoption of fiat money backed by the government opposed to a commodity backed currency. This allows for market stabilization, monetary policy flexibility, and control over money supply. Ultimately, Hawtrey's solution to economic fluctuations is disproven because business cycles persist within economies under fiat money systems today. Nevertheless, this early model of monetary business cycles establishes a foundation for more advanced theories to consider (Knoop, 2010).

3.1.1.3 Underconsumption Theory

Beginning in the 19th century, economic crises were described as an instability between aggregate supply and demand of consumption goods. Focusing on savings as a stimulus for the imbalances, it was speculated that high savings lead to diminished demand, and investments of these higher savings lead to increased production and future supplies. Because incomes of consumers do not increase with production, a discrepancy between the expansion of consumption goods and overall consumption appears (Allgoewer, 2002). Underconsumptionist economists, such as John A. Hobson, believed that the insufficient aggregate demand to consume these goods cause overproduction and jeopardize economic prosperity by initiating business cycles (Allgoewer, 2002; Knoop, 2010).

Comparable to the early monetary theory, Hobson's underconsumption theory is also endogenous and acts as a closed loop. An increase in a country's aggregate income causes households to save and invest larger shares of their income, but by choosing to invest, the need

to consume is reduced. A gap forms between the increased income and consumption within the economy, causing excess supplies. The production surplus lowers aggregate income which in turn increases consumption, but by eradicating overproduction, the reintroduction of consumption increases income, igniting the cycle again (Knoop, 2010). Hobson's model set out to generate the ideal ratio between spending and saving in a growth equilibrium, and his fiscal policy recommendations concentrated on mitigating demand shortfalls in relation to business cycles. The underconsumption theories would influence and share many of the fundamentals of later theories, such as Keynesian economics (Allgoewer, 2002).

3.1.1.4 Profit Margin Theory

Distinctively, the profit margin theory, established by Wesley Mitchell in the early 20th century, was constructed through empirical analysis of profit behavior. Equating to the difference between revenues and costs, profit is a determinant factor in production, as well as the investments underlying production (Sherman, 2001). Applying the characteristics of imperfectly competitive markets, Mitchell reasoned that profit margins are strongly procyclical, feeding expansions and magnifying contractions (Knoop, 2010). Inclusion of imperfect competition provides an allowance for nuanced cases of firm behavior within the intermediary state between perfect competition and monopolies. Some examples of various firm behavior and instances include information asymmetry, different pricing schemes, product positioning, and horizontal or vertical integration (Cabral, 2017).

In the profit margin theory, it was emphasized by Mitchell that circumstances that allow a company to be profitable are the same conditions that have the ability to instigate profit reduction (Sherman, 2001). Furthermore, expansion of production gives rise to profit margins which increase the expectation of future profits and encourage investment into new projects.

These undertakings are unable to immediately increase capital stock or production capacities. As this occurs, the economy begins to reach capacity and slows, causing higher costs and lower profits. Because decreasing profits also lower profit expectation, investments are slowed, and the expansion quickly turns to a contraction and eventually a depression (Knoop, 2010). As demand flattens near the bottom of the depression, costs of production fall below the prices of goods, and expectation of profits subsequently begins to rise through increased production, starting the cycle again (Sherman, 2001). Similar to many other early business cycle theories, expectations play a significant role in causing cyclical fluctuations, but this initial addition of imperfect competition in profit margin theory is expanded upon in more modern theories.

3.1.1.5 Long Wave Theory

The long wave theory was first developed in the 1930s following many of the above-mentioned early business cycle theories. First hypothesized by N. Kondratieff and further developed by Joseph A. Schumpeter, it was argued that prices, interest rates, wages, production, investment, and consumption oscillate in both short and long waves. Because the previous theories focused on the shorter waves, this theory sought to identify and explain the long-term cyclical trends (Knoop, 2010). Schumpeter's contributions were significant in explaining long wave theory, identifying outstanding technological change and innovation as the driving force for these cycles due to prominent impacts on global economic structure. The causes of five separate long waves between 1775 and the present day have been recorded: water power and textiles, steam and rail, electricity and combustion, electronics and aviation, and software and digital networks.

Long wave theorists came to accept innovation as the driving force for longer business cycles. Schumpeter broke these cycles down into four phases (Narkus, 2012). When a

technological advancement is presented, the beginning of the cycle is conceptualized as creative destruction. This is where a contraction occurs while the new technology is in an implementation phase, drawing resources away for adoption and even making current practices obsolete. Following adoption, productivity and output increases, beginning the boom phase. This growth does not last forever though, and eventually, full integration slows the growth until stagnation is reached. Diminishing returns ensue, decreasing the growth of productivity and output. Two scenarios can happen within this period. A technological advancement can cause a contraction and restart the cycle, or a prolonged time span can pass without innovation, decreasing growth to zero. Skepticism among economists is present when addressing the separation and identification of the phases of long wave cycles from permanent economic changes or successive yet coincidental recessions in short intervals. While solutions to these problems have not been found, relevance persists within this theory. The focus on technology and innovation pioneered by the long wave theory is a crucial determinant of cycles within the more recent Real Business Cycle models (Knoop, 2010).

3.1.2 Keynesian Economics

The Great Depression struck the world in the 1930s, and none of the earlier business cycle theories could provide explanation for such severe economic collapse on the world stage. A new way of economic thinking would be developed by British economist, John M. Keynes, who would later be regarded as the father of macroeconomics. Upending the dominant idea that free markets continuously supply work as long as workers are able to self-modify their wage requirements, Keynes theorized that the most important force driving the economy is aggregate demand (Jahan et al., 2014). In classical economic theories, the demand-side is not considered, and aggregate production is determined by the supply-side, being factor supplies and technology.

This is rationalized by equating aggregate production and aggregate income, where income is either attributed to consumption or investment. Because income results from production in this model, supply is believed to create its own demand through the classical lens that aggregate demand is equivalent to the sum of consumption and investment (Arnold, 2002).

Keynesian economics is established as a theory of total economic spending, or aggregate demand, and concentrates on the effects that it has on output and inflation. In regard to how the economy functions, there are three tenets outlined by Keynes' theory (Blinder, 2008). First, a variety of economic decisions from both the public and private sectors influence aggregate demand. Decisions within the private sector can have adverse macroeconomic effects like a reduction in consumer spending for example, and when market failure occurs, Keynesian theorists support active governmental actions like fiscal stimulus packages to reignite the economy. Second, episodic shortages and surpluses occur because prices and wages react to changes in supply and demand gradually. Third, variations in aggregate demand have the largest impact on output and employment in the short run, but not prices (Jahan et al., 2014). Prices are considered mostly unresponsive in Keynesian economics, and this allows output to positively shift with any fluctuation in consumption, investment, or government expenditures (Blinder, 2008). In Keynes' theoretical framework, a mixed economy driven by the private sector with a partially active public sector is supported in order to combat the business cycle's direction (Jahan et al., 2014).

The root cause of business cycles in Keynesian economics is a change in expectations. In a recession, consumption decreases, and investor confidence decreases (Knoop, 2010). The decline in spending components initiates a multiplier effect, and output changes by a multiple of the decrease in spending (Jahan et al., 2014). From the principle of acceleration, the decrease in

aggregate production causes even lower levels of investment in the following period, initiating a downswing (Arnold, 2002). Under Keynes' model, there are three possibilities to end the recession. The first is a slow reformulation of public expectations to increase demand, but this is not absolute as there is no definable market mechanism guaranteeing recovery. The second is movement towards full employment as workers alter their nominal wage demands after observing other workers accepting wage cuts, but like the first possibility, there is no assurance. The third is state intervention through monetary policy to stabilize aggregate demand and increase spending (Knoop, 2010). Thus, fiscal policy and public sector involvement as a way to offset business cycles activated from the private sector and caused by changes in expectations and aggregate demand is advocated within Keynesian economics.

3.1.3 Monetarism

As a counter proposition to Keynesian models placing emphasis on aggregate demand and the role of the government, monetarism was developed to study supply-side impacts on economic fluctuations. Associated with Milton Friedman in the 1960s, the importance of money supply was brought back to the forefront (Arnold, 2002). It was believed that cyclical variance in money stock and inflation was the source for business cycles (De Long, 2000). Monetarism holds beliefs in a predictable velocity of money, which is the rate at which money trades hands (Jana & Papageorgiou, 2014). While this predictability is controversial, monetarist theory prescribes reformation within the banking system and Federal Reserve to stabilize the velocity (De Long, 2000). From the quantity theory of money, four main ideas are outlined in order to accomplish this. The first is long-run money neutrality which states that increasing money stock would have no effects on consumption or output due to the overall increase in price levels over time. Next is short-run money non-neutrality. Changes in money stock have temporary impacts

on real output and short-run employment, but adjustment in wages and prices take time. Third is the constant money growth rule. Proposed by Friedman, federal powers should follow stricter rules in monetary policy and set money supply growth equal to real GDP or output growth. This growth rule allows the fourth belief of interest rate flexibility where a larger focus on expected inflation and real interest rate variability is taken into account by borrowers and lenders (Jahan & Papageorgiou, 2014).

As the leading solution to easing economic cycles and fluctuations, monetarism supports the reduction of governmental discretion and a fixed monetary policy to keep money supply stable and predictable (Arnold, 2002). The most emphasized and defended components of monetarist theory include the sufficiency of money growth as an indicator of demand, the stability of velocity, and the assumption that it was easy and straightforward for the central bank to find and control the most relevant measure of the money stock (De Long, 2000). Gaining prominence in the 1970s, policy driven by monetarist theory lessened inflation in both the United States and United Kingdom due to the predictability of money velocity, but in the decades to follow, empirical evidence demonstrated instability and volatility in velocity. Financial innovations and changes in banking rules in the 1980s are believed to have caused a transformation in the relationship between money supply and economic performance. Economists ultimately abandoned the monetarist approach centered around the velocity of money (Jahan & Papageorgiou, 2014). Although much of the emphasized points of monetarism were refuted, there was success in the movement by the attention brought to the supply-side impacts on average aggregate output without diminishing the importance of aggregate demand (Arnold, 2002).

3.1.4 Real Business Cycle Theory

Prior to the theorization of "Real Business Cycle" models, two primary economic schools of thought were widely backed: the classical school and Keynesian school. The classical school stressed private individual optimization, the adjustment of relative prices in order to equate supply and demand, and free market efficiency. As mentioned in the above section, the Keynesian school allowed for failures and believed that business cycle study required more than a focus on the nuances of general equilibrium (Mankiw, 1989). In the early 1980s, economists Finn Kydland and Edward Prescott pioneered what is now called Real Business Cycle, or RBC, theory. In Kydland and Prescott's work, real shocks, specifically technology shocks, were given weight as leading factors in causing economic fluctuations (Rebelo, 2005). Originating from the classical view, RBC suggests that individuals alter their labor supply and consumption levels as a response from these fluctuations. Therefore, business cycles are considered naturally occurring and efficient reactions to changes in production technology (Mankiw, 1989).

In opposition to Keynesian economics, real business cycle theory explains economic fluctuations as a strictly supply-side phenomenon. Given that there are exogenous causes for fluctuations in production, the RBC theory presents several notions. Markets are efficient, and government intervention is unnecessary given three hard assumptions: households maximize intertemporal utility, firms maximize profits, and there are no market imperfections (Arnold, 2002). The resulting principles of real business cycles are monetary shock insignificance and agent response to real shocks in productivity growth (Deng, 2009). Using total factor productivity, or TFP, as a measure for exogenous technology shocks causing business cycles, RBC theory was considered highly controversial. Forecasting evidence proved that endogenous variables, such as government spending and monetary policy, comprise TFP as well, and these

findings bring into question the true impacts of production technology on economic fluctuations (Rebelo, 2005). Extending from original RBC theory, many models were developed which included other variables like inter-industry dynamics, money, and the international economy. While there was a significant impact on macroeconomic science, changes to overall business cycle understanding were light (Arnold, 2002). As a purely supply-side explanation, Real Business Cycle theory places importance on exogenous shocks as the cause for aggregate economic fluctuations and ensues in providing an alternative school of thought to macroeconomic theory.

3.1.5 New Keynesian Economics

New Keynesian economics began as an effort to expand upon Real Business Cycle theory using principles established by Keynes (Galí, 2018). Covering an assortment of diverse papers after RBC, this branch of theory agrees with rational expectations and optimizing behavior to study the rigidity of real and nominal prices and wages given short-term economic fluctuations (Arnold, 2002). Distinctly, there are three assumptions underpinning the foundations of New Keynesian Economics. First, imperfect market conditions prevail with a lack of coordination between markets (Hiç, 2019). Due to the externalities of aggregate demand, one firm's decision can affect the decisions of another, and multiple equilibria with different outcomes arise as a result (Arnold, 2002; Mankiw, 2018). The second basic assumption of New Keynesian economics is the rational expectations hypothesis. Microeconomic analyses are used for more macroeconomic investigations, and the use of profit and utility maximization provide the basis that both entrepreneurs and laborers have future expectations of prices (Hiç, 2019). The third assumption is price and wage rigidity. Through imperfect competition within the goods and labor markets, only a limited number of firms have the ability to modify their good's prices and wages

causing slow adjustment and broad stickiness (Galí, 2018). The rational expectations hypothesis is acknowledged by New Keynesian theorists, but the assumption of inflexibility in prices and wages are considered more important within their framework (Hiç, 2019).

A synthesis of ideas between multiple new schools of economic theory began in the 1990s. To explain the short-run fluctuations in the economy while also accounting for the role of monetary and fiscal policy, the New Keynesian school supports the understanding of an economy following a dynamic equilibrium. Taking into account sticky prices and other various market imperfections, this modern view deviates from traditionally held views of efficient allocation of resources (Mankiw, 2018). Furthermore, the lack of demand emerging from imperfect market conditions cause involuntary unemployment, specifically in the short run, but a natural rate of unemployment equilibrium is present in the long run. New Keynesian theory draws elements from many preceding theories and has been extended to numerous models classified by imperfect competition, constant price contractions, coordination failures, labor market and efficiency wages, and even more (Hiç, 2019). Some form of an economy-wide market failure is agreed to be the cause for recessions and economic fluctuations (Mankiw, 2018). A final working theory has yet to be formulated, but New Keynesian economics has adapted over the years and continues to grow through the extensions and inclusions of additional assumptions and new phenomena (Galí, 2019).

3.1.6 Austrian Business Cycle Theory

With roots predating Keynesian economics, the Austrian school has beginnings from the 1870s with Carl Menger and his theory of capital goods (Foldvary, 2015). Friedrich Hayek in the 1930s would eventually develop a capital-based explanation for the Austrian Business Cycle Theory and a critique of central banking and governmental intervention (Skousen, 1990).

Although the original concept was widely rejected in favor of Keynes' theory, features from Austrian Business Cycle Theory, or ABCT, can be observed in modern economic fluctuations (Oppers, 2002). Viewed as a deviation from mainstream economics, the Austrian business cycle is a supply-side theory based upon the relationship between interest rate and time preference. Following a "natural rate of interest," Austrian economists interpret this rate as a systematic discounting of future values, and in the case of a free market without central bank intervention, this interest rate would be the natural rate (Foldvary, 2015). Due to this importance of interest rates, the role of central banks and their real-world influence become a major factor. Through increases in money supply, interest rate manipulation by these monetary authorities affects the loanable funds market (Oppers, 2002). The Austrian business cycle theorizes that economic fluctuations are caused by state manipulation of credit (Roberts, 2021). This aspect is further considered when dealing with technological innovation and investment in projects of longer time horizons, and as such, fixed capital demand is more sensitive to interest rates than demand for variable capital (Skousen, 1990).

The boom phase of ABCT begins from the lowering of interest rates from the central banks. Both consumption and investment are increased, but because the financing is credit-induced, consumer preference and willingness to save is not considered. Therefore, the business sector receives greater command of resources for capital goods or fixed capital. With longer yield times of consumer goods, these production investments cause shortages as consumer demand then rises. This triggers an increase in prices, which correspond to rising interest rates (Oppers, 2002). Effectively, the monetary inflation from the central banks causes an incidental price inflation. Labeled as malinvestments, the investment projects profitable in a low interest environment become lossmaking when higher rates occur and are consequentially reduced, launching a

recession. Labor demand falls, household income drops, and overall economic production dwindles (Foldvary, 2015). From the Austrian school's perspective, the recession is an inevitability as the economy readjusts from the malinvestments (Roberts, 2021). Firms then restructure in an effort to bring their capital stock in line with consumer demand. The economy will not recover until production structure and the spending plans of consumers are aligned.

Austrian business cycle supporters primarily corroborate the theoretical basis with evidence divided into three groups: apparent trends during upswings, manifested trends during recessions, and effectiveness of government policies in response to recessions (Oppers, 2002). The Austrian Business Cycle Theory was first rejected in favor of Keynesian economics during the Great Depression. It has been rejected by economists many times due to swift labeling and a strong credence in their respective schools of macroeconomic thought (Skousen, 1990). There has yet to be a recognized integration of ABCT into mainstream economic theory despite the fact that there are consistencies with historical events and data (Foldvary, 2015). Austrian Business Cycle Theory is a supply-side centered concept that positions monetary authority intervention and interest rates as an important driving factor in economic fluctuations (Oppers, 2002).

3.1.7 Review

In summation, this section establishes the evolution of business cycle theory and schools of macroeconomic thought. Although there are a multitude of developed theories spanning over a century, this overview concentrates on the most prominent in order to highlight features and considerations most relevant and accepted as causes to the business cycle. Many of the early theories are considered simple, pointing to specific causes. The later theories use these preliminary building blocks to construct more involved models and study complex relationships

between several variables in the formation of business cycles. The following table offers a condensed review of the abovementioned theories.

Table 3: Business Cycle Theories.

Source: *Author Creation*

Business Cycle Theories		
	Assumptions	Key Points
Early Business Cycle Theories	- Agriculture: agent reaction and expectations - Monetary: bank rates under gold standard - Underconsumption: savings reduce consumption - Profit Margin: imperfect competition - Long Wave: innovation in major technologies	Early theories are limited by singular causes and restricted economic environments.
Keynesian Economics	- Public and private sectors influence cycles - Prices and wages react slowly to supply and demand changes - Aggregate demand variations have short run impacts	This is a demand-side theory. Changes in expectations are considered. Government intervention is supported to offset business cycles.
Monetarism	- Money supply has no effect on long run - Money supply temporarily impacts short run employment and real output - Velocity of money can be predicted if monetary policy is fixed	Advocates strict federal rules for money supply growth. Successful in bringing attention to inflation control and supply-side effects.
Real Business Cycle	- Markets are assumed efficient, and government intervention is unnecessary - TFP used as a measure for exogenous technology shocks - Agent response to technology shocks in production drive business cycles	Exogenous shocks as purely supply-side causes with an emphasis on technology are considered.
New Keynesian Economics	- There is not coordination present in markets causing imperfect conditions - Rational expectations are included - Prices and wages are rigid	Placing sticky prices and wages at the forefront, market failure from imperfect competition is viewed as the cause for recessions on both the supply and demand side.
Austrian Business Cycle	- A natural rate of interest is accepted - Manipulation of credit through the effect of interest rates in loanable funds is the cause - Recessions are necessary for restoring the economy	Never accepted into mainstream theory, the supply-side was posited as the cycle source. Lower interest rates increase investments of longer time horizons and begin cycles.

There is a diverse collection of business cycle theories with distinct assumptions. Most theories actively support their own relative ideas rather than challenging other beliefs.

Macroeconomic thought on economic fluctuations has evolved, yet a few key features have become widely acknowledged. Three main presumptions are consistently reoccurring as important considerations for modern business cycle theory. The first is expectations. Included in some of the earliest theories, the importance of expectations persists to modern schools of macroeconomic thought and continues to play a role in the understanding of business cycles today. Secondly, the source of economic fluctuations is believed to come from both the supply and demand side depending on the theory. Thus, recognition of factors from both sides is essential. Finally, monetary and fiscal policy have influence on the money supply which can affect output and impact the variability of economic conditions. Although no singular theory on the business cycle has been established, numerous characteristics from studies over the years continue to reemerge. As such, business cycle theory is an area of study under constant development, and this section serves to provide a brief evolution of macroeconomic history.

3.2 Primary Commodities

Covering the topic of primary commodities in relation to industrial production and macroeconomics, this section of theory is partitioned into several segments. To introduce the subject, primary commodities and classifications are defined with descriptions of the various sectors. Next, financial instruments and the role of trading in commodities are acknowledged. A brief view of short-run and long-run commodity price behavior follows. Finally, commodity price cycles are identified with explanations of their underlying drivers.

3.2.1 Classification and Sectors

As a fundamental input for the production of other goods and services, a primary commodity, or simply commodity for short, is the most basic good used in commerce. Raw materials are essential in all activities of production and manufacturing (McGinnis, 2022). The definition of primary commodities originates from national accounts of output value derived from the primary sector. There are a variety of classification systems for primary commodities. The International Standard Industrial Classification, or ISIC, narrows its grouping of commodities solely to primary sector outputs. This does not allow for adaptation for meaningful analysis because value is added to raw materials through manufacturing activities (Radetzki & Wårell, 2021). As a result, the Standard International Trade Classification, or SITC, is more widely accepted for economic activity analysis, as the nuances of added value are recognized. The system outlines ten sectors with hundreds of groups and subgroups (McGinnis, 2022). The SITC can be used to alter the composition of groupings for a variety of analyses. One popular approach to reorganization contains four categories: food in a broad sense, agricultural raw materials, minerals and metals, and mineral fuels (Radetzki & Wårell, 2021). For the purposes of this research project, the simplified divisions of agriculture, mining, and energy sectors are used.

Agriculture commodities, also known as soft commodities, comprises goods from farming. A few key components of this sector include grains and oilseeds, livestock, sugar, cocoa, coffee, cotton, and orange juice. Grains and oilseeds contain wheat, corn, soybeans, oats, and more. Livestock are mainly cattle and hogs. Another vital inclusion as an agricultural product is ethanol for fuel, which is fabricated from corn, sugar cane, and other crops (McGinnis, 2022). Commodities from the agricultural sector have been traded for centuries, yet a central driver of agricultural production in the past century is credited to technological innovation and improvement. Transportation, storage, and packaging technologies have enabled consumption of

practically every agricultural product throughout the entire calendar year. Biotechnology, satellite information, and fertilizer technologies are expected to boost production with wider adoption. Supply chain improvements, lower transportation costs, and improved information technology apply downward pressure upon prices in the soft commodities sector. Technological change has profoundly transformed production, transportation, storage, and even the consumption of agricultural primary commodities (Baffes & Nagle, 2022).

The metals sector contains both precious and industrial metals. Despite the distinction, precious metals also have uses within industry (McGinnis, 2022). Notable industrial metals include iron ore, copper, tin, aluminum, lead, zinc, and nickel. Precious metals include gold, silver, platinum, and palladium. There are a variety of uses for these metals in a multitude of markets: construction, automotive, electronics, machinery, and consumer goods (Baffes & Nagle, 2022). Like agriculture, the metals commodities sector also benefit from both technological advancement and the effects of increased productivity and decreased production costs (Radetzki & Wårell, 2021). The fact that metals are non-renewable is particularly relevant when reviewing feasible rates of extraction as a determinant in supply (McGinnis, 2022). The metals sector has historically experienced several price cycles. Aside from growth in demand, the leading cause for these fluctuations is the long lead times associated with discovery, exploration and development. Largely, the demand for metals has grown significantly in the past century due to industrialization and usage in the formation of the modern world (Baffes & Nagle, 2002).

Globally important, the energy sector covers fossil fuels and alternative energies. Oil, natural gas, and coal make up fossil fuels. Alternative energies involve solar, wind, water, biomass, geothermal, and fuel cells. Additionally, uranium and nuclear energy is contained

within the energy sector (McGinnis, 2022). Fossil fuels have been a mainstay within the energy sector since the beginning of fuel and production documentation in the early 1900s (Radetzki & Wårell, 2021). Approximately 83% of total energy consumption is attributed to fossil fuels with oil at the epicenter. The large share of crude oil usage is a reflection on its functional versatility, limited substitutes, volume of readily available reserves, low cost of production, and ease of transportation (Baffes & Nagle, 2002). Energy is one of the most fundamental factors in industrial production, and the need for creation, transportation, and distribution of energy is necessary within global markets of non-stop consumption (McGinnis, 2022). The applications of energy sector commodities are transportation and electricity (Baffes & Nagle, 2002). The energy sector is subject to many different macroeconomic effects such as economic activity, reserves, supply chains, substitutes, and geopolitics (McGinnis, 2022).

3.2.2 Trading and Financialization

Historically, commodities have been traded in specific and definable locations where goods, mainly agricultural, are literally negotiated and exchanged. Open outcry systems were the original means of trading where traders shouted bids and offers to one another within a pit, but since the turn into the twenty-first century, electronic trading gained traction and essentially took over the open outcry practice. Electronic trading provides many benefits. A main motivating factor is lower transaction costs, greater flow of information between trading parties, and a standardization of the bidding process. Additionally, the shift has indisputably opened exchanges from local rural sites to a dedicated international and global scale. Lastly, a greater access to the futures market through electronic trading provides easier entry by participants and the use and development of financial instruments under commodities (Radetzki & Wårell, 2021). Some of the largest global exchanges include CME Group, National Stock Exchange of India,

International Commodity Exchange, London Metals Exchange, and Tokyo Commodity Exchange (McGinnis, 2022; Radetzki & Wårell, 2021).

Not every commodity is listed for trade on exchanges because specific conditions must be met for commodity inclusion. A bulleted list of these requirements adapted from A Handbook of Primary Commodities in the Global Economy by Marian Radetzki and Linda Wårell (2021) follows:

- Continuous market quotations must be established through the presence of enough buyers and sellers for sufficient liquidity.
- Physical commodities dealers must be prepared to use the market for hedging. Deals must be matched by speculators (distinct from regular investors, speculators seek high profits from rise or fall in market value).
- Grading of commodities must be easily measurable, and a standardization of quality must be met.
- Storability and preservation of commodities for spot and future price relationships are vital.
- Commodity price variability must be extensive. Low price elasticity and instability in supply and demand must be present.

Commodity exchanges are effectively markets where several buyers and sellers are concurrently active. There are numerous types of transactions for trading commodities. The most basic is a spot transaction, which is an immediate delivery of the commodity. From bilateral contracts and auctions, the actual transfer of a physical commodity is conducted without the use of exchange based financial instruments. As an alternative, derivatives such as futures and options are offered by exchanges to suit specific needs of both buyers and sellers (McGinnis,

2022). Determined by trade practices set by the exchange, futures contracts are agreements to buy or sell a decided quantity of a commodity at an agreed price, and the transaction and delivery of the commodity is set for a particular time in the future (Radetzki & Wårell, 2021). Because traders are engaged in futures contracts on commodities to generate a profit opposed to dealing in the physical commodities themselves, the futures traded on the exchange provide a secondary market, and buyers and sellers avoid taking the delivery of underlying commodities through systems in exchanges (McGinnis, 2022).

It is possible that secondary market speculation and trade can impact commodity pricing. As an example, futures prices are bid up by speculators following harvest, or futures prices are contrarily bid down at the peak of an industrial boom. Spot prices are strengthened or reduced respectively. The theory of speculative expectational purchasing of futures and options in driving commodity price variations persists, but a wide array of literature shies away from this line of thinking primarily due to the issue of causality direction (Radetzki & Wårell, 2021). An ongoing discourse is present about whether commodity characteristics are a product of exchange trade or commodity characteristics allow for exchange trade. While exchanges and the financialization of commodities remain an important feature to primary commodities as a topic, price variations in commodities are supported by academic beliefs in economic fundamentals.

3.2.3 Price Formation and Behavior

From a broad and generalized understanding, global supply and demand imbalances are identified as the central determinants of primary commodity prices (McGinnis, 2022). Important to price formation, attention to both the short run and the long run is necessary. From the basis of unregulated competitive markets, commodity prices are expected to increase with positive surges in demand and negative shifts in supply, where demand could be affected by economic growth or

favorable business conditions and supply may be impacted by harvest failures or mining halts (Radetzki & Wårell, 2021). Another important short-run observation is price elasticity of supply, which is the change in quantity when there is a 1% change in price (Shapiro et al., 2022). At lower capacity utilization, price is modestly affected by demand orders, but as capacity reaches maximum, prices exponentially increase with rises in demand (Radetzki & Wårell, 2021). The short run is characterized by both fixed and variable factors, where capacity is considered fixed (Shapiro et al., 2022). The real-world nature of primary commodities supplied in the short run shines light on instability and ambiguity of price formation. The price elasticity of demand for primary commodities is low because resources used in finished products constitutes a small portion of the product price, yet increased demand for the final product will cause an accentuated increase in demand for the raw materials used. Thus, larger price adjustments in primary commodities can occur when compared to the finished product. The inverse occurs if demand for the final product declines. Supply can also contribute to price instability. While geographical diversification and globalization have reduced the significance of supply and capacity changes on prices, it is still worth noting. Commodity prices in the short run are highly volatile, and the unpredictability of movements can cause supplier behavior to heighten these effects (Radetzki & Wårell, 2021).

The long run is characterized by factor variability. Therefore, the fixed nature of capacities in the short run can be adjustable through the lengthening of time horizon (Shapiro et al., 2022). Endeavors to study and establish long-run commodity price trends have been made with an assortment of findings, ranging from stagnation to substantial decline. Because nominal prices must be converted to real ones in order to express consistency in money across time, various approaches can be taken to accomplish this. Examples can include the use of an implicit deflator

of GDP conveyed in USD, price indexes for producers or consumers in the USA, and more. From numerous studies, a dominant descending trend in commodity prices in the long-run is observed. In relation to manufacture prices, the prevailing commodity price decline has multiple explanations: lower income elasticity of demand for commodities, transport costs as higher proportions in commodity prices than manufactures, and a superior advancement in finished product quality over raw material quality (Radetzki & Wårell, 2021). A recent study in the wake of the COVID-19 pandemic by Erten and Ocampo provide an extensive view of primary commodity price trends spanning 150 years and is an exemplar of the ongoing discussion. Using manufacturing unit value to capture the real price trends, their analysis distinguishes between two commodity groupings, non-oil and oil. Predominant downward trends in non-oil commodities, comprised of agriculture and metals, and upward trends in the oil commodity group are observed. Recognized explanatory factors impacting global commodity prices hypothesized in this study are global aggregate demand, global energy response to climate change, and increasing populations in developing country regions, specifically sub-Saharan Africa (Erten & Ocampo, 2021). Long-run observations and studies of commodity prices have been a point of academic contention, but the interest in global macroeconomic conditions prevails as pertinent and descriptive of global commodity price fluctuations (Baffes & Nagle, 2022).

3.2.4 Price Cycles

Over the past century, a cyclical behavior has been observed within the primary commodities market. Defined as sharp increases in broad commodity group prices, commodity booms are an important phenomenon for the examination of commodity price fluctuations. Primarily affected by conditions in the aggregate economy, fast macroeconomic expansion

characterized by high growth rates in GDP and industrial production mark the beginning of commodity booms (Radetzki & Wårell, 2021). Commodity booms and their underlying causes in changes of global demand are indicative of potential super cycles within primary commodities (Erten & Ocampo, 2021). A super cycle is defined as a sustained price cycle within a broad range of commodities. The upward trend lasts from 10 to 35 years, and the entire cycle can last from 20 to 70 years (Radetzki & Wårell, 2021). Three and a half super cycles have occurred in the past century. The first began at the end of the 19th century and was caused by development in widespread electrification, invention of the automobile, and overall expansion in the US economy. The second occurred between 1945 and 1970, specifically in the post-war period, and is defined by the reconstruction of Europe and Japan. The third was ignited from unrest in the Middle East in the 1970s. Oil supply cuts and price shocks instigated by exporters had strong ramifications on the commodity index (Erten & Ocampo, 2021; Radetzki & Wårell, 2021). The most recent cycle followed rapid expansion of emerging markets, particularly China. Peak commodity prices were reached in 2013, and the global primary commodity price cycle has been in the contraction phase since (Erten & Ocampo, 2021).

In determining the key features of commodity price cycles, Commodity Markets: Evolution, Challenges, and Policies (2022) from The World Bank provides a significant contribution through a review and compilation of findings from several studies over decades. Cycle components and drivers from the mentioned analysis ensues. The fluctuations of primary commodity price movements can be split into two parts: the transitory and permanent. The transitory component is comprised of three elements: short-term fluctuations less than 2 years in length, traditional business cycles connected to economic activity ranging from 2 to 8 years, and medium-term cycles linked to long-term investment trends from 8 to 20 years. The permanent

component encapsulates super cycles with movement of 20 or more years. While both transitory and permanent are nearly equivalent in parts of the whole study, short-term elements hold stronger relevance to industrial commodities, and the permanent factor is more applicable to agriculture (Baffes & Nagle, 2022).

Primary commodity price cycles have several identified key drivers. The most popular macroeconomic explanation for commodity price cycles lies within global economic activity, specifically demand (Radetzki & Wårell, 2021). Acknowledgement of other factors including supply conditions within and around commodity markets assist in studying price movements (Baffes & Nagle, 2022). An example of factor effects other than demand is the case of oil and energy products. Because energy is a key input for metal production and a cost component for agriculture, energy prices cause other commodity group prices to increase concurrently (Baffes, 2007). The recognized price cycle drivers are demand, supply, and commodity specific shocks. Global demand shocks raise global industrial production, inflation, and prices of commodities. Contrarily, global supply shocks increase global industrial production but decrease inflation. Specific to commodity markets, global commodity consumption increases, and prices subsequently increase. Finally, commodity-specific shocks are separate from demand and supply. Nevertheless, these shocks are characterized by decreases in industrial production and increases to price. Disturbances of the commodity-specific category can originate from geopolitical, financial, or public expectancy. These shocks can occur simultaneously and even affect one another (Baffes & Nagle, 2022).

3.2.5 Review

Primary commodities are fundamental as economical building blocks for industrial production. With the ability to be segmented in a plethora of different ways, three main sectors emerge: agriculture, metals, and energy. Commodities are traded candidly, yet the financialization of commodities and the use of exchange instruments create a secondary market in futures. The impacts of trading on commodity price variations are debated, but as a feature, financial markets have indisputably increased accessibility and transparency of primary commodities trade. The economic principles of supply and demand are the causes of price variations in commodities. Evidence has established a volatile nature of short-run commodity prices. Commodities are an input to finished goods, and due to this, a central downward facing trend has emerged in the long-run prices of commodities when compared to manufactures. Major price cycles in primary commodities have occurred over the past century as a result of industrialization, war-reconstruction, and geopolitical instability. It is concluded that the main cycle drivers are global demand shocks, global supply shocks, and commodity-specific shocks.

3.3 Price Analysis and Forecasting Methods

Forecasting can roughly be defined as the means of predicting the future and the impacts of the future in order to make informed decisions. Forecasts are essential within business, economic, and financial environments (Holden et al., 1999). Price analysis is an important tool adjacent to forecasting. As a backward facing methodology, its central goal is to understand the complex array of economic factors that contribute to price fluctuation and behavior (Mallory, 2023). Firm managers rely on future outlooks to make decisions in day-to-day planning and operations. Governments utilize forecasts of the macroeconomic landscape to promote changes in policy. Due to relationships between various present and future rates and changes in governmental policy, financial market agents depend on forecasting to drive their judgements

and recommendations (Holden et al., 1999). For the purpose of merging macroeconomics, primary commodities, and optimal firm behavior, forecasting techniques arise as a narrowed topic. In particular, econometric approaches used for fundamental analysis and technical analysis as well as applications of leading indicators are the most significant. From a broad perspective in the context of this work, econometric processes of forecasting include regression and time-series analyses.

3.3.1 Regression Analysis

Necessary as a foundational econometric area of focus, regression analysis serves to build forecasting models, produce forecasts, and evaluate them (Diabold, 2017). A linear regression explains the effect on a single economic variable, known as the dependent variable, by the change in another economic variable, called the explanatory or independent variable. Other independent variables and their impacts on the dependent variable are fixed (Ouliaris, 2011). The statistical strategy used is called least squares, where data points are first plotted on a graph. Then, a "regression is run" or a "regression line is fitted" (Diabold, 2017). The averaged line from this analysis is a means used to mathematically explain theories and intuition in economics (Ouliaris, 2011).

In a regression analysis, the estimated marginal impact of the explanatory variable, holding all other independent variables constant, is realized (Navarro, 2022). The differences between the actual data points and the prediction from the fitted line are called residuals (Diabold, 2017). A number of assumptions must hold for the findings from a linear regression analysis to be trusted and reliable. As the name suggests, the relationship between the dependent and independent variables must be linear. Residuals are assumed to hold a normal probability distribution with a mean of 0, have equivalent standard deviations, and be independent of one another. Additionally,

predictor variables must be weakly correlated, or problems in identifying the true impacts of explanatory variables on the dependent variable can occur (Navarro, 2022).

As a tool in econometrics, the linear regression analysis method provides the ability to quantify economic phenomena. Estimated parameters and the value in their explanatory power are dependent on the economic models underlying the statistics. In the use of regression analysis, the exclusion of a relevant variable can be damaging to the outcome through poor parameter estimates. Values produced through this analysis technique will almost never match the actual values used to generate the estimated values, but as the set of raw data expands, the statistical potency and accuracy of the analysis increases. Economics underpin the empirical models and econometric supported predictions, and as such, econometric procedures such as linear regressions require forethought and effective judgement to be successful (Ouliaris, 2011).

3.3.2 Time Series Analysis

Another key foundational topic area of econometrics is time series analysis which studies the underlying forces and structure of data sets presented as an ordered sequence of values observed at equally spaced time intervals. There is an assortment of models and techniques that are included within the time series category (Croarkin & Tobias, 2012). When conducting this type of analysis, the fluctuations over time due to components found in trends, seasonality, and covariance instability must be resolved, and the condition of stationarity must be met within the data series (Diabold, 2017). To be able to investigate and distinguish changes separate from these components, smoothing techniques are utilized. There are two distinct groups of smoothing, averaging methods and exponential smoothing methods (Croarkin & Tobias, 2012). The moving average procedure begins from a serial collection of data. This process smooths the data points by selecting the values in a number of subsequent periods to average, and successive averages

are created by removing the first period and adding the next to the calculation. This iterative computation continues until the entire data set has been included and the originally recorded inconsistencies have been settled. As an expansion on moving average smoothing, exponential smoothing places stronger weight upon observations in the recent past than the distant past. Thus, newer observations hold more influence than older observations (Croarkin & Tobias, 2012; Holden et al., 1999).

Models for time series analysis are created from two fundamental types of time series, univariate and multivariate. Univariate time series consist of single observations sequentially recorded over equal increments. Multivariate time series refer to the inclusion of multiple time series variables (Croarkin & Tobias, 2012). A frequently used approach is autoregressive modeling, which is when a variable is regressed on lagged or past values of itself. Basically, this is a simple method of forecasting the future based on history (Diabold, 2017). A combination of autoregression and moving average known as ARMA models underpin quantitative forecasting of univariate time-series data. Depending on the prior processes needed to reach stationarity of data, integrating an ARMA model, called an ARIMA, through differencing techniques removes the nonstationary component of a time series. Additionally, the inclusion of multiple variables can enhance the overall complexity of the analysis (Holden et al., 1999). For instance, Multivariate time series analysis only commences with the vector autoregression form which requires linear algebra calculations of matrices of involved variables and the inclusion of a zero mean vector representing interactions and white noise between those variables. As a statistical means of forecasting the future, time series analysis as whole assumes and accounts for an internal structure within the sets of data being studied. There are countless applications of time

series approaches within business and economics, but an important consideration is the impact that historical shocks can have on future predictions (Croarkin & Tobias, 2012).

3.3.3 Fundamental Analysis

As a forecasting method including a variety of considered factors, fundamental analysis can be broadly defined as the use of economic models and data on production, consumption, income, and more to forecast prices. In assessing price, supply and demand factors reinforce this type of analysis (Mallory, 2023). Noteworthy aspects included within fundamental analyses of companies or assets include financial statements, economic conditions, industry trends, management, or other influences on future growth and profitability (Khan, 2023).

Within commodities, fundamental analysis largely relies upon the maintenance of natural resource balance sheets for countries, regions, or the world (Mallory, 2023). Balance sheets become the focal point of this analysis because information on supply and usage or demand variables is provided. Supply consists of beginning stocks, production, and imports. Demand is represented by consumption, residuals, and exports (Mattos, 2014). Through careful accounting of these factors, a predicted price can be found. This calculated figure for price essentially acts as a control for the many competing uses for limited commodity supply (Mallory, 2023). Because supply and demand data are not considered timely, it is important to note that fundamental analysis delivers a generalized view of price movement, which is most useful in long-run time horizons (Mattos, 2014).

3.3.4 Technical Analysis

Most simply defined, technical analysis is the study of market action for the purpose of forecasting future price trends. This approach predominantly uses financial charts to study the market environment, and the specific market in question suggestive of primary commodities is

the commodities futures price market (Murphy, 1999). An emphasis on price fluctuation and trade volume found in technical analysis is used to forecast short run price movements (Khan, 2023; Kojoh, 2018). There are numerous ways of conducting technical analysis, but two highlighted concepts are price recording and trend analysis (Murphy, 1999; Kojoh, 2018).

As a globally used price recording method, the candlestick chart indicates the current market situation at all times. The chart creates a figure based upon the open, close, highest, and lowest prices for a specified period in order to convey data for informed decisions (Kojoh, 2018). Candle pattern analysis is a short-run tool and functions as a means for timing trades. Reversals and continuations of price developments can be identified through this technique (Murphy, 1999). Trend analysis is another useful technique under the umbrella of technical analysis and expands to a longer-run perspective. The trends in question refer to direction of price movement. Trendlines are drawn as a straight line from a recorded turning point in the past price and extended to the future. Because of the understood inflexibility of trendlines and independence from future price movements, prices crossing trendlines can be used as warning tools and aid decision making of position strategies (Kojoh, 2018).

Described as a smoothing method previously, moving average can also be applied as an alternative indicator in technical analysis. Although it is time lagged, this trend following device can identify when movements end or even reverse (Murphy, 1999). Regarded as a broad trend itself, moving average calculations differ from the former trendlines since they are automatically drawn from price changes (Kojoh, 2018). As an example, a specialized Bollinger band technique is utilized. A moving average of prices is established, and two bands are also plotted two standard deviations above and below the moving average. Prices can fluctuate between the upper and lower bands, and as such, the variable price targets can direct trading decisions and

employment of different strategies depending on where the current prices are plotted (Murphy, 1999).

3.3.5 Economic Indicators

In seeking to understand business cycles and create forecasts based upon the cyclical behavior of the economy, the indicator approach was conceived. Models were developed to explain the economy by classifying the relevant economic variables as leading, coincident, or lagging. Leading indicators are measures of commitments or actions taken in the present that affect economic activity in the following periods. Occurring in conjunction with fluctuations in the economy, coincident indicators are categorized as simultaneous changes in lockstep with the current business cycle phase. Last of all, lagging indicators reach turning points later than the presently changing conditions identified by coincident indicators (Boehm & Summers, 1999). Specific to the main idea of predicting future events, leading indicators are the primary vehicle for forecast creation. There are a number of conditions that must be met for a variable to be classified as a useful leading indicator. First and foremost, timing must be consistent, as the systematic anticipation of peaks and troughs is crucial. The variable must generally be free of prominent high frequency movements and conform to the shape of the business cycle, not just the extreme highs and lows. Another important factor is economic significance or an explanation of change derived from macroeconomic theory. Measurability is also necessary in order for meaningful statistical analysis to be conducted (Boehm & Summers, 1999; Marcellino et al., 2006; Nilsson & Guidetti, 2008).

Before leading indicators can even be selected, a target variable must be specified. Many variables have the potential to be suitable for a variety of reasons. Coincident variables are largely advantageous as they chart the present changes in the business cycle. Additionally, the

variable chosen must be a good measure of economic activity, available within a short frequency, preferably monthly, and unaffected from major later revisions (Marcellino et al., 2006). There are drawbacks from using a single variable such as the shifting of cyclical turning points over time and the addition of excessive cycles absent from the central business cycle (Boehm & Summers, 1999). To solve these issues, the practice of combining multiple identified coincident indicators into composite coincident indexes as target variables has flourished (Boehm & Summers, 1999; Marcellino et al., 2006). Analogous to the target variable choice, using a single leading indicator can also be haphazard. Thus, the use of a composite index of several leading indicators provides a multifaceted and deep-seated representation through the capture of signals from a diverse array of sectors in the economy (Marcellino et al., 2006).

Due to the cyclical timing characteristics present in key economic variables, both theoretical and empirical interest rose in business cycle forecasting using leading and coincident indexes (Boehm & Summers, 1999). In particular, the Organization for Economic Co-operation and Development, or OECD, has had extensive practice in applying a composite leading indicator, or CLI, approach (Nilsson & Guidetti, 2008). Intended to signal early signs of turning points in business cycles, the OECD system for CLIs was first created in the 1970s and uses GDP as the target variable. Following monthly updates and revisions, their aim is to head actual short-term economic movements by a lead time of 6 to 9 months. Strong co-movement has been recorded, and turning points logged by the CLI forecast has consistently preceded actual business cycle turning points (OECD, 2023). In conclusion, the economic indicator approach to business cycle forecasting has become a mainstay within the field with foundations in economic intuition and real-world applications.

3.3.6 Review

In price analysis and forecasting, there are several unique techniques used within the modern business landscape. The three main analyses include fundamental analysis, technical analysis, and economic indicators. Econometric methodologies such as linear regressions and moving averages are statistical procedures that are utilized within larger analysis methods like fundamental or technical. The econometric processes serve to mathematically underpin the broader approaches that focus upon economic variables, industry trends, financial markets, and business cycles. In the primary commodities framework, fundamental analysis places an emphasis upon economic factors specific to pertinent industries. Notable variables can include inventories, production, consumption, and imports and exports. Technical analysis stresses the market structure of commodities futures price markets. By using charts, trend analysis, and a variety of moving average models, market action trends can be predicted. Finally, the use of economic indicators employs data derived from aggregated indices, which are indicative of large macroeconomic variables and business cycles. Accordingly, forecasting and price analysis is a multifaceted topic area with interactions in economics, finance, and business analytics.

4. CONTEXT

The context chapter serves as a connection between the literature review of pertinent theory and the analysis which explores the real-world applications of the previously mentioned concepts. There are two purposes of the context. First, an overview of commodities forecasting and its relevance within industry is established. Second, a synopsized outline of case firms used in primary data collection is presented. This relevant information is important as an introduction to later analyses and drawn conclusions.

4.1 Commodities Forecasting Relevance

Primary commodities are the natural resources necessary for production and consumption, and it is undeniably evident that agriculture, metals, minerals, and energy are significant within the world. Because they are supplied without qualitative differences, this characteristic of fungibility allows large market or even global forces to have an influence on prices (Mallory, 2023). Pressure on multiple levels of the economy include individual, firm, and national (Kwas & Rubaszek, 2021). Additionally, primary commodity transformation over space, time, and form are important for price analyses. These three categories connect to factors such as geographic origin, storage for later use, and entrance to the supply chain or market (Mallory, 2023).

When considering firm and industry in particular, strategic policies, investment decisions, and profits are all directly impacted (Kwas & Rubaszek, 2021). The business models of many companies can leave them exposed to the risks associated with commodity price volatility and cycles. Companies dealing in commodities with the need to hedge risks as well as strategize around these price fluctuations spend extensive amounts of resources in order to forecast prices (Mallory, 2023). A dependence on quality commodity price forecasts has become a leading dynamic within both the public and private sectors (Khadan &Ohnsorge, 2023). Forecasting and

commodity data consideration are important inputs to the decision-making processes in operations and strategy (Khadan & Ohnsorge, 2023; Mallory, 2023).

4.2 Firms in Focus

With technological innovations, the dependence and use of primary commodities is far-reaching within the modern world, and as such, commodity prices can affect a multitude of industries. While sensitivity to price can vary, modern firms can markedly benefit from primary commodity price forecasting. Below is an abbreviated introduction to firms included within this study. Firms range from solely analytics and data to direct involvement and handling of primary commodities within the supply chain.

4.2.1 Mintec Limited

Mintec Limited is a price reporting agency and global information provider based out of the United Kingdom. Accredited by the International Organization of Securities Commissions (IOSCO), Mintec operates in Europe, the Americas, Asia, and more (Mintec Ltd, n.d.). The firm generates proprietary price data and commodity forecasting solutions within agri-food commodities as well as industrial and manufacturing. Mintec utilizes both an application programming interface (API) and their Mintec Analytics platform to support clients. The API integrates client enterprise applications with Mintec pricing models and systems to supplement decision making in procurement, analytics, and supply chain management. Mintec Analytics is an online platform that provides commodity price and cost model forecasts. Users access the platform to measure risk exposure in procurement and predict price changes in raw materials. As an independent provider of commodity price data in food ingredients, industrial materials, and energy, Mintec bolsters business practices in manufacturing, retail, food service, health and beauty, and more (Mintec Limited, 2023).

4.2.2 The Smart Cube

The Smart Cube is a United Kingdom headquartered business and analytics consulting company with specialties in data science, procurement, supply chain, strategy, and marketing (The Smart Cube, n.d.). As a subsidiary of WNS Global Services, The Smart Cube offers several organizational intelligence solutions within the Americas, Europe, and South Asia. Commodity intelligence solutions are offered within the procurement and supply chain categories of the consulting firm. The Smart Cube employs an on-demand procurement intelligence platform called Amplified PRO to customize and create commodities forecasting models based upon the internal data and needs of the client. Commodity specialists enhance price forecasts with fundamental, technical, and artificial intelligence techniques to provide contextualized insights and recommendations. Commodity purchase strategies, event-related risk mitigation, and ongoing hedging governance in consumer-packaged goods, chemicals and industrials, life sciences, retail, and more are supported by The Smart Cube (The Smart Cube, 2023).

4.2.3 Premia Capital Management

Premia Capital Management is a proprietary trading and research firm located in the United States. Originally operating as a Commodity Trading Advisor, the firm has since established the consulting division as Premia Research (Premia Capital, n.d.). Premia Research founded the S&P Dow Jones Index called the Premia Research Bancor Index in 2015. Considering primary commodities asset class contribution to balanced portfolio diversification, the firm believes that pricing analysis can determine commodities allocation within portfolios. Additionally, the firm has found that fundamental commodity market information can be embedded within price relationship data. As such, the Premia Research Bancor Index reflect these views and observed correlations (S&P Dow Jones Indices, 2023). With specialty in multiple asset classes, financial

instruments, and notably commodities, Premia Capital Management utilizes the notion that fundamentals can be inferred by futures price curves to conduct financial transactions.

4.2.4 NJR Group

NJR Group is a full-service industrial construction company headquartered in North Carolina in the United States. As a civil engineering and construction contractor, NJR specializes in a diverse array of infrastructural development projects including commercial, residential, heavy highway, environmental, industrial, airport, and railroad. Some examples of specialized projects include but are not limited to asphalt paving, storm drain systems, bridge construction, water pump stations, pipe fabrication, and fuel tank farms. In addition to providing labor and expertise in roadway construction and other heavy civil offerings, an asphalt plant is also owned and operated where the manufactured construction material is used for both firm projects and material sales. With specialties in highway and asphalt, NJR Group is an encompassing industrial construction company operating throughout the Carolinas of America (NJR Group, 2023).

4.2.5 Lowes Home Improvement

Lowes is a hardware retail chain specializing in home improvement within North America. As a Fortune 50 company and the world's second largest home improvement retailer, Lowes Home Improvement operates within the Building Material and Garden Equipment and Supplies Dealers Subsector of the Retail Trade Sector within the North American Industry Classification System. Products, maintenance, repair, remodeling, and decorating are offered by Lowes within these categories: appliances, building materials, décor, electrical, flooring, hardware, kitchens and baths, lawn and garden, lighting, lumber, millwork, paint, rough plumbing, seasonal and outdoor living, and tools. Customers of Lowes include retail customers, such as individual

homeowners and renters, as well as professional customers within maintenance, repair, operations, and construction trades. As a retailer, Lowes Home Improvement sells and provides a large variety of products and services within the home-related sales market (Lowes Home Improvement, 2022).

5. ANALYSIS

The analysis chapter organizes findings from semi-structured interviews of the firms disclosed in the context chapter. Through triangulation, theoretical foundations from the literature review are conjoined with explanations and details from the qualitative interviews to narratively illustrate the subsequently covered themes: commodities within firms, theory in the real world, forecasting in practice, and applications of forecasting. In citing information and findings from specific interviews within the text, Appendix B is referenced (i.e., Appendix B1). Provided below is a key linking respondent firms with respective appendix notations.

Table 4: Appendix B Interview Key.

Source: *Author Creation*

Appendix B Interview Key	
Mintec Limited	B1
The Smart Cube	B2
Premia Capital Management	B3
NJR Group	B4
Lowes Home Improvement	B5

5.1 Commodities within Firms

Established earlier, primary commodities are the most basic units of input for industrial production in goods and services. With the abundance of modern firms engaging in a wide variety of production, manufacturing, and service-related activities, substantial weight is placed upon the role of commodities within today's commercial environment (McGinnis, 2022). Numerous industries have dependence upon commodities. Airlines are heavily dependent upon jet fuel prices (Kwas & Rubaszek, 2021). Consumer Packaged Goods (CPGs) are subject to

changes in aluminum. Automobile, general construction, and renewables are impacted by copper (Appendix B2). Home improvement and residential construction are affected by lumber prices (Appendix B5). Industrial food producers are exposed to agricultural segments like grains, oilseeds, livestock, and more (Mallory, 2023). Manufacturing plants are influenced by energy markets, like natural gas. And the costs of transportation, freight, and logistical operations for any type of industry are directly connected to crude oil products, like diesel (Appendix B3). No matter the industry, commodities are a vital consideration in business.

5.2 Theory in the Real World

Understanding commodity dynamics and the effects from economic shocks that cause changes in prices is a major concern. The importance of the foundational principles of supply and demand as well as rational expectation theory is present in real-world settings and firm analyses of commodities. Key drivers of primary commodity price fluctuations stem from global economic activity, supply and demand shocks, and commodity specific developments (Baffes & Nagle, 2022; Radtezki & Wårell, 2021).

Rational expectation theory follows a self-fulfilling framework found in agent reaction and behavior. When agents within the market expect prices to increase or decrease, their anticipation and corresponding actions can cause beliefs to come true (Peart, 1991). As stated by Premia Capital Management, both speculators and commercial hedging pressure can affect the price of a commodity within the futures market. By predicting future prices and hedging accordingly, institutions and producers can guide the direction of primary commodity prices. Backwardation and contango of futures price curves are valuable in observing the market beliefs of agents. In a backwardated market, the front month future prices are higher than prices in the later months. A contango market is the opposite, and months farther into the future are trading at a higher price

than the months in the near future (Appendix B3). The price direction of the futures market is indicative of the aggregated expectations and confidence of other market participants or speculators (Appendix B1).

In contrast, unexpected events and unforeseen occurrences can have great effects on price, especially in the short-run. Geopolitics are an exemplar of this unpredictability highlighted by professionals at both The Smart Cube and NJR Group. For instance, the Russia Ukraine war caused significant volatility due to Russia's role as a major contributor within the oil and energy markets (Appendix B2; Appendix B4). Resulting from the ambiguous nature of macroeconomic and geographic conditions surrounding the war, record highs in energy prices were recorded. Because reactions are short term and transitory, price levels shift toward the original in the long-run as circumstances develop (Appendix B2). According to Premia Capital Management, price functions as a means to resolve supply and demand disequilibria. Thus, the elevated levels of price persist until the markets reach clarity and the previously mentioned imbalance is addressed (Appendix B3). Furthermore, companies exposed to the effects from a reduction in oil supply, like NJR Group, gain clarity as determinations for alternative resource suppliers are made (Appendix B4).

Disturbances with impacts on primary commodities markets can stem from supply, demand, or separate commodity specific factors (Baffes & Nagle, 2022). In the lumber and forestry space, which affects Lowes and the home improvement market (see Appendix B5), a supply shock such as an Oriented Strand Board (OSB) mill catching fire and closing production in Texas alone could have ramifications on the entire national market in the United States (Oliver, 2023). Determining whether the scale of such a shock can cause a scarcity of supply is an essential consideration when predicting the impact on price. In the circumstances surrounding the

COVID-19 pandemic, both demand and supply disruptions in lumber occurred. With more discretionary income and time at home, consumer behavior shifted and demand for home improvement materials increased, which in turn caused volatility in prices (Appendix B5). For supply, worker shortages and supply chain disruptions triggered by the pandemic caused lumber prices to quadruple (McDaniel 2020). With the unpredictable variation and exorbitantly high prices present, the increase in consumer demand came to a screeching halt and even reversed (Appendix B5). Hence, global, national, or even seemingly local disturbances can affect primary commodity prices.

5.3 Forecasting in Practice

In terms of primary commodity forecasting and price analysis in a real-world context, the numerous techniques and methodologies covered within the literature review are presently used: fundamental analysis, technical analysis, and economic indicator approaches. Econometric approaches such as linear regression and time series analysis serve as particular practices under both fundamental and technical analyses respectively (Appendix B2). By providing specialized data platforms and industry recommendations, Mintec Limited and The Smart Cube serve as information brokers and consultants to firms. Both of these analytics firms utilize a combination of all the above-mentioned methods of analysis to forecast primary commodities prices (Appendix B1; Appendix B2). Lowes Home Improvement is an example of a firm that is new to primary commodities forecasting and has begun to explore and apply price analysis techniques in recent years (Appendix B5). While forecast time horizons can vary depending on the commodity group or even the firm's needs at the time, it is standard practice to forecast 4 to 6 quarters or 12 to 18 months ahead. In particular, the forecasts for closer time horizons to the present are more accurate than forecasts extending farther into the future (Appendix B1; Appendix B2).

Factors relevant for price calculations in fundamental analysis fall within supply, demand, and the macroeconomic. According to the interview with The Smart Cube (see Appendix B2), understanding commodity dynamics for fundamental analysis begins with a question. “What all factors could have an impact on the commodity prices?” Consumption, incomes, general industry data, and other surrounding economic elements are deemed impactful (Mallory, 2023). Through the lens of Mintec, the fundamentals approach covers basic supply, demand, inventories, the cost of production, and other variables specific to the firm and the market in which it operates. Another noteworthy aspect is seasonality, which can affect prices. For oil, the western world gets colder in the winter months, and as a result, oil prices increase during these periods. By including fundamental data points and accounting for seasonality, a linear regression can be generated (Appendix B1). In Lowes Home Improvement specifically, fundamentals are derived from market insights and vendor conversations. Housing data and figures on the customer profiles such as repair and remodel as well as home builds and home starts are crucial points in the market intelligence. Production line times and supply is also taken into account. Finally, industry pricing in competing home improvement retailers like Home Depot or conventional lumber yards are important insights as well (Appendix B5). Acting as an assessment for both qualitative and quantitative factors, financial statements, economic data, and industry intuitions are used. Fundamental analysis focuses on the business landscape of a company and is most usually applied in a long-term time horizon rather than short-term (Khan, 2023).

As a tool for studying market action and price trends, technical analysis approaches forecasting from a statistically dense perspective (Murphy, 1999). In statistical modelling on financial futures price markets, commodities can react and differ greatly to technical methods. Some speculative futures markets provide useful information and trend very well. Others can

fluctuate frequently, break through moving averages, and produce white noise (Appendix B1). Because every commodity has its own unique dynamic and situation, the complexity of modelling plays an important role. As a standard in analytical practice, overcomplicating and utilizing stringent models, like an autoregressive integrated moving average (ARIMA), can create unnecessary complexity if the most basic of methodologies like a linear regression is able to produce apt results (Appendix B2). Noted by Mintec Limited and The Smart Cube, seasonal decomposition and exponential smoothing are incorporated in conjunction with oscillators and trend following techniques (Appendix B1; Appendix B2). Through financial market evaluation and future price movement prediction, technical analysis utilizes charting tools and technical indicators to forecast commodity fluctuations in the short-term (Khan, 2023).

The third forecasting practice is the use of economic indicators. This analytical approach employs leading, coincident, and lagging macroeconomic variables to study systemic cyclical behavior present in largescale business cycles (Boehm & Summers, 1999). While a variety of published indices contain valuable information, leading indicator data points such as the Purchasing Manager Index (PMI), Consumer Price Index (CPI), and the Consumer Confidence Index (CCI) are effective in forecast creation (Appendix B1; Appendix B2). Leading indicators affect economic conditions and activity into the future (Boehm & Summers, 1999). An example of a lagging indicator is Gross Domestic Product (Appendix B2). Lagging indicators reach cycle turning points later than the current phase of the business cycle, which is characterized by coincident indicators (Boehm & Summers, 1999). When conducting a sentiment analysis with PMI as an example economic indicator, there are two conditions outlined by the expert at The Smart Cube (Appendix B2). J. P. Morgan aggregates data from manufacturers and producers from many different geographical regions and publishes the PMI every month (Appendix B1).

First, PMI data for the current period is compared with past data in order to observe or study potential trends or cyclical changes over history. Second, PMI data is compared with analyst expectations to assess market sentiments. If PMI data is below market sentiments, then expectations did not materialize, and as a result, demand is anticipated to slow and even potentially decrease (Appendix B2). By taking advantage of indices of regionally or globally amassed data, firms can utilize economic indicators to recognize changes in business cycles and macroeconomic conditions.

As forecasting and analytics focused firms, both Mintec Limited and The Smart Cube use the three foundational methodologies of fundamental, technical, and economic indicator (Appendix B1; Appendix B2). As a growing area of expertise, different opinions and perspectives on the functionality of various techniques persist. Fundamental analysts determine valuations in long-term time horizons based upon market conditions and economic factors appropriate for the relevant industry. Technical analysts emphasize market structure, and by studying past trends, they are equipped with knowledge on future price movements (Khan, 2023). A dichotomy in arguments is present within the forecasting and price analysis field. Some viewpoints believe one type of analysis is superior or provides better results than another (Appendix B1). As an example, Premia Capital Management, which is a speculative proprietary trading firm, is aligned with an exclusively technical analysis perspective and considers the futures price curve to be a full-service solution. Knowing that fundamentals are key, the firm's professionals recognize fundamental variables as embedded within the prices curve, and intrinsically, their belief lies in the notion that the futures price curve reflects information and data before a fundamental analysis can provide it (Appendix B3).

As a juxtaposition to highly speculative firms, commercially or industrially concentrated firms are attentive to fundamental approaches, but with evolutions in artificial intelligence, machine learning techniques, and coding capabilities, technical analysis is becoming an increasingly relevant topic (Appendix B1). Statistical modelling is an important piece of realistic forecast creation and should not be ignored (Appendix B2). To illustrate, Lowes Home Improvement utilizes a fundamentals approach and economic indicators as a supplementary tool, yet interest for technical analysis inclusion has been expressed by professionals within the home improvement firm (Appendix B5). In this way, a blend of analysis techniques and forecasting methods are necessary in order to construct a comprehensive and well-defined prediction of future primary commodities behavior.

5.4 Applications of Forecasting

As a valuable and effective tool for calculating and projecting the future dynamics of commodity prices, primary commodities forecasting can provide compelling insights to underpin strategic decisions within firms today. Because this analytical area specific to commodities is still developing, firms such as Lowes Home Improvement are in the beginning stages of implementation (Appendix B5). Although the impacts and consequences of primary commodities are understood and recognized, other firms such as NJR Group do not actively conduct forecasting (Appendix B4). Three major scenarios can be identified: large firms with established forecasting capabilities, companies inexperienced but earnestly introducing predictive processes, and businesses with no background and no interest in expanding analytics competencies at all. In any of these circumstances, firms with specialties in data provision, forecasting, and commodities consulting like Mintec Limited and The Smart Cube can support and offer informative insights, figures, and guidance (Appendix B1; Appendix B2).

Clients of intelligence providers specialized in primary commodities can vary in the handling of services. Some firms have internal teams calculating their own forecasts, and they merely utilize the separate unbiased data for in-house discussions. Other firms may redirect resources in favor of outsourcing information and solely rely upon third-party provider data to make strategic decisions (Appendix B1). In the case of Lowes Home Improvement, professionals at the firm perform fundamental analysis using industry data, news outlets, company figures, and intuition from experience, and in producing their own price analyses, the firm's professionals collaborate between multiple segments within the business to create their own predictive trajectories. Created by professional economists, the sourced forecasts grounded in aggregated regional data are used as a vital component for referencing and model verification. Lowes particularly uses RISI commodity forecasts to inform and corroborate their own forecasts (Appendix B3). Fastmarkets has incorporated RISI and Random Lengths commodities market expertise to become a leading price reporting agency within a multitude of primary commodities sectors. Specific to Lowes, Fastmarkets provides macroeconomic intelligence and analytics on forestry products across the globe (Fastmarkets, 2023).

Another example is NJR Group's use of forecasting and commodities price data. The civil engineering and construction firm is contracted to complete industrial construction and roadway projects for both commercial and governmental work. In order to operate, project bidding at competitive prices becomes a centerpiece. While NJR predominantly follows market prices for asphalt and crude oil, energy markets have an impact upon construction material rates. When adjusting for costs of natural gas or diesel usage in plant operations and production, the posted freight-on-board (FOB) asphalt rates are directly affected by energy price changes. As a point of clarification, crude oil is the primary input for asphalt manufacturing, and the use of diesel or

natural gas supply power to these operations. Economic indicators and indices provided by the North Carolina Department of Transportation (NCDOT) are crucial to project bidding (Appendix B4). Some of the most influential monthly data points and indicators provided by the NCDOT include average terminal prices for fuel and asphalt-cement, asphalt binder FOB prices, and a Consumer Price Index (CPI), which is sourced from the Bureau of Labor Statistics (NCDOT, 2023). In using these indicators, NJR Group aligns itself with NCDOT recommendations, adjusts plant operations to the most cost-effective fuel sources considering current market rates, and secures projects by positioning bids supported by posted index prices (Appendix B4).

Primary commodities forecasting can benefit every conceivable industry. Price movements of commodities within the market are a large consideration, and effects can impact a plethora of commercial segments, especially when complications or times of volatility occur (Appendix B2). For explicit firm purposes, strategic processes to mitigate the risk of price movement such as hedging raw materials or negotiating fixed contracts with suppliers can be informed by price analysis. In essence, budgetary purposes are the main motivation for firms to invest in primary commodities forecasting, whether it be in-house analysis, outsourcing to price reporting firms, or both (Appendix B1; Appendix B2). Revisiting one of the central firms in this analysis, Lowes Home Improvement uses forecasting commodities as an intermediary stage in the process of maximizing volume to drive sales. Commodity prices dictate costs for Lowes. Lumber prices are printed weekly, and as part of agreements with suppliers and vendors, costs change on a weekly basis. There is a sales and margin consequence from lumber that can result in a slew of outcomes. The lumber forecasts are combined with other commercially relevant commodity forecasts in copper and metals as well as other computations like rate of churn, which is the degree that merchandise consumption is slowing. At the store-front, retail hours and staffing

decisions in hiring and firing are made by utilizing the calculations from commodities forecasting. It has fiscal implications, and the lumber and building materials forecasts are a singular yet important element in informing the earnings per share calculation at the bottom line (Appendix B5). Forecasting applications are advantageous to firms, and the statistically descriptive influence found in price analysis has the potential to aid in profit maximization. Ultimately, primary commodities forecasting and price analysis are capable of providing major contributions to greater strategic management processes.

6. DISCUSSION

The previous chapters of this thesis sought to investigate and answer the sub-research questions by conducting a literature review comprised of suitable theories. In addition to the study of academic topics and models, a triangulated analysis of qualitative interviews was organized with experienced professionals in or related to the primary commodities forecasting space. Therefore, the discussion chapter deliberates on these findings and presents significant implications within research, management, and society. Moreover, the limitations of this research project as well as suggestions for future research are reported.

6.1 Research Implications

This thesis follows a pragmatic research philosophy, and the findings delivered within this work are meant to provide actionable information with practical uses in business environments. For this reason, the investigation is intended to function as an effective conduit between theory and practice. Theory is comprised of former research within academic literature pertaining to business cycles, primary commodities, and forecasting methods. Practice is represented by a case study of firms and authoritative figures knowledgeable in primary commodities forecasting and the applications to business strategy and management.

Through a theoretically motivated perspective, a basis of economic and statistical concepts within business academia has been established by this project. A detailed overview and history of developments in business cycle theory and the greater macroeconomic schools of thought is formulated. The key takeaways from the preexisting academic research are included within a study of the interdisciplinary driven topics of primary commodities and price analysis. The impact on theory originates from the clarification and purposeful design in reporting upon the interwoven components that comprise business cycle forecasting and its distinctive relevance to

primary commodities. In doing so, the research implications to theory production and enhancement can be measured as a contribution in a contextualized dialogue presenting an intersection between economics, finance, and business analytics.

In entering a discourse about this project's analysis and methodologies for data acquisition, a qualitative process is the core vehicle in obtaining central information for the investigation. Based upon pragmatic evidence and testimonies from reputable sources, such as companies and professionals in primary commodities forecasting, a real-world angle is realized. As an addition to interview standards and research methods, pursuing and including business sources with a variety of experiences including price reporting, commodities consulting, speculative, supply chain, and commercial firms provides a baseline for knowledge expansion stemming from the intention to be comprehensive and all-inclusive.

6.2 Managerial Implications

To maintain the central theme and purpose of investigating functional business applications of academic theory and literature, the managerial implications from this work are categorized into two essential actions. The following suggestions are formed given the assumption that target firms have a clear understanding of the role that primary commodities have on their company's operations as well as the greater commercial sector. If this criterion is not met, then a knowledge of commodity impacts within the specific business must be garnered. As the first implication, primary commodities forecasting and price analysis can greatly benefit a firm if implementation is completed with efficiency and efficacy in mind. As the second implication, an emphasis on the informative nature of analytical processes and results can benefit firm intelligence, advise strategic decisions, and promote advantageous actions.

As a necessary consideration, the use of economic, financial market, and industry data in primary commodities forecasting has the capability to significantly improve operational judgements and firm processes. Implementing a diverse array of techniques including fundamental, technical, econometric, and economic indicator-based approaches can deliver the most substantial and sophisticated information. While it may not be necessary to employ every mentioned technique or the most mathematically rigorous methodologies within a company, forecasting approaches are highly contextual and case-oriented. However, one paramount certainty featured in this managerial implication is the effectiveness and success from maintaining a variety of and diversification in price analysis procedures.

Continuing from the necessity to utilize multiple forecasting and price analysis methods, the second implication for firm managers is the benefit and positive contribution to the firm that these statistically and economically focused processes can offer. With exceedingly informative potential, primary commodities forecasting can support business practice and directly impact fiscal outcomes. Because the decisions within strategic management are largely budgetary in nature, the built-in descriptive and predictive power allow companies to determine the most cost effective or profit maximizing course of action. As a result, companies can optimize efficiency in decision-making and acquire a competitive edge within their respective marketplace.

6.3 General Implications

While research and managerial implications are easily perceptible and palpable in view of the project's purpose in studying business-centric applications of business cycle forecasting, a broadened perspective illuminates a presence of societal connotations relevant as well. Primary commodities forecasting and price analysis is associated with firm practices and commercial utilization, but the forces upon which these analytical techniques predict and evaluate can in part

be traced to the public. Drawing upon common economic principles and the academic underpinnings found in the theories and methodologies discussed in this work, individuals within society hold exclusive levels of consumption, regardless of choice or imposition. An aggregated consumption defined by purchasing habits is an unequivocal variable within the demand of goods and services. By this logic, it can be undoubtedly surmised that significant societal implications are present when revealing the relationship between the populace and wide-ranging economic conditions, which have previously been proven to seriously influence primary commodities behavior.

Although this theoretical presentation provides an exposition of the individual household's role in business cycles, directing the conversation to the real-world aligns with the pragmatic motif that persists throughout this thesis. One case of a shock or disruption highly relevant to the present day that assists in illustrating general implications is the Russia Ukraine war. Because of Russia's position within the oil and energy markets, the conflict and surrounding geopolitics disturbed the supply of a largescale input to industrial production, and as a result, ramifications were felt across the globe. In the absence of Russia's supply within the market due to worldwide governmental sanctions and restrictions, the volatility in energy prices rose tremendously. Not only did this affect obvious energy consumption for general populations within Europe previously consuming Russian energy, it can also impact costs within primary, secondary, and tertiary markets that use the primary commodities within energy and fuel markets for production, manufacturing, transportation, and more (Congressional Research Service, 2022). These effects present within the highest tiers of production filter through the following stages and ultimately reach the end consumers of products, goods, and services. The end consumers constitute the

populace and society as a whole. Thus, the general implications from this thesis can influence and shape the lives of everyday people.

6.4 Limitations

While this research project accomplishes a successful academic investigation into widespread business cycle theory, the nuances of primary commodities, detailed price analysis and forecasting techniques, and the applications of analytical processes in company management and strategy, there are limitations apparent within this work. The research restrictions that restrain and impede this explorative study from reaching its full potential originate from both methodological choice and the availability of data sources.

Methodologically founded in a qualitative approach, this thesis could benefit from introducing a mixed methods research design with supportive information and statistics through quantitative analysis procedures. A social and human element within the forecasting and primary commodities field of expertise is effectively demonstrated. However, mathematically based measures would deliver more compelling arguments and could provide additional perspective currently lacking within the project's design.

The second limitation is the availability of sources for data analysis. Because the main technique for data acquisition and analysis is qualitative interviews, the interview respondent component is critical. Willingness and responsiveness of professionals and firms was a major hindrance. The bulk of inquiries for interviewees went largely unanswered. Another obstruction was the release of information by companies. Due to company specific ethics and compliance guidelines, professionals were actively discouraged to take part in this study, although academic ethics, morality codes, and use of data were proactively emphasized to potential participants. A

greater number of interviewed professionals and diverse firms would improve the thesis by exploring forecasting techniques in different industries, commodity groups, or environments.

6.5 Suggestions for Future Research

The subject of business cycle forecasting for company competitiveness within the context of primary commodities can be expanded upon in many different ways. In the present work, the commodities pricing agencies of Mintec Limited and The Smart Cube served to be informative on general forecasting procedures. The proprietary trading firm, Premia Capital Management, offered theoretical context and a technical analyst perspective. The cases of NJR Group and Lowes Home Improvement provided specific background and applications of commodities within different industries. Future research in this subject area could potentially be conducted within financial and capital markets or other commodities and industries absent from this thesis.

For financial and capital markets research, a divergence from company specific applications of commodities forecasting to investing and portfolio optimization could build upon the price prediction tenets established by Premia Capital Management. Through an incorporation of the futures price curve and trend following models, a study in conjunction with other proprietary trading firms could possibly expand upon this research project into asset diversification and capital market theory.

Other areas worth further investigation are more closely affiliated with this work's purpose and main research question. The present research is explorative and seeks to broadly determine the applications and subsequent benefits of commodities market forecasting. Nevertheless, a more detailed and specific focus for academic inquiry has the potential to scrutinize specific industries. Examples could include food industries, aerospace, technology, clothing retail, and more. Several feasible possibilities have the potential to develop from foundations laid here.

7. CONCLUSION

The conclusion provides a culmination of the theoretical groundwork, analytical findings, and subsequent implications realized through this thesis. In order to accomplish this, revisiting the established problem statement is the most appropriate means. Because the summation of the seven sub-research questions originally outlined in the introductory pages equate to the main research question, brief resolutions to each of these inquiries are detailed first and foremost. In closing, the main research question is finally resolved.

1. Which business cycle theories exist?

Business cycle theory and macroeconomic thought have been under near constant development for more than a century, and as the world continues to advance and the nexus of economic variables is studied, progression within the field of research is sure to continue. Early business cycle theories were founded in the nineteenth century farming industry, extinct money systems such as the Gold Standard, and emergent economic ruminations. They became the underpinning for the most widely respected and prevalent developments in macroeconomic research. Throughout the twentieth century leading to the present day, many different business cycle theories were devised. Each were built upon unique assumptions and expectations about the world. Some of these theories include Keynesian Economics, Monetarism, Real Business Cycle Theory, New Keynesian Economics, and Austrian Business Cycle Theory.

Growing from the intention to understand the world and the relationships found within it, these assorted theories keenly supported their own academic positions and economic models, but as time has passed, thought on macroeconomic fluctuations has evolved. Consequently, a few key features delivered from these historical perspectives have become commonly accepted by academics and industrialists alike. The first is rational expectation theory. Agent expectations

and an intrinsic self-fulfilling disposition in human behavior is an important consideration within business cycle theory. Second, both supply and demand factors are fundamental sources in economic fluctuations. Recognizing shocks from a plethora of causes is important. Lastly, governmental policies in both monetary and fiscal can influence money supply and effectively output, which can cause economic condition variability. Ultimately, a singular business cycle theory has yet to be established as the irrefutably best model for reality, but characteristics founded in many of the historical theories continue to reemerge and persist within the modern economic environment.

2. How has the primary commodities market developed over time?

Primary commodities are synonymous with raw materials. However, commodities can also be defined within economics as the most basic good used in commerce as well as the most fundamental input for the industrial production of general goods and services. While commodities classifications organize these materials in a multitude of permutations, a common and simple division of commodity classes partition into the agriculture, metals, and energy sectors. Agricultural commodities are generally grown commodities, which include farming crops, livestock, and forestry. Metals comprise industrial ores like iron, copper, and aluminum and precious metals like gold, silver, and platinum. Finally, the energy sector splits into fossil fuels such as coal, oil, and natural gas and alternative energies such as wind, solar, and geothermal.

The uses of primary commodities have evolved significantly over the past one hundred and fifty years. Due to industrialization and globalization, the commodity sectors of metals and energy in particular have become vital to society. Construction, automotive, electronics, and machinery are just a few of the relevant markets consuming metals in manufacturing. Due to

versatility and usefulness, energy commodities are essential inputs within industrial production for their applications in transportation and electricity.

Another topic important to primary commodities market development is financialization and electronic trading. Original commodity exchanges were physical locations, but the acceptance and growth of technology provided a standardized virtual space for market participants to trade with each other across the globe. The implementation of financial instruments such as futures within commodity trade allows buyers and sellers within the market to agree on a price, months ahead of the commodity delivery date. The futures commodity price market introduces a dynamic in which speculators can potentially affect overall commodity prices through trading based on expectational hypotheses and price analysis.

3. What is the relationship between primary commodities and the business cycle?

As in business cycle theory, key determinants in primary commodities are the economic principles of supply and demand. Additionally, cyclical behaviors within the primary commodities market have been observed over the past century. A definitive coincidental overlap between broader business cycles and commodity specific price cycles cannot be determined, but characteristics shared between the two types of cycles are evident. For example, commodity booms are characterized by fast macroeconomic expansion through high growth rates in GDP and industrial production, and an observed increase in industrial production can infer increases in demand and consumption which in turn indicate a boom phase of a business cycle. Furthermore, technological advancement is proven to have positive impacts in driving economic cycles, and because primary commodities across all sectors are influenced by innovations in technology, it can be surmised that the improved processes for harvesting, manufacturing, or refining commodities influence supply and demand of production inputs. Thus, a relationship between

impacts within commodities and the general macroeconomic factors of business cycles is established.

4. What factors contribute to changes in commodity market price?

As mentioned above, primary commodity prices experience cycles from times of expansion to recession. Time horizon is an important factor in understanding commodity price fluctuations, where cycles are split into two components: transitory and permanent. Transitory components include short-term cycles of less than 2 years, traditional business cycles from 2 to 8 years, and medium-term cycles from 8 to 20 years. The permanent component portrays super cycles which are price movements of twenty years or more. These differences are important in the context of specific commodity sectors. Industrial commodities closely associated with energy and metals are affected within the short run. Agricultural commodities are more relevant to longer-term cycles.

The major drivers identified as root causes in primary commodity price cycles are demand, supply, and commodity specific shocks. The implications to macroeconomic conditions differ between the types of shocks. Demand could be affected by government stimulus or policy implementation. Supply could be influenced by a supply chain disruption or production innovation. Commodity specific shocks are separate from supply or demand and can originate from geopolitical, financial, or public expectancy. Oil and energy products are a prime case for shocks derived from places other than supply and demand. As a key input for industrial production and manufacturing, a change in energy prices can also have ramifications upon the prices of other commodity groups. Moreover, the identification of specific root variables and causes can prove to be challenging as many of these shocks can occur simultaneously or in lockstep with one another.

5. What techniques are companies utilizing to forecast and analyze commodity prices?

Several price analysis and forecasting techniques are utilized within the business environment to predict primary commodities prices. These analytical procedures are categorized into three main groups: fundamental analysis, technical analysis, and the economic indicator approach. More specifically, econometric practices such as linear regression and time series analysis are particular methods under fundamental and technical analyses.

Fundamental analysis is defined as the use of economic models of industry specific variables to forecast commodity prices. The consideration of information in company financial statements, economic conditions, industry trends, and management are important to this type of analysis. Because supply and demand are pivotal for commodities, the use of balance sheet variables such as beginning stocks, production, consumption, residuals, imports, and exports are necessary.

Technical analysis can most accurately be described as an examination of market structure to predict commodity price trends within the futures market. Time series computations using moving averages can assist technical analysis in smoothing trendlines to order and display the data for more predictive power. As a mathematically demanding procedure, the uses of chart evaluation, trend analysis, and numerous moving average models can forecast commodity futures market prices.

As the final analytical approach, economic indicator methods are based upon wide-spanning macroeconomic variables present within business cycles. There are a number of different indicators, but the most pertinently used for forecasting are leading indicators, which are measures of market or economic actions in the present that affect the future. By employing data

derived from aggregated indices, the changes in macroeconomic conditions or business cycles can be recognized.

6. *What are the benefits of different techniques?*

Each of the three techniques offer useful information on the different aspects of primary commodities price behavior. Fundamental analysis is most beneficial in long-run time horizons and works well when focusing on variables unique to an industry. Technical analysis performs well in predicting the price movements in the short run and applies rational expectation theory and speculative agent behavior within the commodity futures market. Economic indicators provide an expansive view of the macroeconomic environment and globally impacted factors relevant to business cycle theory. In practice, companies use a combination of all three of the price analysis and forecasting methodologies for the most effective results.

7. *How do companies implement forecasting results in decision-making processes?*

Forecasting the dynamics of primary commodities prices and behaviors acts as an informative basis upon which firm managers can make strategic decisions. Companies within industry forecast prices themselves, but it is common practice to consult or even completely outsource to analytics and price reporting agencies with specializations in commodities. Price analysis and primary commodities forecasting can benefit all industries. Budgetary concerns and fiscal implications are the central motivation for firms to implement data from these analytical practices.

Previously established, primary commodities are an essential input to industrial production. Instances illustrative of this relationship include energy for manufacturing, fuel for transport within the supply chain, industry specific uses in commercial product fabrication, and more. Ultimately, commodities prices can influence a multitude of aspects within a company. The cost

calculations informed by forecasting and price analysis at the beginning stages of production are prominent in the budgetary allowance for the rest of the firm. Thus, the advisement provided by analytical data from primary commodities forecasting direct the strategic management and decision-making processes that have consequences on sales and profit margins.

How can companies improve competitiveness through commodities forecasting?

With foundations in business cycle theory, acknowledged macroeconomic factors, primary commodities price behavior, and statistical and fundamental analysis methodologies, business cycle forecasting and primary commodities price analysis promote improved strategic management within modern companies. Understanding key factors within business cycles and the macroeconomy such as supply, demand, and rational expectations reinforce the industry-related variables most pertinent to primary commodity price fluctuations.

Through the applications of the industrial, financial, market structure, and economic relationships established by theory, a toolset of several commodities price analysis and forecasting techniques can be utilized to inform firm decision-making and promote organizational efficiencies. Because primary commodities are vital industrial production inputs, budgetary consequences as well as influences to the overall firm financials must be considered. Primary commodities forecasting can improve company competitiveness as a descriptive and informative instrument in strategic decision-making processes with implications on added firm value and profit maximization.

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9. APPENDIX A: INTERVIEW GUIDE

Remarks Prior to Interview:

- Thank the respondent for their participation in this study
- Provide brief introduction as the student interviewer
- State the purpose of research, being the main research question, "How can companies improve competitiveness through commodities forecasting and trading?"
- State the respondent's role in the analysis portion as expert interviewees to provide the real-world application of the literature review concerning commodities and forecasting

Ethics:

- Independence of research is maintained, no conflict of interest is present, and responses gathered through the interview will exclusively be applied for this thesis project
- Confidentiality is taken seriously, and all information can only be accessed by the researcher and thesis examination evaluators
- By being present for the interview, the respondent agrees to participate, yet the option to withdraw participation at any time can still be exercised
- Request the approval of quotes and information given through the interview to be utilized within the research project

Participant and Target Firm Questions:

- What is your full name, age, and position within **(insert firm name)**?
- How long have you been with **(insert firm name)**?
- Can you briefly describe **(insert firm name)** and its specific use of or commercial link to commodities?

Forecasting Questions:

- If the firm deals in procurement and trading specifically, how important is commodities forecasting to **(insert firm name)'s** operations? To what degree are forecasting techniques utilized?
- What are the main forecasting procedures and techniques used by **(insert firm name)**?
    - How has commodities forecasting developed and changed over time?
    - What time horizons into the future are forecasted?
    - How consistent or reliable are forecasting results?
- Which techniques and models are the most effective? Why is that?

Model Variable Questions:

- Are business cycles taken into account when constructing forecasts?
    - If yes, could you expand on this and explain key factors or economic variables included in forecasting models?
        - What other general factors are considered besides business cycles?
    - If no, then what factors are primarily considered in forecast construction?
- How are models adjusted by commodity group (agriculture, metals, energy)?
    - What variables or indicators are the most influential for each commodity sector?

Implementation and Practice Questions:

- What industries or types of firms are most impacted by changes in commodities?
- What are some general actions taken in managing commodities?
- How do forecasting results support planning and prompt decision making?
    - What are some examples of decision-making processes affected by forecasting results?
    - How could commodities forecasting be leveraged for the future?

Conclusion:

- State that the interview has concluded
- Ask the respondent if they have any questions for the interviewer
- Thank the respondent once again for taking the time to be interviewed and provide field expertise

10. APPENDIX B: QUALITATIVE INTERVIEWS

10.1 Appendix B1: Interview with Mintec

Date: 16 November 2023
Medium: Microsoft Teams
Duration: 34m 4s
List of Acronyms: I = Interviewer, R = Respondent

Consent for interview recording is received by the interviewee.

[Begin Transcript 0:05]

I: I'll go over some of the ethics again, just so that it's clear and evident. So of course, the independence of the research is maintained. I don't have any conflicts of interest. Everything is solely used for academia and my thesis project. Additionally, confidentiality is taken seriously. The only people that are going to be able to see any information that we discussed is myself, my supervisor, and thesis examiners. Nothing is going public, purely academic.

R: Yeah, that's true. Yeah. Yeah, Yeah, Yeah, that's fine.

I: And I guess finally, I just want to get your approval to be able to use these quotes and any information in my thesis research paper.

R: Yeah, of course. And, as I said that you're welcome to use it. Whatever. I just, yeah, my only concern was my company name was going to be used publicly or anything or even just my name just because they might complain about it. So yeah, but if it's staying in your thesis, and that's not a problem.

I: Perfect. I guess I'll introduce myself. So again, thank you so much. I know you're a busy guy, and I just really appreciate you helping me out with my thesis.

R: No problem.

I: So, my name is Miles Shen. I am a double degree graduate student at Copenhagen Business School and the University of North Carolina at Charlotte. My main research question is how can companies improve competitiveness through primary commodities forecasting and trading? I've already done a lot of the literature review of like business cycles, primary commodities and cycles and forecasting from an academic perspective. So, as an interviewee, you are kind of coming in to shift it more to the practical side of things to see "how is this actually working in business and the real world?" Let me just give you the opportunity to introduce yourself.

R: Yeah, I've worked in commodities in one form or another for maybe six years. So, I did business in economics then did my master's in economics. I did a similar sort of thesis on what causes the price fluctuations in the oil market to determine its price movements. How much is

fundamental? How much is speculative movement? Things like that. Then I went and joined an [organization] called Conoco Phillips or Phillips 66. I don't know if you're aware.

I: I'm aware.

R: So, I joined them and worked as an analyst for their trading arm of the business doing profit loss analysis. I did that for a year or just over, and then I went to be a market analyst at a company called Argus where I worked on their crude market coverage. And then, that was very niche doing pricing and market reporting just in the crude market, mainly on the North Sea crudes and some African markets. Now, I work at a company where is much broader. Before it was very niche crude oil markets. Now, I'm actually covering different markets now. So, doing Forex markets and a few other ones like that. I'm actually just starting on some power markets and a few metals as well.

I: OK.

R: I supposed that's my background, but it's definitely been a change for me over the last year or two where I worked, not even on crude markets, but very niche markets and very sort of specialized knowledge. Then, it's very different at the company I'm at now where everyone covers everything.

I: Yeah

R: But right now, it's less about being an expert on specific markets and more of this focus on, I suppose, the forecasting process. And applying that to as many markets as they can.

I: OK. So, what is your technical position name at Mintec now?

R: So, I'm a forecast analyst.

I: OK, OK. So, I know that Mintec is primarily just a forecasting analytics firm, but could you just briefly, top level, explain Mintec to me?

R: Yes. So, it's actually the forecasting on the business, which is obviously where I am. It actually was bought by Mintec maybe a year or two back. They were a small Danish company actually in Copenhagen.

I: Kairos.

R: Yeah, that's right. I don't know if you talked to anyone else at Mintec.

I: No, you're actually my first interview. I've had a time trying to get people so you are kind of like a God send.

R: Yeah. That's fine. I remember doing my thesis, and I thought, "Yeah. It sounds difficult working on interview people." So, I did mine on secondary data. I'd rather spend 8 hours

scrolling through data rather than trying to get people to talk. So yeah, working with Kairos. How have you heard of them?

I: Well, I was talking to my supervisor, and I studied in Copenhagen. And, my supervisor is Danish, and he said to look into this company. They were bought by Mintec.

R: Yeah, yeah. So, they got bought by Mintec. They do more pricing and data. They come up with their own primary data and sell some secondary data. They were more focused on market coverage and market analysis. They were really involved with forecasting until Mintec.

I: Ah.

R: Joining Mintec was the first time I really worked into forecasting myself as well.

I: OK.

R: Previously, it was market and pricing analysis and things like that, profit and loss.
I: I'm curious, how long have you been in your position?

R: 18 months. Somewhere between a year and 18 months.

I: OK, OK. What roles around forecasting do you actually do now?

R: Umm. What do you mean by that?

I: What procedures and techniques do you go through? So, I'm assuming you create models.

R: So, how do I do the forecasts?

I: Yeah, yeah.

R: Yeah, so there's probably 3 pillars to do what we do. There's fundamental analysis. We look at things like supply and demand data, inventories, costs. That's one of the three pillars. If we're looking at things like if we can see the costs are going up while prices are going down, we know that that diverge probably can't continue. So, we do fundamental analysis on that side of things. We do then a large part of technical analysis as well. So that's like look at trends. A lot of that is oscillators and moving averages and all those kinds of different things like that. And then some macro analysis as well, business cycles and things like that. We put those three things together to come up with forecasts and then present the forecast to the client. Generally, we forecasting price for each quarter.

I: So, how far out are you looking.

R: I think it's 18 months or something like that.

I: OK.

R: As we forecast, it's very difficult. Everyone has their own sort of methodology about how forecasting works. So, we have a following quarter which we call the next active target, which is what most of the earnest is being put on now. Like now for us, we're looking at Q4 prices and Q1 prices. Whereas, we will also be forecasting out 18 months from now, but by the time those times come around, those forecasts probably would have been adjusted. Whereas now, we won't be really adjusting things, so Q1. Or if we do change our outlook, that I suppose is the whole procedural methodology we would have to go through to tell people why and send out updates that we're changing our quarters. If I change my target in 18 months, I won't be sending out to notify clients because no one really looks at that.

I: Ok. Got it. Thank you. I wanted to go back a bit to the third pillar. I'm really interested in that. You were talking about macro-meso levels specific to, I guess, business cycles. Can you just expand on that? Explain more about that construction.

R: Yes. So, one of the key things we look at is the PMI. Have you spent much time look at the PMI or anything like that? It's an index which is produced I think by JP Morgan. It's essentially a survey that they send out to manufacturers and producers. And, they fill it in, and JP Morgan aggregates it and essentially boils it down to a few numbers for different regions. And, I'm sure it's much more complex than that, but that's one of the big things we look at with where the macro-economy is at because it says so. So that tends to be what a lot of people will like for figures like GDP, CPI, and things like that to see where the economy is at.

I: So, the PMI, at least at the macro and meso level, is more like economic indicator type stuff.

R: Yes. Yeah, that's it.

I: Okay. I'm trying to piece it all together because I have all these moving parts, but I'm thinking, how does that specifically differ from maybe the fundamentals where you're looking at supply and demand?

R: So, so sorry. When you say how does that differ from supply and demand…?

I: I guess what I'm asking is, I'm assuming that everything is tailored to each client of course. On your 3 pillars, technical I get and economic indicators I get, but I guess, is the fundamental analysis more market specific? What's the difference?

R: Yeah. Yeah. That's definitely market specific. So, there's a few ways we do it. One of the big things we do is we have a fundamental regression which we have all these different fundamental data points, like say supply and run. Let's just say, oil. You've got the cost of production, inventory levels, and supply and demand. But the there's obviously overlap there within the trees, but with supply and demand, you've got seasonality. Perhaps prices typically go up as it gets colder in the Western world. We'll have all kind of different fundamental data points, and we'll also look at the market structure with the futures contracts and if they're in contango or backwardation. I don't know if you watch with futures contracts.

I: A little bit. I was rereading some of my theory today, but I found that it seems like there's a bit in the literature saying they're not really sure how indicative a lot of the financial side of things really is.

R: There's definitely, say from a lot of people, an overemphasis on market structure with futures. I suppose some people think that the future markets prices of the December contract, let's say that we're in the November contract, and the December contract prices are going up, then they tend to follow each other. The price might come down from there, and that's not the price we're going to be at in December. So, there's definitely time its useful. So, I was looking at some of the steel markets earlier, and they're in a really strong contango, and I think when you see all the future month contracts all going up pretty aggressively that's a good indicator. And, also, if you don't want to use it for an indicator for price, it tells you things like where everyone else's perception is. People are expecting prices to go up.

I: OK.

R: There's another way we look at that as well through the CFTC (The Commitment of Traders Report). I don't know if you have come across that before.

I: No.

R: Again, for us it's a small piece of the pub. It tells you the net positions of speculators. It takes all the long contracts and all the short contracts basically and tells you if speculators in the market are net long or net short.

I: OK.

R: Again, some markets that's a really good indicator, and some markets is kind of irrelevant.

I: That's good. What you've said so far has been great. It's really shed a lot of light on all the stuff I've been reading. That's awesome. Moving forward, how are your models adjusted specifically. Do you do it by client or commodity group?

R: Yeah. Yeah. It would be by commodity group.

I: Can you explain some of the key differences and factors?

R: Yeah, but I can't give away fully, but essentially, it's about looking through the different things we talked about like different technical indicators, different fundamental data, and seeing what is relevant for some markets. Some speculative markets could be a really useful piece of data to look at and use in your analysis, and some markets you can see that it's just white noise. It's totally irrelevant to how price fluctuates. It's about going through and seeing which markets from a technical perspective trend very well, and some markets are really noisy and fluctuate a lot and breakthrough moving averages constantly. So it's about look at each market, how it operates, and determining which data points and variables you want to use for each market.

I: OK. Perfect. Moving forward past forecasting, and maybe you don't have as much information, but I'm going to ask anyway. What might a company or client do as far as decision making and actions to take with the forecasting data that your firm [Mintec] provides?

R: Sorry. What do companies do with the information that we forecast and provide?

I: Essentially.

R: Yeah. I think that's definitely an interesting question, and it will really vary a lot. Generally, the biggest is it's got to be worth their money to pay for a subscription and then got to be buying enough of the commodity to make it worth paying a reasonable amount of money for forecasts. They're generally bigger, but some will be massive clients, and they will have huge teams internally. They will be taking our forecasts and data that we present and thing like that. They will sit at a table themselves and say, "Do we agree with it or don't really agree with it? Well, if we don't agree or we agree it's also going to go up, but we think that that is too bullish. We think it's going to go up, but not as much." We have some that will use it as a tool for their own internal discussions, and then there will be some which, I mean this is just an assumption and I don't actually know, but then I'd say perhaps some of the smaller companies that don't have their own teams to do this sort of thing may take it very much at face value. "Essentially, we're outsourcing that. We take that information as gospel and whether it's right or wrong, that's what we're going to use." I suppose that's the two different ways they can use the information, or they can think about the information. In terms of specific uses, it goes on to be used for some companies for budgeting the start of the year. So, to prepare for their costs and doing their financial statements and their expected expenses, whatever it would amount to be $1,000,000 of corn or whatever commodity that they're buying. I mean the primary use of what we also provide them with would be forecast hedging recommendations. It would really be for companies to take this information and hedge their exposure to these commodities.

I: OK.

R: So ideally, they are going to be hedging when the prices are low and fixing their prices for the next year or whatever it may be. They're probably using the information for hedging purposes, some budgeting, and then also some negotiations. So may be if they have to, maybe the way that the industry work is to fix yearlong contracts with suppliers. They obviously have to set these prices and one party may say, "This is unfair. This is not where the market is. The market is expected to go up. Look at Mintec's forecasts." I suppose another use is for it to be an independent figure out in contract negotiations and things like that.

I: OK. Perfect. And just to be clear, these firms are actually putting these commodities potentially to use. Either in like maybe manufacturing and construction and so on and so forth.

R: Yes. Yes. Yes. Definitely. I'm not even privy to our client lists myself, but I think we'll have almost no speculative firms or trading firms who are trading financial contracts to make a profit.

I: OK.

R: This is 95% either consumers or producers, which are looking to hedge their exposure to the volatility in the commodity markets.

I: OK. Perfect. Into the future, what do you see for forecasts? You have only been there [Mintec] for 18 months and you have a pretty wide experience in commodities in general. What are your thoughts as a professional?

R: I think probably an increasing acceptance and use and demand for technical analysis and things like that. I think there's a kind of dichotomy between people who think with fundamental analysis and technical analysis is rubbish. Or people who think fundamentals are no good by the time you get fundamental data. There's sort of an argument between the two. I think in coming forward, firms start to use technical analysis more, especially with increasing coding capabilities and AI and things like that. It's going to become much easier for firms to build their own models to do these sorts of things. So, I think increasing technical analysis usage. As I said, we're not working with sort of high speculative firms and things like that, but one of my colleagues was saying the other day that in the last couple of years, there has been an increasing number of clients who want to be able to see the technical analysis and use it themselves and have access to the tools, which probably wasn't the case some years ago.

I: I think what you've said has been great. Again, I just want to say thank you so much for taking the time to talk with me. I mean, it's really been so insightful. That's the conclusion of my interview. Do you have any questions for me?

R: No. No. Nothing for me.

I: Do you have any feedback for me and how I contacted you cause that might help with finding more interviewees?

R: So, you probably just want to mass send out. Many people are going to say no.

I: Well, regardless, I really appreciate it. And thank you again for taking the time.

R: No problem. Is forecasting something you're looking to go into when you finish your thesis?

I: I'm not entirely sure. It's definitely a point of interest, which is what even had me think of doing a thesis like this. We'll see.

R: Well, good luck with that.

I: Thank you so much [respondent]. I appreciate it. You have a good afternoon and evening.

R: Have a good day. Cheers. Bye.

[End Transcript 34:04]

10.2 Appendix B2: Interview with The Smart Cube

Date: 2 December 2023
Medium: Microsoft Teams
Duration: 32m 27s
List of Acronyms: I = Interviewer, R = Respondent

Consent for interview recording is received by the interviewee.

[Begin Transcript 0:17]

I: OK. So, before we get into it. I'm just going to cover the ethics. I've got a few bullet points that way we're on the same page and everything is really clear. So first and foremost, independence of research is maintained. I don't have any conflicts of interest. All the responses gather during this interview is being purely applied to academics and for the research project. Confidentiality is taken seriously. None of this is going to be public. Again, it's just going to my university, and it'll be accessed by evaluators and myself, of course, as the researcher. By being present, essentially, you're agreeing to participate, but you can always withdraw or leave at any time. And finally, do I have your approval to use what we talked about in my research?

R: Yes. You can.

I: Perfect. OK. So, thank you so much, [respondent], for helping on this. It is going to be such a big help to my research. Just as a brief introduction, my name is Miles Shen. I am a student at Copenhagen Business School and the University of North Carolina at Charlotte, and I'm doing my thesis, which is on how companies can improve competitiveness through commodities forecasting and trading. Because you're an expert in this at The Smart Cube, I think it would be great to talk to you. You can let me know about a little bit about your role and how forecasting plays into that within the realm of primary commodities. So, I guess, let me leave the stage to you to give me a brief introduction about yourself and your background and experience.

R: I've been graduated from an economics background. So I've done my bachelors as well as masters in economics, and it's been three years now since I've been in The Smart Cube and majorly the commodities domain. My current roles and responsibilities include commodity price forecasting where I'm involved in the handling of bars and different baskets, but I'm currently taking care of a base metals basket, which includes base and precious metals.

I: OK.

R: Base metals include copper, aluminum, zinc, and others which are the industrial metals and backbone of the economy. Precious metals include gold, silver, platinum, palladium, and more that goes into speculative hatchings but can also contribute to the industrial side.

I: OK. So, you do both? Your analysis is for both industry and speculation.

R: No. So basically, the forecasts that we do in our organization is not for speculation purposes because the speculation market is very dynamic and can react to very small changes in the news.

I: Ah.

R: Our goal is to provide some procurement intelligence to our clients.

I: Ah. OK. OK. That's what I was asking. Could you expand on that just a bit more and The Smart Cube's role in assisting in industry and procurement with your data and forecasts?

R: So generally, if a client is asking for commodity price forecasting, our work is to provide the forecast. It could be a 12-month or 18-month forecast depending on the client's requirement. Our work includes 70-80% research about the commodity and its specifications and 20-30% in the analytics portion.

I: OK.

R: So, we basically start with the fundamental analysis, which includes commodity drivers: demand side, supply side, and the macroeconomic. To understand commodity dynamics, we ask "What all factors could have an impact on the commodity prices?" So that is the fundamentals. Then we have the technical analysis where we see the daily price futures chart of the commodity. Then based on that, we can foresee where the prices will go up or where it will become support or resistance and where could be the next support or resistance for commodity prices. Then, we also have the sentiment analysis, which includes the market reaction to various macroeconomic indicators like lagging or leading indicators. So, let's suppose we have data on the PMI, which is Purchasing Manager Index, which indicates the industrial activity of an economy. So, we have PMI of let's say China and other economies. Based on that, we can understand what the current industrial or manufacturing situation of that country.

I: Can I just in and get a clarifying point?

R: Yes.

I: OK. You mentioned fundamental analysis, technical analysis, and sentiment analysis. What percentage does the sentiment play into? Would you say that this is more fundamental side, technical side, or its own thing?

R: Market is majorly driven by fundamentals.

I: Yes.

R: In case of any unforeseen events, we have the Russia Ukraine war and then currently we have the Israel Hamas war. So, these can be cases where we can see sentiment wise price movement in the market, but eventually, the market gets more clarity about its fundamentals. Eventually, prices will get back to a normal state. I can tell you during the Russia Ukraine war, we saw significant volatility, especially in the energy market because Russia is a major contributor in

that market, but once the market gets clarity on Russia's contribution and the production cuts post the imposition of sanctions from the US, prices went back to original levels.

I: OK. Great.

R: In the case of unforeseen events or circumstances, prices react very much, but that is for a very short period of time for like one or two weeks. Once the market gets more clarity, prices get back to original levels.

I: I guess, I'm curious about forecasts when it comes to these unforeseen events. What impacts do they have? I know in the short term its very volatile for a week or two, but in the long term, do they have a greater impact or does it balance out?

R: So, it impacts the commodity baskets first, and then, it also impacts the geographical locations.

I: OK.

R: Since COVID-19, energy prices have been very volatile, and they have been rising since. The Russia Ukraine war took energy prices to record high levels, but once the market got more clarity about the war, price went back down to pre-COVID levels. It depends on the macroeconomic conditions and the geographic conditions as well. Since Europe has been facing energy issues since September 2021, we saw natural gas prices start to rise. If you see the current prices of natural gas as well in Europe, they have been at elevated levels. Although they have declined since the Russia Ukraine war, prices are still elevated compared to September 2021.

I: OK. Great. Moving into more specifics to forecasting procedures and techniques, how have you seen forecasting change in the past few years? Or has it? We'll start with that.

R: OK. I told you about fundamental, technical, and sentiment analysis. We have this to understand the commodity market and its dynamics. Something we also apply is statistical modelling to come up with forecasts. We majorly use linear regression modelling.

I: OK.

R: We also have time series models including ARIMA modeling, seasonality analysis, seasonal decomposition, Holt-Winters, and exponential smoothing. So, these are some other techniques that we focus on for commodities prices. Once we are done with the commodity modelling, we have model driven estimates that we have but cannot incorporate because of statistical limitations. We cannot incorporate every variable into each and every model that is impacting commodity prices. This is where expertise and basic understanding of the market comes in to adjust or tweak forecasts to make them more realistic for the clients.

I: Speaking on model construction, what variables might go into a forecast?

R: Again. It is very subjective depending on the commodity. I'll tell you about my commodity. Let's suppose you are working on a commodity price for cars for copper. So, in copper, we have demand variables, supply variables, and the macroeconomic variables. We have these three broad categories. In this, we apply copper as a mineral for extraction from the mines. First, we need to understand the mine market for copper. Then, we have refining of the ore and concentrate from the mines. This other side is the refining side of the market. Then, we have the end use of that copper from the mines. So, we need to understand those dynamics. Chile, Peru, or other LATAM countries are major contributors in the mining market. Refining is majorly concentrated to Asia, specifically in China. That is how we understand the commodities fundamentals. And then, our next goal is to majorly find the indices for these variables.

I: OK.

R: So, Miles, if I tell you Chile and Peru are the largest producers in the ore market, I'll try to find the variable data related to Chile and Peru such as Chile exports to the world, Peru exports to the world, Chile copper production, Peru copper production, and anything related to copper for these two countries.

I: So, that's on the fundamental side of things to understand more market wide effects.

R: Yes. Yes. Yes. That is from the supply side since both are major suppliers of the market. Then, we have [copper] in terms of demand. We know copper is used heavily in the automobile, construction, and renewables sectors. So, we try to find data related to those segments. We try to find construction data of any economy like U.S. housing charts, U.S. construction data, and Europe housing charts. And, in the automobile [segment] we can get the automobile production and the EV segment. So that's how we find data related to the demand side.

I: OK. And then the macro side.

R: Yes. The macro side may differ. The USD index is a very crucial variable in deciding the base metals market because base metals are generally quoted in dollars, and any change in the USD index will have a direct impact on the currency holders of different countries. So majorly any depreciation or an appreciation will have a negative impact on the copper prices.

I: Yeah.

R: So, we can consider the GDP growth of the top five economies like US, Europe, India, China and Germany. That is how we generally code. And then, exchange rate of difference currencies also plays an important role like Yuan verses USD exchange rate. Because if we see a depreciation or an appreciation in the Yuan, then it will basically impact the China imports.

I: OK, I see. So that has to do with more logistical effects, as far as like when you're moving these resources from place to place. That might have an impact on the commodity price too, no?

R: Yes. Yes. So, freight rate also has an effect on the commodity market. In the exchange rate, let's suppose, if we are facing any depreciation in the Yuan, it will very expensive for a Chinese

buyer to import copper from the overseas market. Being the largest copper importer in the world, that will have a direct impact on the copper demand of the world and hence it's prices.

I: Perfect. That makes a lot of sense.

R: Then we have freight rate. Like we also saw during COVID-19 when everything was shut down, there was a massive condition at the various shipping ports that led to a supply chain disruption in each and every basket of the commodity. It then led to a sharp rise in the prices as well. If you see the prices pre-COVID in 2018-2019 and compare prices during COVID-19 until now, there will be a rising trend. So, any logistical issue or any congestion at the port will lead to a sharp rise in the prices because that is majorly impacting the contracts fulfillment of the buyers. If they are facing any logistical issues, they are not getting any deliveries of their contracts. That will create a major panic demand in the market and drive-up prices.

I: I see. So that's a good overview of the fundamentals of the market: supply side, demand side, and macro side. Can you explain how the 20-30% of the technical analysis plays a role in your overall forecast as well?

R: Analytics accounts for 20-30%, but I'll tell you about technicals as well. Once we have the current prices of that commodity, let's suppose I'm having prices at $1000 today and I have some news like a supply disruption, I can anticipate prices to rise in the short term. Technical analysis helps us to decide the levels at which the prices may go up. So, prices may go up to $1100 or $1200 or even $2000, but based on technicals, we have the daily charts of commodity prices and apply indicators in the analysis. This includes support and resistance. Commodity support is where the price will not majorly fall below a level, and resistance is the point where price will not majorly go above that level.
MS: Ah, OK. To clarify, these are in more of the financials and looking at the financial market like futures prices?

R: Yes. Yes. So, these indicators are available online and they are more into stock market movement and stock volatility. Investors use those kinds of indicators to understand overall volatility in the stock market, but that also helps us in deciding the levels at which the prices may go up or go down.

I: Got it. I see. That's perfect and gives me a good understanding of that. So, you talked about the idea of sentiment analysis. Can you talk to me about how that concept translates to putting the sentiment analysis in practice?

R: So, in the sentiment analysis, we have the leading indicator and lagging indicator. So leading indicators, we'll talk about the futures like I mentioned, PMI index, and Consumer Confidence Index. While GDP data of an economy is a lagging indicator.

I: I see.

R: PMI data publishes on the 1st of every single month. So, on the 1st, we have the PMI data for U.S., China, Europe. I will continue with the copper example. In China, copper is a major

demand side driver currently because Europe and the U.S. are facing recessionary issues. In December 2022, China lifted its zero COVID policy. Since then, we have seen the market was majorly driven by China on the expectation that China's economy will grow and rebound from COVID-19. This kind of data plays a very important role. I get the PMI data on the 1st of December, and there are two conditions.

I: OK.

R: First, I have that PMI data compared with last month's, and then I also have to compare that PMI data as per the analyst expectations. If the PMI data is below the market sentiments or market level, so let's suppose the market was expecting that PMI should be around 52 levels and is actually 49 levels, the slowness or the rise that the market was expecting did not materialize first. That will majorly erode investor sentiment in that particular economy.

I: I see.

R: Since we are generally tracking PMI of the manufacturing sector, we can interpret that there is no anticipation for a recovery in the short term in the manufacturing sector of China. This helps us in understanding the demand side, like copper demand, in China from the manufacturing sector will likely go down. I can consider that this will prevail in the following month and can expect slowness in demand from copper in China.

I: OK. Thank you. That shed a lot of light and has been really good. Let me shift gears to what you actually do with the forecasts. What industries can benefit from your forecasts? Like manufacturing, construction, etc.

R: Forecasting is something that is heavily required in each and every industry. We serve various clients of each industry. We are not focusing on any particular industry and every client has different requirements. If a client is CPG (Consumer Packaged Goods), then for packaging, aluminum may be important to them, but if we go to the construction segment, then aluminum aspects and roles will differ. So, our commodity solutions to our client are very flexible in terms of that. Basically, we tweak as per the client specifications, but we do not focus on any one segment. We generally cater across the different categories. You can consider CPG, pharma, construction, manufacturing, and others.

I: OK. I guess, moving on to implementation, I know that you're providing forecasts to your clients, but theoretically, how might clients be able to use the data that you provide to make their own business decisions based on your recommendations? I know that changes from industry to industry.

R: Majorly, they use their forecasts for their budgeting purposes in the next year or in the short term. Everyone wants to know about the market. If there are unforeseen events or complications and the market becomes volatile, everyone wants to know how far the prices can go or how low the prices can reach. They can negotiate with their suppliers or their partners to procure those materials. Budgeting purposes is the main thing. Hedging and speculations can also be done based on our forecasts.

I: OK. You were very detailed in the modelling questions, and I really appreciate that. Do you think that there is anything else that you could tell me about that you think might be helpful?

R: I've noticed statistical modelling also plays an important role. Like I mentioned, we do linear regression modelling and others that play a role in the commodity price forecasting. The more robust the model, the more realistic forecast it can provide. So, you cannot ignore this technical part of forecasting.

I: When you talk about statistical modelling, do you mean more like linear regressions, ARIMA, the types of models where you're adding factors?

R: Yes. Those types of models. So, there can be more ML techniques as well. You can use logistical regression as well as multiple linear regression. Other techniques I mentioned like ARIMA and Holt-Winters also play a major role.

I: I'm sure you use a whole tool set of methods, but which models do you think would be the most prominent or helpful?

R: Again. That is very subjective. Every commodity has its own dynamic and situation. You may find more information with base metals but not petrol chemicals. In the petrol chemicals case, more stringent models or developed models should be used, but for base metals, you can go ahead with the linear regression. In my perspective, if linear regression is providing good results, then why would you use more complex models? That will create unnecessary complexity. In some cases, linear regression does have some limitations, and so, multiple linear regression models and other models can be used. This does differ case to case between commodities.

I: When you're speaking of commodity to commodity, how do you group the commodities? Is it just by agriculture, metals, energy? Or is it segmented even further?

R: We majorly have those, but you can also categorize by derivatives and end use as well. So, like copper and other minerals extracted from the earth can be categorized as industrial metals or base metals. Base metal is an elaborate word in itself. Then, we have the energy markets, and the agri-side of the market where we consider the agriculture commodities. You can then consider different oil markets such as vegetable oil, sunflower oil, palm oil. So based on the end use of a commodity, the market majorly categorizes them into one basket.

I: OK. Great. Well, you covered a lot, and you've answered all of my questions. Do you have anything else for me or any comments?

R: No. I think I am done with my explanation. There is no more that I can add to.

I: Good. I really appreciate it. And, thanks again. It's been difficult to find people on LinkedIn, and this is going to be a big help in my research. And again, none of this is public. It will purely be used of my research project.

R: No worries. No worries. I also want to congratulate you and want you to finalize your thesis as soon as possible.

I: Thank you. I want to finish it too. I hope you have a good night, and I appreciate it.

R: Thank you. Have a great day.

I: OK. You too.

I: Thank you.

I: Bye bye.

R: Bye bye.

[End transcript 32:27]

10.3 Appendix B3: Interview with Premia Capital Management

Date: 4 December 2023
Medium: Phone Interview
Duration: 23m 23s
List of Acronyms: I = Interviewer, R = Respondent

Consent for interview recording is received by the interviewee.

[Begin Transcript 0:31]

I: Before we get into it, I will give you a rundown of some of the ethics of the research. First and foremost, independence of research is maintained. I don't have a conflict of interest, and responses gathered through this interview will be exclusively applied for this research project. Confidentiality is taken seriously, and all information can only be accessed by myself, my thesis supervisor, and examiners. Essentially, by being present for this interview, the you're agreeing to participate, and you can withdraw at any time. You don't have to answer all my questions. Finally, do I have your permission to use quotes and information through this interview in my project?

R: Sure. I would like to give it a once over before agreeing to certain things.

I: If there is anything you don't want me to include, I would be more than happy to remove or redact anything from my transcript.

R: OK.

I: Just an introduction about myself, my name is Miles Shen, and I am a graduate student at Copenhagen Business School and the University of North Carolina at Charlotte. Essentially, my thesis is on "How can companies improve competitiveness through primary commodities forecasting and trading?" When I found you on LinkedIn, your profile really matched a lot of criteria that I was looking for, and I think that you have a lot to offer as far as your research and breadth of experience.

R: OK. Good.

I: OK. Just to start, could you explain a little bit about Premia Capital Management and your experience in forecasting, trading, and commodities specifically.

R: Yeah. Premia started initially as a CTA, or Commodity Trading Advisor. And then, we pivoted and became a proprietary trading outfit. So, we're just trading with the firm's own capital. And, as a CTA, a lot of what we were doing is taking on first order risk, so directional risk. Is crude oil going up or down? And, as a proprietary trading firm, a lot of the trading we did is centered around spreads. So, both intra and inter market spreads.

I: Can you explain between the two for me?

R: So, intra would be trying to take advantage of the kinks in the crude curve or the cattle curve. So, you're trading one month versus another. And usually for the market makers, it's a pretty popular form of trading. Most guys are spreading stuff. Rarely are they looking at first order risk because they're highly levered, and the risk is too great to do first order and make a living. And then, inter would be sort of crude oil versus gasoline.

I: OK.

R: And so, when we were trading as a CTA and taking on more directional risk, a lot of what we were doing was trading against the seasonals. So, it was a case that we would look for seasonal patterns and build models around those seasonal patterns that were predictive. And so, the idea is that you want to have as much working in your favor as possible. And so, you take your seasonal, and that's something should be working. I mean it's worked throughout history. If you can model that seasonality so that you can lever it up, then you're ahead of the game.

I: So, as far as modelling and creating forecasts and analyses, seasonality? Does that fall under more of a technical forecasting or technical analysis?

R: No. No. Nothing we did would fall under technical analysis, which is usually like moving averages.

I: Then, how would you describe it? I guess there's three principal large techniques: fundamental, technical, and leading indicators. What do you lean more towards? Or is it something else?

R: For us, we have found is that the curve contains a ton of information. And so, if you're doing fundamental analysis and you're looking at fundamental variables, it's often the case that that information is already embedded in the futures curve. And, that's a sort of big breakthrough in knowledge. So, if you're going to try to take EIA (Energy Information Administration) data or something like that and work from that, it's almost always the case that whatever you find in the data is already embedded in the futures curve. That's what sort of trips a lot of economists and folks that want to work from first principle, but the stuff you're pointing to is already embedded in the curve. Insider trading is allowed in commodities. That's the other really basic point. A curve in the prices contain information that's not going to be released for weeks, but its already embedded in the prices and various curve relationships.

I: So, you're saying that the futures curve itself already has everything.

R: Yes. Exactly.

I: I'm curious, and I've done a little bit of research on the financial side of commodities versus the economic things like supply and demand. Would you say that the prices and financials make a move before or are they kind of lagging?

R: Well, what you'll see is the futures is where the price discovery takes place, and the data will be released sometime after that. Then the other thing that people sort of forget is that demand for commodities tends to be pretty inelastic so price has to do a lot of work to equilibrate supply and demand. So, price is serving a function in commodities future markets that you don't see in the financials.

I: Let me shift just a bit to your operations and the role of your forecasts in particular. You said you're using your own capital and firm resources.

R: Yes.

I: Is there no advisement whatsoever? The reason I ask is I want to pivot towards how the analysis you're doing be applied to industries. Like, how could they leverage or hedge or take this data and apply it?

R: Well, you'd be doing the exact same work we're doing. If you're hedging, you're making a prediction about future prices and hedging accordingly. So, on some level, it's the exact same process that we're doing. And then, it's often the case that what we're taking on is the other side of commercial hedging pressure. You'll see the impact of large institutions on the curve, and you'll find these kinks in the curve that shouldn't exist. Or you're putting a trade on in the liquid part of the curve hoping that as this thing goes toward the liquid side of things that the real valuation will sort itself.

I: When you say commercial pressure, that means institutions making decision that might affect?

R: Yes. Either that, or producers.

I: Going back to forecast construction and you mentioned seasonality. Could you go into a little more detail about the factors or variables that are included in the modelling?

R: What you're trying to detect is seasonal price patterns. And then, you're hoping to figure out what's driving those seasonal patterns. So, for us, if we find a seasonal pattern that persists, we'll try to link it back to fundamental drivers. There's always the chance that you'll find a statistical artifact, but there isn't really a seasonal. If we can link it back to fundamental drivers, then we feel comfortable to try to model that. If you want to look at seasonals, MOORE research produces a lot of seasonal graphs and things like that. You can go in there and see all the seasonal patterns.

I: Just to make sure that I completely understand. So, your principles for creating forecasts and models are first you identify what might look like a seasonal pattern, and then, you backtrack to fundamentals and what variables. And then, you model it?

R: Yeah. Exactly. But, it's not always that case. So, we're looking for indicators that suggest the market is positioned in a certain way or if certain things happen, then you'll get a price spike. Are you familiar with backwardation and contango?

I: I've heard the terms thrown around. Could you just briefly explain it to me?

R: If the market is backwardated then the front months are trading at a higher price than the back months. So, your nearby contracts are going to be price at a premium to your second, third, fourth different contracts. And the other thing is, the entire curve doesn't have to be backward or contango. You could have parts of it that are in backwardation and other parts of it that are in contango.

I: I See.

R: There are so many things that I cannot stress enough like how valuable the curve is in identifying different states of the world. And so, it's the case that if a market is backward, then it's signaling that there's a supply demand imbalance.

I: In relating back to economic fundamentals, if there's a supply and demand inequality, it'll come back, no?

R: Not necessarily. If you're going to be making money in commodities, you're going to be making it off of the curve. There are all sorts of research corroborating this. What results in price reverting back to longer term equilibrium point is a supply demand imbalance that needs to be addressed. Once supply and demand are equilibrated through price, then you can have persistent backwardation where it lasts for years. And again, what you really want to do is understand what function price is serving.

I: Mhmm.

R: So, here's a great trade that we used to do. So, the gasoline crack is you're buying gasoline and shorting crude oil against it. So, what will happen is if the crude curve is trading beyond full carry, which means that oh ---- there's not enough storage capacity left. So, what you're trying to do is pull out secondary and tertiary forms of storage. And when that happens, one of things that you'll find that is sort of counterintuitive, is the gasoline crack will blow out. And what they're trying to do is to convert as much crude oil as possible into gasoline to free up ever more storage. And so, when things like that happen, you'll see in the popular press, "Oh, this is predatory. Why is gasoline taking off now? There's a glut of crude oil." That's precisely why it's taking off. What the market is trying to do is free up as much storage capacity as possible, and one of the ways to do that is incentivize refiners to convert their crude oil to gasoline.

I: That's really interesting.

R: It's not intuitive, and you really have to think it through. My business partner, Hillary Till, and I have written a ton of articles. One article is about fundamental information being embedded in futures prices. I would point you to that one.

I: OK. So, you mentioned specific oil products, but how would you adjust by other commodity groups? I'm sure that you trade over all the groups.

R: Sort of yes. No. I have traded across most commodities, but for us, we've had the most success where we can identify markets like cattle for instance. You can only feed a cow so much before you're wasting money.

I: What might be the key differences between the three main overarching commodity groups being agriculture, metals, and energy?

R: You mean trending guys, fundamental guys, systematic guys?

I: Yeah. Yeah. Fundamental and systematic, and the curve too.

R: One of the ways to start thinking about it is, is the commodity storable and what the underlying dynamics of a market where you can store things. It's very different than a market where you can't store things. If you can't store the commodity, then everything is happening within the curve in terms of pockets of predictability. And that's the other thing is, you have to understand what's driving price, and it's not always going to be the same thing. That's a foundational mistake that certain people do. They think they're going to have this grand unit of driving price, but that can vary throughout time. What variable is most impactful to the market at this point.

I: I find that very interesting because I never thought about storability as a major factor that you need to take into account. It makes sense now that you explain it to me. Correct me if I'm wrong. Let's say there's a commodity that's trading, and it's not necessarily as storable. More of the economic variables like demand, supply, and then sales can affect production and price.

R: The other thing is that it's difficult to bring on new supply. There's a lead time, and it's often quite lengthy. I think what I would suggest is looking into Hillary Till's articles for a primer to get an idea of how we view the world.

I: OK. That's great, and I appreciate you. I'm baffled about the storability fact, and I had never thought about that fact before. You're my first trader specifically that I've had a chance to talk to, and thank you for taking my call. Do you have anything else that you can add?

R: Intelligent Commodity Investing would be a good primer to expose you to all the different ways that people are looking into commodities.

I: Alright, [respondent]. I really appreciate it. This is all new to me, and I'm very interested in it.

R: You'll get a very different view of the world if you're talking to a trader versus an economist, and nothing distills research more than having your money at risk. If you have any questions or anything, you can message me, and I can walk you through it. That'll give you the foundational knowledge that I think is required.

I: OK. I appreciate it. I'll look into the articles, and if I have any questions, I'll be sure to reach out. I don't have anything else. Thank you again for taking the time.

R: No problem. Good Luck.

I: Thank you. Have a great day.

R: OK. Take care.

[End Transcript 23:23]

10.4 Appendix B4: Interview with NJR Group

Date: 6 December 2023
Medium: In-person
Duration: 34m 4s
List of Acronyms: I = Interviewer, R = Respondent

Consent for interview recording is received by the interviewee.

[Begin Transcript 0:02]

I: I'll just give you a rundown of the ethics of everything. So, I'm a student. Independence of research is maintained. There's no conflict of interest. This is purely for academic purposes. Confidentiality is taken seriously so none of this is going to be public. This is strictly for my thesis project.

R: OK.

I: Essentially, by being present for this interview, you are agreeing to participate, but you don't have to answer all my questions. We can also stop at any time. Finally, here is your first question. Do I have your permission to use quotes and information from this interview in my project.

R: Yes.

I: Great. OK. So, I'll just give you a quick little rundown of who I am. So, I am Miles Shen, and I am a graduate student at Copenhagen Business School and the University of North Carolina at Charlotte. My main research question is, "How can companies improve competitiveness through commodities forecasting and trading?" I know that you are a construction company, and you also have an asphalt plant. I think that's really interesting, and I think from your perspective you can talk about how when you get these prices and data to purchase raw materials, hedge, etc. I'm curious about the innerworkings of commodities on your business operations. Let me give you the opportunity to introduce yourself and a little bit about NJR as well.

R: Yeah. NJR. [respondent]. President. So, we started back in 2015 in highway heavy construction, building bridges, roads, asphalt plants, and mainly being a highway prime contractor. The majority of what we do is grading, paving, and bidding on NCDOT (North Carolina Department of Transportation) jobs.

I: Okay.

R: And some municipality stuff, mostly bonded work.

I: Got it. So, mainly government jobs.

R: Yeah. With usually anything government related; you have to have payment performance jobs. That means guaranteed payment and guaranteed performance.

I: I'm curious because I looked through your website as well. What's the industrial side of things?

R: So, we'll do fuel piping terminals. So, we'll run pipelines in gasoline tank farms, and we've done a lot for ethanol because ethanol has to get introduced into gas into the terminal side of wherever there's a depot at for a pipeline. So usually, they start in Louisiana and Texas, and they go all the way up to New York. They drop off gas at each. There's an underground line (colonial pipeline, plantation pipeline). So, it runs up. So then back in '08, '07-'08, maybe back in '05, you had to blend so much ethanol because the way they do the carbon stuff is very environmentally friendly. So, you had to blend 10% into all gasoline. And, the only way to do that is at the gasoline tank farms.

I: So, you help with the construction.

R: So, we would go in there and run the infrastructure for that. And, we would do what they call unit trains. We would build unit trains so they can load up 2.3 million gallons because the majority of the ethanol comes from the Midwest. And, you come in here and offload it all within 24 hours and then ship the rail cars back. So, we would build those facilities that went up and down the east coast close to a gasoline terminal.

I: I know that you have your asphalt plant. Do you solely use that for your paving operations?

R: About 80% of it. The other 20% of it we would sell.

I: I see.

R: So, it would be people doing driveways or anything we can't get to or don't bid.

I: They can just get it from you and do the job themselves. Let me switch gears a bit on touching on forecasting prices a bit on some of the commodities. What type of commodities or natural resources do you have to source for operations?

R: So, mainly, on road diesel, offroad diesel, gas, and then some of our plants run off natural gas, but majority of its diesel. And then, we also do liquid asphalt, which is part of the heavy crude instead of the light crude.

I: OK. I see. I guess that goes through a process.

R: The refinery takes the crude, and they process it. The light ends are like gasoline and natural gas. The bottom crude is micro fuels for ships, and then all the way to liquid asphalt, which is very thick. It is the bottom of the crude.

I: OK. I'm exploring.

R: In the refinery world, you have light ends and bottom ends. Light ends are gas, diesel, and jet fuel. Bottom ends are like bunker fuel for ships when they move outside 100 miles of the east and west coast. Then, you have asphalt, which is the real thick part. Then, you have lubricant oils and engine oils.

I: OK. So, you mainly source the top end for truck fleets and then bottom for asphalt production. Is there anything else like metals?

R: Yeah. We do stone, and we have suppliers that supply stone.

I: Shifting gears specific to pricing and working with suppliers, do you do any forecasting or analysis of the prices or what the market is looking at, specific to the natural resources that you source?

R: For any public job, usually, we have an index. So, we don't have to hedge as much. They'll give me a price that's good for that project, and the project will last for about a year and a half. They'll honor that price for a year and half, which is stone wise. On liquid wise, we have an index. If oil goes up, ours goes up. So, we get paid more. If it goes down, we get paid less. DOT found that they like that better because they got better pricing. So, people aren't hedging as much.

I: I see. So, what index do you follow?

R: We follow the NCDOT index.

I: So, they provide it.

R: Yeah. So, they provide it. You have certain terminals around here that post their price. And, we get paid based on that. Per ton. So, if it's $600 per ton, I bid at $600, and the price goes to $700, I'll get $700.

I: OK. Is there any negotiation in the process of making these bids?

R: I'm bidding something today, and it's counting down. So, I've got all the way to 2 o' clock today to submit it, and once it hits 2 o' clock, they post it. And, you know if you got the bid or not. Not with NCDOT.

I: How does it play into you making a bid and trying to get it accepted?

R: Most of the time, unless you're over the engineers estimate, they'll accept it. We do a lot off of unit pricing, and we follow the market. If costs go up, then you have an idea of where you're going to be.

I: How would you say that changes in crude affect your operations, pricing, budgeting, or anything like that?

R: Well, the pricing of it would change, and I get an index. The volatility is usually safe. In the DOT and municipality world, it's hard to make, and you're safe with where you're at. So, if I'm buying at $600, then I might say $700. If it goes up to $700, then I'll say $800. I'm getting paid $800. I can't hedge off that. With private stuff, you can. It works out great when it's coming down. So, this past year oil has come down in the asphalt world. It went up the year before, but it's come down and has held pretty stable. If you really follow the market and the barrel from WTI (West Texas Intermediate), it follows that. If it goes up 10$, asphalt might go up $5.

I: It still has minor impacts; would you say that there's any predictive power? OR would you say that it happens in the market and you adjust?

R: It'll happen, but the more that you can have storage it can help. Like right now, I don't want to use diesel at the plant, and we're waiting to run natural gas. It'll be half the price, but we're having to run diesel while we wait for natural gas. That diesel will fluctuate quite a bit. I go from buying a tanker load for $10,000, and the next tanker load could be at $20,000. It takes more working capital. Eventually, it'll be resupplied, but it takes more working capital to hold that. Next month, my price will go up, and we'll put that into the bids. With DOT, you're secure with the index, and you'll get that paid if it goes up. Here's a good example. I bid a job this past month, and we got an extra $15,000 that went toward diesel because the index is $0.50 higher.

I: Is that a decision that you made?

R: No. It's built into the bid, but it can also go the opposite way. They can take it away from you too. If it goes down, it gets taken away, but as it goes up, you get more.

I: Can you walk me through the thought process on asphalt production?

R: With the DOT, you can click a diesel adjustment or a natural gas adjustment. So, I'm having to buy diesel tank loads at a time that just sits in a tank. The natural gas is in a pipeline and is more efficient. It burns cleaner and hotter. It's just a better product than diesel fuel.

I: How does that affect production? Considering you're waiting for it.

R: Well, I charge more. So, somebody might not go to me. They might go to somebody else. I just pass it along to my end users, my customers. So, it just gets passed along to them as they come and buy. I publish a rate for FOB asphalt once a month. If they want to go down the road, they might be $2 cheaper per ton on natural gas, but they may also need 3 extra trucks costing $3 more dollars. In that case, it would just be easier to come to me because they may be closer. So, proximity to a plant is key too.

I: You mentioned that you have a little bit of experience with hedging.

R: Yeah. When we had the terminals, we would hedge on the asphalt.

I: Can you walk me through that?

R: You would pretty much buy it in the winter and sell it in the summer. That's the easiest thing. It's been kind of backwards because of the open market.
I: Looking at data and prices, could you explain decision making based one analytics?

R: A lot of it is historical numbers. You try to use best guess. As an example, you're looking at it at on a 100,000-foot level. If you know North Carolina, South Carolina, and Virginia is a good market for asphalt and their DOT is doing good and is letting a lot of work, then you know that there would be a lot of asphalt to be supplied to the plant. If you feel like it's a good year, then you would fill tanks based on that in the winter time. As it works its way up, you sell it during the summer time.

I: What indicators do you look at to know if there's a demand for your liquid?

R: Usually with asphalt, the only time that you can place it depends on the weather. In the summer, the days are longer, it's hotter. So, we can start. Asphalt has that limitation of 40 degrees and rising. So, today it's cold. Those guys are very short term, working 8 hours compared to 12. There's going to be higher demand in the summer time. Weather is more consistent. You can get more production. It's drier and hotter and all that. People may be driving for Thanksgiving and Christmas, but in January and February and March, most people aren't driving as much and are stuck in place using propane. Demand goes down so price usually goes down. If you want to fill your tanks up and reserves up, so as the days get longer and driving more in the summer time then demand goes up and price goes up. During the winter time, we're not doing as much. A lot of times we're doing our maintenance in January to get ready for the year.

I: As far as myself making conclusions, I've done interviews with more analytics firms. You're doing industry knowledge and comparative stuff.

R: Yeah. The analytics don't find is like going to Ukraine to fight. If everyone would stop fighting and shake hands tomorrow, then oil would drop big time because Russia is back on the pipeline. We would have a lot of production going. But we can't control that. That's what makes it go up, trying to figure out who, where, and what we're going to get that oil from. You can look at it and say that the demand is here and growing at 4% in the Charlotte area, but we do a lot of stuff with our CAPA association, which we go over the DOT to try to forecast and create more jobs.

I: CAPA? What is that?

R: Carolina Asphalt Pavement Association.

I: OK.

R: You go online to the DOT site and see how much they plan on letting happen. We do get a 36-month forecasted list that shows us what projects they plan on doing. They might slide, move back, or move up depending on funding availability. We kind of know what they're going to

build out. They also do a 10-year STIP. So, the 10-year, they'll know what they're going to be doing in the next 10 to 15 years and what jobs are going to be allocated. In forecasting, it is really big. This job might cost $20 million to build it now, but in 5 years it'll be $27 million.

I: I see.

R: We just use basic industry knowledge and know things are going to go up 4-5% each year.

I: You mentioned the war in Ukraine and more macroeconomic things. How would you say that they impact the business? Of course, you spoke about that putting pressure in Europe and the whole world with energy. Is that something that you look at or pay attention to?

R: Oh yeah. If we're not doing DOT, then we're doing more commercial projects. Interest rates are going up. We've been doing a bunch of budgetary stuff, but they might not be doing that project because they're waiting for rates to subside and go down a little bit. We kind of build off of that. We try to keep very diverse. We usually pave every day, but that crew could go lay water line if we had to. Charlotte is a good and growing area. There is demand there for work. It's a matter of finding people that know how to get it done. That's a big issue. The knowledge is just not there every year as you go and do stuff.

I: What do you mean by knowledge?

R: People don't know how to complete the projects.

I: So, like labor?

R: Yes. Workforce and labor. All that. Having the knowledge to get it down is getting challenging year after year.
I: I know a lot of your experience is NCDOT and government stuff, but what experience do you have with more commercial projects?

R: Probably 20%. A lot of it is working with certain clients like with the ethanol stuff.

I: Could you compare the process of bidding commercial versus government?

R: When it comes to projects, the faster it can be done the better. So, a lot of the commercial stuff are yearlong projects. To help with that, what you could do is prepaid or stored materials.

I: Explain that to me.

R: You would get bonds on them. So, I can go ahead and buy the rebar or anything like metal. I would do stored materials and go ahead and deliver it on site and cover it up. Or, we could pay the supplier, and they would have it sitting on their yard. We would have to have the paperwork. They would issue us a bond. If they went out of business, we would turn to the bond company, and they would resupply us.

I: OK. Let's talk about timeline with coordinating with suppliers versus accepting a bid and deciding to a job. Explain the whole process as far as getting the materials ready for a job and then starting the job.

R: Once you bid it and get it, you issue a purchase order. Those guys know that 90 days out is built in their price. They're probably hedging on it too to try to get it cheaper. If it starts going up, they might tell you in their quote, "quote good for 60 days. Price subject to change." We take that and apply that to our bid. We might mark that up 20% to help if it does go up. We try to get it done as soon as we can, and then they'll issue bonds. We'll do prepaid material. Especially, steel stuff like girders, bridges, and rebar.

I: I don't have anything else. Do you have anything else that you think that you could add? You covered a lot here.

R: If you come up with something, you could just email me. Asphalt with the DOT is kept on a pretty tight leash. Thank you for coming.

I: Well, thank you. Really. I appreciate you taking the time to speak with me.

[End Transcript 34:04]

10.5 Appendix B5: Interview with Lowes Home Improvement

Date: 8 December 2023
Medium: Microsoft Teams
Duration: 31m 2s
List of Acronyms: I = Interviewer, R = Respondent

Consent for interview recording is received by the interviewee.

[Begin Transcript 0:04]

R: Fair warning. I'm having extreme Teams issues. I got kicked out of the last call four different times. If that happens, we can reschedule.

I: We'll figure it out. Don't worry. It's okay. Before we actually jump into any questions or introductions, I'll just go over some of the ethics of my research. That way we're on the same page, and you understand everything about everything.

R: Sure.

I: So, first and foremost, independence of research is maintained. There's no conflict of interest. This is purely for academic purposes, and all the responses gathered will be applied strictly for the thesis project. Additionally, confidentiality is taken seriously. The information is only going to be accessed by myself as the researcher, my supervisor, and the thesis evaluators. And, by being present for the interview, you're essentially agreeing to participate, but you don't have to answer all of my questions. You can withdraw at any time. And finally, do I have your approval to use your quotes and anything we discuss for the thesis project?

R: I'm sure. I just need to be thoughtful about what I say.

I: OK. If you feel that there's anything you're not comfortable with me using, then I can redact it. Don't worry.

R: OK.

I: Let's jump into it. My name is Miles Shen. I am a double degree student at the University of North Carolina at Charlotte and Copenhagen Business School. Essentially, my research project is "How can companies improve competitiveness through commodities forecasting and trading?" And, this is where you come in because you're an expert in forecasting with Lowes. I'm very interested to see what you have to say. So, let me leave the stage and give you an opportunity to introduce yourself.

R: Sure. So, [respondent]. I've been working at Lowes for about 3½ years. The entire time that I've been there, I've been working on the lumber business, plus or minus other businesses that have come and gone off my desk. I had never looked at lumber before and didn't know anything

about commodity prices until I started in this role. But I have done planning and forecasting now in different areas for over 20 years. So, I mean it is something I like.

I: OK.

R: It's just every time you do it at a new company it is a little bit different. Right?

I: Of course.

R: So, I'm happy to answer whatever questions you have about processes. Tell me what you need to know from me.

I: OK. Well, let's begin with, how does your role as a lumber price forecaster coincide with Lowes in particular and their business and operations?

R: So, for being responsible for lumber at Lowes, I don't just look at commodity prices. I also help inform the company how I believe their commodity prices are going to inform retail decisions. Right? So, sales dollars out the door. Retails of course have an implied impact on units. Too high and people check out. So, I also write the sale and margin forecast for lumber. So, I don't just do commodity prices. Commodity prices is just the way that I start my process because I have to have an opinion about what's going to happen in the market to inform the sales and margin consequences that I think will deliver.

I: OK. I've spoken to other specific analytics companies that do this type of thing, and they've given me 3 primary modes of forecasting that they do. So, they do look at fundamental type stuff where maybe they're look at a specific company and maybe supply and demand of a specific market. Then, they'll do more technical stuff, looking at moving averages with maybe more price specific data. And then, they'll look at leading indicators. Could you give me a little bit more insight into what you think about that and if you employ some of these practices.

R: So, we definitely take a look at leading indicators. We are also very interested in what's happening in repair and remodel versus home builds and home starts. The customers are different, and the scale of purchase is different.

I: OK.

R: So, it's important to know which part of the business is going to grow. Home improvement has those two distinct segments. Right?

I: Yes.

R: And I'll be honest. We do our own forecasts, and it's not nearly as scientific as you would like it to be. So, a lot of what I do to forecast commodities includes speaking to vendors or people who are looking at pricing all day, every day.

I: That's OK.

R: So, I'm gleaning key vendor market insights. Usually, they also go over their key indicators with me. At the same time, right, they'll pull massive decks in order to understand where they think prices are going to go. We also subscribe to RISI. It's either random links or RISI. I don't know which is the accurate name. It changed names at some point and people refer to It both ways. We get their forecasts. I will say, during the height of the pandemic, their forecasts were incredibly inaccurate, but as were mine, right? I use it to directionally sound check what I'm thinking is going to happen based on the conversations and the market research that I've done to make sure that I'm not moving out of scope. So, sometimes they will have a much more rapid inflation or deflation for looking cadence than I do. I just need to make sure that I feel comfortable not moving it to that same degree.

I: OK.

R: And, what's more troublesome is if we're moving in opposite directions. So, I think it's going to inflate, and they think it's going to deflate. Then, I have to work with my partners to come up with a better decision.

I: What variables or factors might you look at in particular that would be driving your opinions and forecasts on whether it will inflate or deflate?

R: So, production line times and supply are always really important. For instance, just this week one of the OSB suppliers had a fire in their plant, and it shut down production in Texas. So, I have to determine if I think that's enough scale to inflate commodity prices because supply may be scarce now.

I: Oh, OK.

R: So, those kinds of things are important. Mud slides across railroad tracks can impact price, right? If you can't move the product, that's something important to know. If it's a longer-term impact and other stuff as well. Pine beetles too. So, a lot of odd things I never thought I would need to know about.

I: Wow. That's great. Let me shift gears a bit and take a step back. I know about Lowes Home Improvement generally. I mean, we have a Lowes in my home town. So, I know Lowes, but I'm curious. What is the role of lumber in the customer and Lowes in particular? What would you say about that?

R: I think it's fair to say that lumber both at Lowes and Home Depot is a very heavily pro-centric business.

I: OK.

R: So, it is professionals who are small pros or big pros. These are professional who are doing jobs on behalf of somebody else. You're probably not going to need 60 2x4x8s for your own construction, but a pro will always buy a bigger size order. It's important making sure we're

cognizant of the price, not only at our competitor, but at the lumber yard, who recognize prices much faster. They will move their retails that they charge people to match what commodity prices have done in the week prior. So, they may be very quick. We don't move quite as quickly, but we make sure that we don't get out of the scope in retails that we cost ourselves customers.

I: I see.

R: So, when you think about commodity prices inflating, the lumber yard moves instantly, and we're moving on a little bit of a lag. We bring in more professionals in the short term because our prices are going to be cheaper.

I: OK.

R: Conversely, when there is a deflation, lumber yards have already moved while we're a little bit behind. So, we shift our customer base unintentionally over to a lumber yard.

I: How does Lowes source lumber then?

R: We just buy from treaters and the same vendors that someone else might. Sam Tuckers, Sunbelt, and Hickson. Those guys are pretty big on treated lumber.

I: OK. Alright, perfect. I think that gives me a really clear idea of lumber generally and the impact with Lowes and supply and demand. So on and so forth. Let's shift back to forecasting again. I'm curious about the maybe more specific procedures. Could you revisit that in a little more detail.

R: Sure. It's so much. Well, like I said, we're fast and loose a little bit because they're dependent on me. I have no degree in this space, and I have an environmental geologist degree. I would tell you that after getting all the contacts from the market and talking to all the different people, reading all the articles, anything else that I think might be important, looking at whatever Stadia might have printed or housing data might have printed, then I just sit down and workshop with my vice president in lumber to make sure that he and I are thinking that they're going to move along the same size and trajectory. Then, he just lets me do it. It's that unscientific. Don't be appalled. I'm pretty accurate It's gut feel.

I: So, I'm trying to listen to what you're saying and attach that to some of the economics that I might be a little more familiar with.

R: Well, that's why the RISI forecast is so important because that's so thoroughly grounded and created by economists with knowledge in things that I don't have a background. So, I am this poor person, relatively uneducated compared to people who do that for a living and doing my own insanity checking.

I: OK. I guess, I'm curious what type of experience, because you've said that you've had 20 years of experience in forecasting, talk to me about that and lead me up to Lowes.

R: For sure. I guess when I first started forecasting, I was working for Coca Cola bottling here in Charlotte. And, basically, it's again sales and revenue forecasting for key accounts. So, Coke is the bottlers delivering product to a retailer. I mean, I think in my 13 years there I had Walmart on my desk. So, I did all of our forecasting and budgeting for Walmart, saying we're going to sell X millions of dollars in product to Lowers in these different packages at this different time at retail. So, I didn't have to do commodities. They had a whole other arm of the organization that managed aluminum and sugar and those things that are really important. And then, they gave us a fixed cost for the year that we just held unless there was something incredibly abnormal that happened, and it got out of synch. So, we just used a stagnant estimate of cost on my side of things. They were much more attuned on their side, of course, right sizing, hedging, whatever. We've tried a little bit of hedging at Lowes, but we tried it at the wrong time. It didn't' work as well as we would have hoped, but It was also our first foray in that for lumbers.

I: I see.

R: Since, everything's stabilized, and it would really not be a necessary component. If we wanted to do that, we would have done that much earlier. I worked at Coke, and I went to work for Fontem Ventures, which is E-cigarettes. I did some forecasting over there. Again, specific key accounts like what we were going to sell, what price points, what mix, etcetera. So, not supply chain forecasting. I'm not going to the item, right? I'm going to a much higher group, like product group or like all two liters at one time. Not coke 2 liters. Not sprite 2 liters. That's the same way we do it over here.

I: Ah. OK.

R: I do all of treated lumber. I don't do treated lumber 2x4x8 or 2x4x6 on studs. I do all studs at one time.

I: OK. I see.

R: I might not be the person that you need.

I: No. No. I think that you still have a lot of valuable information. And, I still just appreciate you hopping on the call, and you hearing me out and letting me talk to you. Sorry. I had a thought and it escaped me. OK. After you make your forecasts, because you mentioned hedging as something that you've tried, in making forecasts, how is that data used after you make your forecasts? What types of decisions would Lowes be making based on that data?

R: Oh. Sure. I'm going to forecast commodities, which really is just my stepping stone in volume to drive sales. Commodity prices are also going to help me dictate costs. Costs change weekly based on the print prior. This Friday's print will dictate costs for next week.

I: OK. OK.

R: Every week, our cost changes based on what happens in the commodity market because that's kind of our agreement with our suppliers and vendors. So, I'm going to make all these decisions.

I'll have a sales and margin consequence. It's just lumber, but it rolls up to the total company, and then of course, they making hiring, firing, and staffing decisions on that. It depends. You know, how many hours in the stores does a store have in staff to run the registers at the front? Don't blame me. It's not a lumber problem. But you know we're also making decisions about how much of old aged inventory might we be able to write off or dispose of at the end of a quarter. You constantly have churn in some of the other categories. Remember, the trim and trees right now are a great example. Lots of Christmas stuff in stores. A lot of it's going to sell, right? But there will be some little bit that's left over that you have to decide if you have the capabilities as a company to write off and exit or if that's something you need to continue a clearance program on. It's a fiscal decision. How do you spend your money? My forecast tells them how much money they have to go spend in whatever way they want to.

I: OK. Ah, OK. So, I mean it could go all the way down to the bottom line essentially.

R: It absolutely does. My forecast helps inform the EPS calculation at the bottom. So, it's just part of the total, and right now, I do lumber and building materials. So, I've got a piece of the pie that I'm responsible for making sure is accurate.

I: So, you've been with Lowes for 3 ½ years, and you've said that Lowes is kind of new to this forecasting kind of thing.

R: Correct, but they're not new to forecasting. The fact that we're forecasting commodities on our own is new. If you think about '19 backwards, commodity prices for lumber moved less than $10 week over week, never really moving outside of a span of maybe plus or minus $40 or $50 per thousand board foot.

I: OK.

R: You did not need to predict commodity price when it's that stable, and it's not moving. But over the last 2 1/3 years, the roller coaster that we've been on made knowing or having an opinion about what commodity prices were going to do and how it was going to drive sales and units in your store important. That part's new. It's not that Lowes is new to forecasting. It's just that they never had to think about commodities in the way that they do now.

I: From your perspective, what would you say are some of the leading causes for this high volatility that we're seeing or that we've been seeing.

R: So, this years' been incredibly stable, comparatively stable, right? So, I wouldn't say there's volatility, but with people stuck at home doing projects over COVID or hiring people to do projects also at home, it's had an effect. I can't tell you how amazing decking was doing over COVID. When people were behaving differently, they had more discretionary income in their pockets. Because of that upside, they just took care of a lot of things around the home because that's where they were spending their time that they probably wouldn't have done normally. It just drove a lot of volatility because certainly nobody went into 2020 thinking that the demand would be there. Supply was very constrained and prices skyrocketed, you know, and then sometimes prices got so high that people are like, hey, man, uncle, we're not going to spend 30%

more to build a home. So, we're going to pause what we're doing and wait for things to get a little bit better. 30% is an exaggeration and just illustrative. Don't quote that number.

I: No. You're fine.

R: But in 2019, call it around $400 to $1400 at its highest in 2021. And then, it rapidly fell, which is, of course, if you're like Lowes FIFO accounting, something to manage through.

I: I see. So, I am curious in the past 3 ½ years, how have your forecasting methods changed?

R: A whole lot. I can't even remember all of them. Random forest was one. There were a couple of regression models and things that we tried. Volatility was such that we had a hard time coming to a reasonable output.

I: Hmm.

R: We would do these graphs of commodity prices and retails. For the same commodity price, you might have five different retails. Occurrences spanning a spread of $3, and if you're talking about a stud, that's really unpredictable. So, you use the modeling to inform and the art of forecasting to say, "Hey, man. That's probably wrong." So, we did a lot of modeling in that way.

I: OK. Yeah.

R: All of the things that we were trying were kind of abandoned since they didn't seem to have strong correlated values at the time.

I: You started with more statistical models, and you mentioned regression. But now, you've moved more to…

R: My gut feel.

I: More market stuff.

R: Yeah. More informed by market intelligence and conversation rather than pure mathematical models. Even now, we're seeing some flex in that relationships than we wouldn't necessarily expect.

I: I know you stack it up against RISI, but is there a place for any mathematical models now?

R: I think so. I've been talking to my team about that. I have two people that work for me in lumber. I think now that it's not hyper inflating or hyper deflating and driving completely out of the norm consequences we have the ability to go back to some better modeling and be more scientific.

I: OK.

R: It's just that we haven't had a pause in the business long enough to rethink what that looks like. I'm only just now staffed. We had a lot of people promote out and do other roles. It just took a while to get both people back. I've only been full-staffed for about five weeks. I would very much like to go back and apply a little more science. I've been really fortunate in the educating guesses I'm making, but we probably could put a little more rigor into it. I think now without the radical ups and downs we probably get a good consequence.

I: So, you're solely lumber. Because for Lowes, what are the main commodity groups?

R: So, I would tell you that there's probably three areas. I think there are three areas that are heavily tied to commodity price, which of course always play a role in cost. But for us to say you're a commodity group, your price has to be indexed to the market and your cost has to change regularly.

I: Hmm. OK.

R: Otherwise, you're informed by commodities, but if you're not changing all the time, we're not calling you that because you have some other drivers in cost. So, lumber is one. And then, electrical cable is very much based on copper. Millwork, think doors and windows, are going to have lumber help inform pricing, which makes sense, right? Also, think about rough plumbing. This is the stuff inside the wall and not the pretty stuff that you see. There's a lot of pipes that commodity informs, maybe not changing weekly, but is still pretty relevant.

I: I guess one final thing that you might have mentioned already. I might have missed this for lumber, but what are the most important variables or indicators that you look at as far as tracking fluctuations?

R: It's like I said, housing starts and remodel information. I'm also going to look at what I know from supply and production, right?

I: Sure.

R: I don't think that this fire in Texas is going to be huge. We don't buy from that particular manufacturer. However, I do need to be aware that they can't produce. So, those people who buy from them normally will source elsewhere. That could have consequences for Lowes, right?

I: I see. That makes sense.

R: So, housing starts and remodel are important. OSB and plywood demand varies based on if it's a remodel project or a complete build. There's a lot to pay attention to.

I: OK. That makes a lot of sense, and you've said a lot of great information. Do you think there's anything else that you could add?

R: Let me think. I think you'll find your conversation with Kevin very interesting because he's going to come from it from a much highly economic perspective. He's got a lot of very strong

passionate feelings that doesn't necessarily touch his businesses since I'm writing his forecasts for him. He can give me things that he's looking at when he's challenging me on assumptions. We push and pull on the forecasts. I put it together, and he tells me why I'm right or wrong. Sometimes, I change his mind, and sometimes, he changes my mind. He can give you his perspective as a merchant.

I: Well, I don't have any more questions. You've been really informative, and this is really great. I appreciate you taking the time to hop on, especially with such short notice.

R: Sure.

I: I'm just so appreciative and thankful.

R: If something comes up that I could answer, just send me a message. I will be out of the country for a couple weeks, but I'll be back in January.

I: I'll be done by then, but I still appreciate it. I hope you have a good time out of the country. That'll be fun.

R: Sure. Thank you. Alright, bye.

I: Thank you, [respondent]. Bye.

[End Transcript 31:02]