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Hot Commodity? The Commodity Currency Hypothesis and the Financialisation of Commodity Markets

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Abstract: Movements in the commodity markets can have profound effects on the global economy by affecting the cost of food, metal, and energy goods. As such, the prospect of predicting commodity price fluctuations, thereby allowing for better inflation control, production planning and even humanitarian aid, has long generated great interest. The Commodity Currency Hypothesis offers such a possibility, allowing researchers and practitioners to predict commodity prices by studying the movements of the so-called commodity currencies. These currencies are thought to move in close tandem with, but ahead of, certain commodities and sometimes even commodity indices, thereby allowing for improved predictions of those commodities. This study has, using more recent data than major studies in the field, provided some support in favour of the Commodity Currency Hypothesis. Moreover, we have also shown that the direction and significance of the commodity-currency relationship described is likely to be time-variant and provided some indications on why this might be the case. Furthermore, we discuss the possible implications of this for the practicality of the Currency Commodity Hypothesis. Our results are of great importance for policy makers and business practitioners.

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1. Introduction

A commodity is generally defined as a, in part or completely, fungible economic good (e.g. wheat, gold, crude oil). The first marketplaces for commodities are thought to have originated around 4500-4000 BC in Sumer, today's Iraq, and developed as a way for producers and buyers to hedge against the various risks they faced. Since then, commodity markets have grown immensely and various derivative instruments have been introduced.[1] After the dot com crash in the early 2000s, many investors turned to commodities as an opportunity to hedge their risks through diversification, causing, among other things, the market for commodity indices-related instruments to grow substantially; upwards of 1300 percent between 2003 and 2008 (Nissanke, 2012; Tang and Xiong, 2012).

However, commodities are not only hedging assets. Commodities are also the basic input goods for much economic activity, and, as such, price movements in the commodity markets can have large effects on other markets. Movements in the commodity markets also affect the general cost levels in society and thereby contribute to inflationary or deflationary pressures, which was evident during the time leading up to the financial crisis of the late 2000s (Bernanke, 2008). Furthermore, energy and food security are issues of national security, and movements in these markets can have profound economic and political consequences.

Because of the above-mentioned factors, the possibility of better predicting the movements in commodity markets has been studied at length, although with few definite results.[2] An original and promising approach is to look at the exchange rates for the so-called commodity currencies. Commodity currencies are generally defined as a group of currencies whose values are largely determined by the price(s) of one or a group of commodity export(s). As commodity export prices are fundamental exchange rate determinants for commodity currencies, these currencies should, *prima facie*, react to recent movements in the corresponding commodity

[1] Financial derivatives are securities that derive their value from an underlying asset or benchmark, e.g. futures, swaps, indices.

[2] One way of deriving forecasts for commodity prices has been to look at the commodity futures markets, a theoretically sound approach however not successful (Bernanke, 2008). Others have focused on developing commodity pricing models taking into account microeconomic factors, such as storage costs, which, while also theoretically plausible, have failed to effectively predict movements in commodity markets (Frankel and Rose, 2010).

prices. However, it appears as if it has been possible for currency traders to anticipate commodity price changes in future periods and react ahead of time, thereby causing exchange rates to lead commodity prices.

An influential paper by Chen, Rogoff and Rossi (2010) (henceforth Chen et al.) showed that the movements of commodity currencies can in fact be used to forecast the movement of specific commodity prices and even broader commodity indices under certain conditions, a relationship often referred to as the Commodity Currency Hypothesis (CCH). They show the effect to be surprisingly robust, a result also found in numerous other studies (e.g. Frank and Garcia, 2010; Kato, 2012).

However, these papers may possibly present too narrow a view of a complex relationship between currencies and commodities. Many papers have since provided nuance and contention. Zhang et al. (2016), inter alia, showed that commodity price movements generally lead and exchange rates follow, as would initially have been expected.[3] Others yet, for example Chan, Tse and Williams (2011), have argued that the movements of exchange rates and commodity prices are contemporaneous. While these results appear contradictory, it should be noted that there are differences between the studies, such as the frequency of the data used, the choice of commodities, and the time period studied. Certain studies (for example Kato, 2012) also argue that the recent financialisation of the commodity markets might have affected the relationship, introducing additional complexity. These discrepancies in time, commodities, and frequency, etc. make the studies hard to compare, but, as we shall see later, suggest ways of reconciling their results.

Our study aims to further investigate the nature of the relation between commodity currencies and commodity prices. Our research question is as follows: *Is the Commodity Currency Hypothesis still relevant? And if so: How can we explain the contradictory results of earlier studies?*

Our main purpose is to test the commodity-currency-relationship anew, using recent data on exchange rate and export commodity prices for Australia, Canada, Chile, New Zealand,

[3] Zhang et al. also find, in accordance with Chen et al., that currencies can lead commodities, however they argue that this effect is lesser in magnitude and therefore less relevant.

Norway and South Africa, from the approximate time of their introducing floating exchange rates up to the present. We will employ tests for Granger-causality to answer the main research question, and a Rolling Window Regression methodology, to our knowledge never before used in the field, to further the discussion and answer the second part of the research question. This way, we will be able confirm or reject the existence of a currency-commodity-relationship and, subsequently, to discuss how the contradicting results obtained in previous studies can perhaps be reconciled.

The rest of the study will be structured as follows: First, we will present the subject matter of the study, as well as discuss the current state of research. Then we will describe our data set and the methods we will use to perform our tests. Lastly, we will present our results and briefly discuss them in the context of our research question.

2. Theoretical background

In the following section, we will present and briefly discuss the theoretical underpinnings of our study as well as our contribution to the literature. We will start by presenting the commodity currency concept. We then introduce the Present-value approach to exchange rate determination (the theoretical fundament of the study) and the Commodity Currency Hypothesis. Lastly, we discuss the commodity spot and future markets more generally.

2.1 Commodity Currencies

Commodity currencies are defined as currencies whose values are to a large extent determined by the price of one or a few commodities. This effect stems from the fact that the countries that issue them are heavily dependent on the export of the associated commodities,[4] and that exchange rates generally reflect terms of trade determined by the prices of exported commodities relative to all other goods in the world market (Chen and Rogoff, 2003). Free floating commodity currencies are especially useful for research, as there are relatively fewer endogenous shocks affecting their value. While domestic policy may have some effect on exchange rate determination, its effect is generally negligible for countries with floating exchange rates (Chen et al., 2010), and their fluctuations can therefore overwhelmingly be attributed to some exogenous shock.

The canonical example of a commodity currency is that of the Chilean peso. Chile is a small open economy with a (partially) floating exchange rate since the late 1970's. Chile historically exports upwards of a third of the world's copper (Mardones and Del Rio, 2019), but is generally a price taker (as shown in exogeneity tests by Chen et al., 2010) meaning that it cannot by itself influence the value of its exports or imports, which reduces the issue of endogeneity. As a high price in copper yields high dollar-profits for Chilean companies, the demand for the peso depends largely on the supply of, and demand for, this single good.

[4] In theory, this also extends to import dependent countries. This is, however, a more complicated situation as one would have to take into consideration the fact that many countries refine and re-export goods. For more information, we refer to Krönmark and Storckenfeldt, 2009.

2.2 The Present-Value Approach to Exchange Rate Determination

As a (floating) exchange rate is in essence the relative price of two currencies, its value should be determined by the relative supply and demand of the two currencies (Frankel and Rose, 1995). Therefore, macroeconomic factors which influence supply and demand, such as money supply, inflation rates and economic output, are all believed to affect exchange rates and should consequently also be helpful in predicting them.

Despite this, no theoretical model's testable predictions on exchange rate determination have held up empirically, at least not out of sample (Engel and West, 2007).[5] The approach taken in this study, encompassing a multitude of theories of exchange rate determination, is a present-value approach. It describes currencies as assets whose values depend on the discounted future values of their fundamentals. We find a generic expression for this theory grouping (eq. 1) in Chen et al. (2010), where s_t is the nominal exchange rate, $E_t\ (f_{t+j} \mid I_t)$ is the expected value at time t of its fundamentals f at time $t+j$ given information I_t, and ψ, γ being parameters given by the specific model (discount factors).

$$s_t = \gamma \sum_{j=0}^{\infty} \psi^j \ E_t\ (f_{t+j} \mid I_t) \qquad (1)$$

In this model, the nominal exchange rate therefore depends on the expected value of its fundamentals (i.e. demand and supply). It is this property that will, in theory, allow exchange rates to depend on the expected future commodity prices (and therefore predict the observed commodity prices).

2.3 The Commodity Currency Hypothesis

Assuming that the currencies are asset-like and therefore forward-looking, they should be useful in predicting movements in the prices of their fundamentals. Commodity currencies would then be able to predict commodity prices. In reality, most researchers acknowledge that

[5] Meese and Rogoff (1983) found that a random walk model would have been just as effective in predicting exchange rate movements as contemporary structural models. As shown in Engel and West (2007), this should not come as a surprise given that exchange rate fluctuations predicted by traditional models can in fact be modelled as random walks under certain circumstances.

the existence of a relationship between commodity currencies and commodity prices is probable, but there is widespread disagreement on the direction of that relationship, its robustness, how it is to be measured (for example in real or nominal prices, in-sample vs. out-of-sample forecasting) and its practical importance.

While Chen et al. (2010) argued that there are theoretical reasons to believe that the exchange rate moves first, others theorise the opposite case (For example Chen and Rogoff, 2003). The empirical evidence is, as mentioned, unclear. Clements and Fry (2008), Chen et al. (2010) and Frank and Garcia (2010) all found that the effect was stronger in the direction from exchange rates to commodity prices,[6] while Amano and Van Norden (1998), Chen and Rogoff (2003) and Zhang et al. (2016) found evidence for the reverse relationship. Others yet, e.g. Chan, Tse and Williams (2011), Groen and Pesenti (2011) and Bork et al. (2014), find that the relationship is "essentially contemporaneous", and that any predictive capability is temporary. Chen et al. (2010) noted that the predictive power of some commodity currencies might be related to the fact that commodity spot prices and futures markets have been less developed and more regulated historically (making them less efficient than foreign exchange markets[7]),[8]. This difference in efficiency, allowing foreign exchange traders to more readily incorporate new information into their trading strategies, would thus give rise to the predictive capability of commodity currencies.

The fact that the above-mentioned market characteristics (i.e. liquidity, regulatory level) are not static should afford the relationship a time-varying quality. It also tentatively suggests that, given no corresponding change in the currency market, an increased financialisation, i.e. market development, would increase market efficiency and subsequently reduce the predictive power of commodity currencies. Kato (2012), however, contrastingly finds the predictive power of exchange rates to have been mainly strengthened due to the commodity market financialisation, a result of decreasing market inefficiency (mainly in the shape of increasing market co-movement). The nature of the commodity-currency relationship thus remains a point of contention in the current literature.

[6] Ferraro et al. (2015) argue that the relationship exists in both directions, but is more short-lived in the case of commodities to exchange rates than vice versa.
[7] Foreign Exchange Markets (Forex or FX) are the markets where currencies are traded, and ergo where exchange rates are set.
[8] Especially non-precious metal and non-energy markets (Tang and Xiong, 2012).

2.4 Commodity and Foreign Exchange Markets

As indicated by previous literature, we expect the direction and strength of the relationship to be dependent on the relative efficiency of the two markets. This section addresses this mechanism and briefly discusses some factors that could influence market efficiency.[9] Since relative is the key word, a discussion on changes assumed to improve both markets to a similar degree (e.g. the introduction of computerised trading reducing trading time-lag) will be omitted.

Exchange rates are generally considered to be hard to predict (see Rossi, 2013, for an overview), strongly indicative of market efficiency. While there is some evidence that the exchange rates markets vary in efficiency (Yamani, 2018), previous literature on the CCH has implicitly assumed a stable efficiency-level and we will follow their example. This is important, as it lets us assume that variability in commodity market efficiency is responsible for the majority of variation in relative efficiency of the two markets.

There is more to be said about efficiency in the commodity markets. The financialisation of commodity markets, as described by Tang and Xiong (2012), is a fairly recent occurrence. As financialisation is expected to increase market efficiency (Chordia et al, 2008), it is a reasonable proposition that commodity markets have become more efficient since most major studies on the topic was carried out, in turn leading to a reduction in predictability.

On the other hand, as was noted by Chinn and Coibion (2014) and Büyükşahin and Robe (2014), commodity markets may have over time become less efficient due to their increased integration, and therefore co-movement, with the global markets. This, they hypothesise, has caused commodity prices to diverge from their fundamental value as inputs and consumable goods. These inefficiencies might also have been exacerbated by the introduction of stabilising legislation after the 2008 financial crisis, most notably the Dodd-Frank act and the Basel III-standards. Among other things, these types of legislation increased the so-called “shadow

[9] The fact that market efficiency is time-variant is well known, as proven by for example Ito and Sugiyama (2009).

funding cost", making it more costly to exploit arbitrage opportunities, allowing market inefficiencies to linger longer (Fleckenstein and Longstaff, 2018).[10]

In summary, efficiency at any one point in time may depend on the strength of the, among others, above mentioned factors: the level of market financialisation and burden of legislation. In combination with relatively static foreign exchange markets, we hypothesise that these factors might have some effect on the strength and direction of the commodity-currency-connection, giving rise to time-variance in the relationship and influencing whether exchange rates or commodity prices are found to move first by papers studying different time periods, and therefore their results.

2.5 Our Contribution

This study contributes to the literature in the following ways: firstly, we include several more years of data than studies in the field (few studies employ data after 2010 while we have data up until March 2021), enabling us to further investigate the Commodity Currency Hypothesis. Secondly, it further investigates time-variance of the relationship, a possible contributing factor to the conflicting results of earlier research. Thirdly and related, while previous papers have generally noted and been concerned with parameter instabilities, they have not typically considered how these relate to the relationship between exchange rates and commodities arising or breaking down. By answering our research question: *"Is the Commodity Currency Hypothesis still relevant? And if so: How can we explain the contradictory results of earlier studies?",* this study will make an important contribution to the literature.

[10] This kind of legislation introduces market inefficiencies which are costly short term but might lead to a more stable financial system long term. For more information on specifically Basel III, we refer to Slovik and Cournède (2011).

3. Data Description and Selection

In our tests we employ monthly data on exchange rates,[11] commodity price indices, and individual commodity prices to test the relationship between commodity currencies and commodity prices. The study focuses on six different commodity currencies: The Australian Dollar (AUD), the Canadian Dollar (CAD), the Chilean Peso (CLP), the New Zealand Dollar (NZD), the Norwegian Krone (NOK) and the South African Rand (ZAR). The six countries were chosen due to their reliance on commodity exports,[12] their currencies' relatively long history of being free floating,[13] and based on the countries being price takers for their respective commodities. These are also all the countries studied either in Chen et al. (2010) or Zhang et al. (2016) or both, allowing us to compare our results to the findings of these seminal papers.

3.1 Exchange Rates

Data on monthly exchange rates were gathered from the International Financial Database provided by the IMF. All exchange rates used are nominal, in the format of local currency to USD.[14]

3.2 Commodity Price Indices

Data on commodity price indices from Canada, Australia and New Zealand respectively are published on a monthly basis by the Bank of Canada (starting 1973M1), the Reserve Bank of Australia (starting 1983M1), and The Australia and New Zealand Banking Group Limited (ANZ) (starting 1986M1) and were collected from their respective websites (see Appendix A). These indices are constructed so as to provide a composite of the value of each country's commodity exports, meaning that they are all different in terms of goods included and the

[11] Additionally, we use quarterly data for some tests, but in such cases, monthly data has been transformed into quarterly end of period and period average, for exchange rates and commodity prices, respectively.
[12] Appendix B contains a description of which commodities are used for each country.
[13] Not all floats are made equal. In the case of Chile, theirs was until 1999 a so-called "Crawling Float" where the currency was allowed to float within a certain band (Morandé and Tapia, 2002). We do not expect this to affect our conclusions to any significant extent.
[14] It has been a concern in the literature that the special status of the U.S. and the U.S. dollar might induce endogeneity, although this has been disproved in several studies using Yen or Pound Sterling.

individual weighting of each good. As an example, wheat constitutes 2.4% of the Australian commodity index. In the case of South Africa, we have constructed the index ourselves, following the example of Chen et al. (2010) and using individual commodity price data.[15]

The indices are constructed in similar ways across the countries, with some important distinctions. The Canada index ("BCPI") is a chain Fisher price index, currently consisting of a mix of 26 commodity spot and futures prices. The Australia index ("ICP") is a Laspeyres index, consisting of 21 major commodities (to our knowledge, all spot rates). The New Zealand index comprises 17 commodities gathered from different sources and is a fixed-weights (Updated yearly, that is, in the index published in any one year, all years in the index will use the same weights?) Laspeyres index (Employee., ANZ). The indices gathered have been modified over time, and are therefore different from the ones used by, among others, Chen et al.[16] We anticipate that this will have a slight impact on the results of our tests, but it should not be prohibitively large.

3.3 Individual Commodity Price Data

Via the IMF we have collected and compiled for use, in a way analogous to the exchange rate data, data on individual commodity prices.[17] The data gathered has to the greatest extent possible consisted of spot prices, so as to provide easily interpretable results.

3.4 Data Considerations

The Commodity Currency Hypothesis literature is divided on issues of data selection and aggregation. This issue merits a brief discussion.

[15] The South African Index consists of spot prices for coal (22%), gold (48%) and platinum (30%). Information on the exact specification of the goods (e.g. type of coal) is available upon request.
[16] As an example, the index published by the Bank of Canada was revised in 2013, incorporating new oil benchmark prices so as to better reflect the prices faced by exporters. The change was then applied to all previous time periods of the index, changing the time series in its entirety.
[17] The individual commodities used are brent crude oil for Norway, copper for Chile, and gold, coal, and platinum for South Africa.

3.4.1 Choice of Frequency

The CCH literature is divided on optimal data frequency and aggregation type. Some studies suggest daily data are superior as a higher resolution might reveal otherwise undetectable effects (Zhang et al., 2016). Further, compiling indices of highly diverse commodities risks attenuating the relationship between the currency and any given good by e.g. making otherwise more discreet and observable movements into more smoothened-out average movements which we lack the statistical power to detect. This would, for example, be the case if the effects lasted on average less than a month. Others argue that the power of the commodity indices, only provided on a monthly basis, is high enough to merit the use of only monthly and quarterly data (Bork et al., 2014). Indices offer a more complete picture of a country's exports thus making a better proxy for the terms of trade of the country as a whole. However, the use of indices is a *faux pas*, argue Bork et al., as averaging may induce spurious correlation, increasing the likelihood of rejecting the null hypothesis. In essence, both end of period data and averaged data have their merits.[18] Instead it is the data availability that, for most studies, is the deciding factor.

3.4.2 Spot vs. Futures

There is also a lack of consensus in the use of spot or futures data when performing tests of the CCH. As mentioned in the introduction, both real goods and derivative instruments are traded on commodity markets. As futures are explicitly forward-looking they are expected to track spot prices closely and thus they should be useful in testing the CCH. In many cases, the derivative markets are much larger and more liquid than spot markets, making them an attractive data source.

However, Chan et al. (2011) and Schwarz and Szakmary (1994) argue that there are differences in the patterns of the two markets making them less optimal for a study of the CCH. The latter paper claims futures are more efficient in incorporating pricing-relevant information and

[18] There is, however, reason to believe that the choice of frequency makes the relative importance of the choice of commodity fundamental higher or lower, see discussion in Ferraro et al. (2015).

therefore "lead" the spot markets.[19] Nonetheless, as shown by Chinn and Coibion (2014), "commodities" are in terms of behavior not a uniform group of goods, nor are their market derivatives (e.g. futures) - there is a substantial difference between how well futures prices track future spot price changes between commodities. E.g., they find a lack of predictive power in metal futures,[20] and similar information content to spot and future prices for energy commodities. To conclude, not all future-spot relationships are the same, and they likely vary over time.[21] We see no reason to believe that the fact that our indices are partially made up of futures should introduce systematic errors in a way that would render incorrect a test of the CCH. In fact, most studies on the CCH employ a combination of futures and spot, so as to maximise data availability.

[19] Bopp and Lady (1991) argued that either one can lead the other depending on the market conditions. Neither time series could be shown to consistently contain more information about the other.

[20] Hypothesised as related to the use of these instruments as hedging devices. Not only can this make futures prices deviate from expected future prices on the underlying, but can also create patterns whereby specific time-horizons (e.g. 3-6 month futures) are disproportionately bad. The use of metals as hedging-vehicles *par excellence* can be attributed to ease of storage and durability (Chinn and Coibion, 2014).

[21] Chinn and Coibion (2014) note that the predictive power of commodity futures in general has deteriorated markedly since the early 2000s, although to a differing extent for different commodities.

4. Method

In this section we describe the statistical methods used in our research.[22]

4.1 Preparatory Data Analysis

If the mean and variance of a time series are constant, the process which generates it is defined as stationary. Many tests and models presuppose stationarity in the time series studied, and testing if a time series is in fact stationary is therefore necessary before running such tests. Firstly, we can conclude that our data is not trend stationary, as all our series exhibit some kind of trend. This fact requires no other explanation than that of inflation in the case of commodities. For exchange rates, possible explanations include having trends different from those of the US in terms of economic growth or monetary supply.

For the above-mentioned reasons, we begin by making our time series *trend stationary*, i.e. we remove the trend (μ) by transforming the time series using the first difference (all tests beyond this are carried out using a dataset consisting of log first differences of the original dataset):

$$Time\ series\ generic\ equation\ (assuming\ AR(1)\ process): y_t = \mu + \phi y_{t-1} + \varepsilon_t \qquad (2)$$

$$First\ difference\ (trend\ stationary): \Delta y = y_t - y_{t-1} = \phi y_{t-1} - \phi y_{t-2} + \varepsilon_t - \varepsilon_{t-1} \qquad (3)$$

We then employ an Augmented Dickey-Fuller (ADF) test. The ADF test determines whether a time series has a unit root, a specific characteristic which renders the time series nonstationary (even in the case of trend stationarity).[23] We conclude that we can reject the null hypothesis of a unit root in our differentiated data, allowing us to proceed with our tests. An ocular inspection reveals variations in volatility, leading us to anticipate remaining parameter instabilities (for example changes in regression coefficients over time) in the data and therefore the presence of

[22] We have primarily used STATA as a tool (code available upon request).
[23] The Augmented Dickey-Fuller test assumes as the null hypothesis that the time series has a unit root, and the alternative hypothesis that it does not.

structural breaks.[24] To identify the structural breaks, we perform a Supremum Wald test. As noted by Chen et al. (2010), the standard Granger-causality test is underpowered in the presence of structural breaks. We address this primarily by subdividing the time series and performing separate tests on each period to reduce the negative effects of structural breaks on the power of our tests.

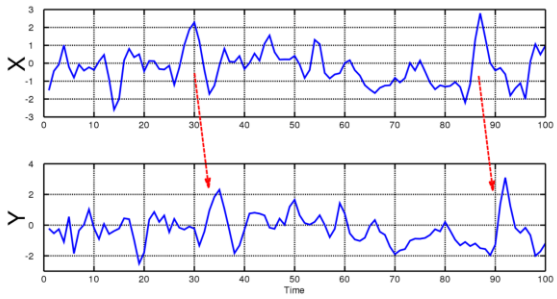
In this paper, we will only control for one structural break, namely the 2008 financial crisis. This is partly due to the fact that there is no exact definition of a structural break (there might be any number of structural breaks in a time series), and also because this allows us to better compare our study to that of Chen et al. (2010), which did not employ data after 2008.

4.2 Granger-causality

We employ tests for Granger-causality as a tool to investigate whether exchange rates can predict commodity price movements or not. In essence, a Granger-causality test determines whether or not a time series X contains any information useful in forecasting a time series Y beyond the information already present in past values of time series Y. Put simply, if a prediction of time series Y using its past values can be improved by adding lagged values of time series X, then time series X is said to "Granger-cause" time series Y, see Figure 1 below. The test statistic reported corresponds to the likelihood that the additional variable has a non-zero effect on the precision of the prediction given the observed data but says nothing about the magnitudes or sign of coefficients.

[24] A structural break is present if the sum of squared residuals is significantly improved by allowing for changes in the regression constant and slope of the coefficients at some known or unknown point in the data. One example of a structural break could be a change in e.g. volatility of a series at a specific point in time.

Figure 1: A Visualisation of Granger-causality



Notes: Time series X contains information about time series Y which is not present in Y itself, and can therefore be employed to better forecast movements in Y. Source: Wikimedia Commons.

Rejecting the null of no Granger-causality is different from uncovering "real" causality, but can be an indication of an underlying causal mechanism.

4.3 VAR and Granger-causality

To be able to perform a Granger-causality analysis, we must first model our time series in the form of a Vector Auto-Regression-model (VAR). This is a way to describe a time series as a function of its own previous values and of the previous values of a one or more other time series. In this case, we modelled a commodity price time series (CPI) as a linear combination of its own previous values, a_{t-n}, and the previous values of an exchange rate time series, b_{t-n} (given $n > 0$). a_t and b_t are then expressed as a vector $\underline{F_t}$ which depends on the value of the coefficient matrix C, the past value of the vector itself and the error term.

$$CPI = a_t = c_{11} * a_{t-1} + c_{12} * b_{t-1} + \epsilon_{a_1 t} \qquad (4)$$

$$Exchange\ rate = b_t = c_{21} * a_{t-1} + c_{22} * b_{t-1} + \epsilon_{b_1 t} \qquad (5)$$

$$\underline{F_t} = C * \underline{F_{t-1}} + \epsilon_t \qquad (6)$$

The number of significant lags (past values of the time series) was determined through a pre-estimation procedure using the Akaike and Bayesian information criteria (AIC/BIC-test). On monthly data, the largest number of lags recommended for any currency-commodity pair was six (6) lags, which was subsequently used for all pairs for consistency and comparability. To replicate Chen et al. (2010) as closely as possible, we also performed all tests using only one (1) lag.

4.4 Rolling Window Regression and Volatility Analysis

Having described our main tests, we also performed a Rolling Window Regression. We regress the commodity price change on a restricted and an unrestricted set of variables. Included in the restricted model is the first lag of the commodity index itself, to account for autocorrelation. The unrestricted model adds the last six lags (6) (as this was the number determined by the AIC/BIC-test described above) of the exchange rate series corresponding to the commodity series. These regressions are performed in a rolling window framework, allowing us to capture changes to the relationship over time. We then calculate an F-statistic to test the joint significance of these added lags, determining if the sum of squared residuals is significantly improved in the unrestricted regression compared to the restricted one for each window. This indicates whether past incorporating exchange rate information is useful in predicting the commodity price. The joint significance of the exchange rate lags is then plotted over time along with its 5% significance level critical value. This illustrates the, if any, parts of the sample where there is evidence for the hypothesis that the exchange rate moves ahead of the commodity price, allowing us to analyse whether or not the relationship might in fact be time variant. The test is also performed with the regression specification “reversed”, allowing us to determine whether there are periods in which exchange rate movements can be predicted by looking at past commodity price movements.

The size of the window used is 96 months (8 years), which is an arbitrarily chosen number. However, we believe that it is sufficiently large to afford the test sufficient statistical power and reduce the effect of any outliers while still allowing for a reasonable number of regression windows. After the Rolling Window Regression, we employ a similar rolling methodology to plot 8-year average volatility over time in our commodity time series.

5. Results

In summary, our research confirms the existence of an asymmetric Granger-causal relationship running from exchange rates to commodity currencies.

When examining the presence of Granger-causality running from exchange rates to commodity prices at quarterly data, all countries but Australia show significance at the five percent level over the entire time period, and when looking at monthly data, all but New Zealand do. The reverse relationship, when examined on monthly level, is significant only for Canada and New Zealand. The results for the two subperiods are equally variable, although exhibit a strong trend in favour of the CCH.

Further, our results from the Rolling Window Regression (Graphs I-XII) show a currency-commodity-relationship that is not only clearly time-variant, but also one where exchange rates are generally better predictors of commodity prices than vice versa. Lastly, the results from our commodity market volatility analysis paint a picture of a market with increasing volatility, indicating a more efficient market. This result is not entirely conformant with our Rolling Window Regression, nor with the Granger-causality tests, which indicate a less efficient market and a higher degree of predictability.

Below we present some of our results more in depth. We begin with our Granger-causality analysis, segmented by data frequency. We then present our results from our Rolling Window Regression. Lastly, we present some results on the volatility of the commodity prices and indices.

5.1 Granger-causality

Using a Granger-causality test and two different lag configurations, we show that lagged values of the exchange rates do indeed predict current values for commodity prices and export indices. The results for the Granger-causality tests (direction exchange rates to indices/commodity prices) are summarised for three different time periods and using quarterly and monthly data in Tables I and II.

For ease of presentation, all results significant at the 10 percent-level or lower are in bold. The results for the opposite direction using quarterly data (indices/commodity prices to exchange rates) are not significant for any time period, and are available in Appendix C. The results are qualitatively similar using six (6) lags instead of one. These results are displayed in Appendix C.

TABLE I - Granger-causality test using **quarterly** data (1 lag)

`Exchange Rate → Index`

	AUS	CAN	CHI	NZ	NOR	SAR
-2008Q1	**0.03****	0.369	**0.01*****	0.983	0.737	0.263
2008Q1-20q4	0.167	**0.011****	**0.000*****	**0.002*****	**0.000*****	**0.003*****
Entire period	0.547	**0.008*****	**0.000*****	**0.009*****	**0.000*****	**0.003*****

*Notes: The table reports the p-values for testing the null of no Granger-causality from exchange rates to commodity indices, using a standard Granger-causality test (STATA: varGranger) using one lag. *** = significant at the 1% level, ** = significant at the 5% level, and * = significant at the 10% level. Tests performed using data from IMF and other sources, see Data Description and Selection.*

TABLE II - Granger-causality test using **monthly** data (1 lag)

`Exchange Rate → Index`

	AUS	CAN	CHI	NZ	NOR	SAR
-2007M12	**0.015****	**0.071***	0.392	0.556	**0.074***	**0.005*****
2008M2-21M2	**0.000*****	**0.000*****	**0.003*****	0.272	**0.000*****	**0.000*****
Entire period	**0.000*****	**0.000*****	**0.000*****	0.199	**0.000*****	**0.004*****

Notes: The table reports the p-values for testing the null of no Granger-causality from exchange rates to commodity indices. Tests performed using data from IMF and other sources, see Data Description and Selection.

Testing for the reverse relationship, we find some evidence for a transmission channel from commodity prices to exchange rates (Table III), supporting results obtained by, e.g., Zhang et al. (2014) and Chen and Rogoff (2003) who argue that this is the relationship to be expected. However, this effect is only present in a few commodity-currency pairs and time periods, indicating that this relationship, while possibly present, is less robust than the link from currencies to commodity prices, in line with the results of Chen et al. (2010).

Using six (6) lags, this effect is also observed before 2008 in the case of New Zealand.[25] This indicates that the New Zealand commodity index has a longer history of predictive capability on the New Zealand dollar.

[25] Results are available upon request.

TABLE III - Granger-causality test using **monthly** data (1 lag)

Index → Exchange Rate

	AUS	CAN	CHI	NZ	NOR	SAR
-2007M12	0.836	0.227	0.527	0.264	0.553	0.657
2008M2-21M2	0.317	**0.001*** **	0.108	**0.037** **	0.168	0.327
Entire period	0.252	**0.009*** **	0.122	**0.002*** **	0.149	0.334

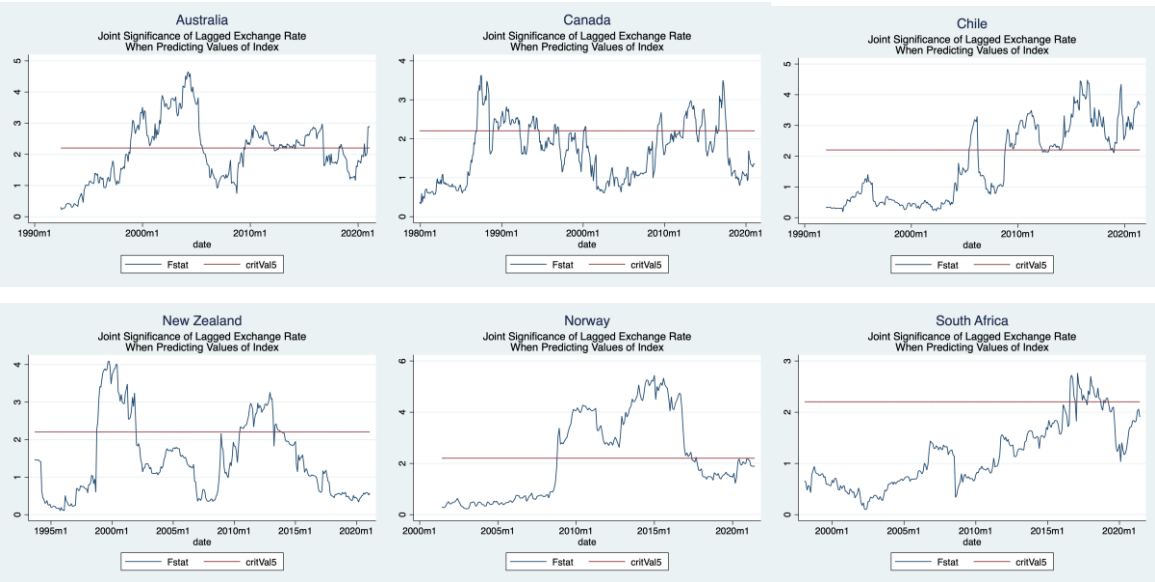
Notes: The table reports the p-values for testing the null of no Granger-causality from commodity indices to exchange rates, using monthly data and one lag. Tests performed using data from IMF and other sources, see Data Description and Selection.

5.2 Rolling Window Regression

Below you find Graphs I through VI, showing the results from our Rolling Window Regressions. Every point on the blue line represents the joint significance of
adding the six (6) most recent lags of the exchange rate (using monthly data) to a VAR-model for the past (8) years. Thus, a single high value of the F-statistic does not indicate significance at that point in the graph, but for the eight (8) years of which the point in the graph is the last period.

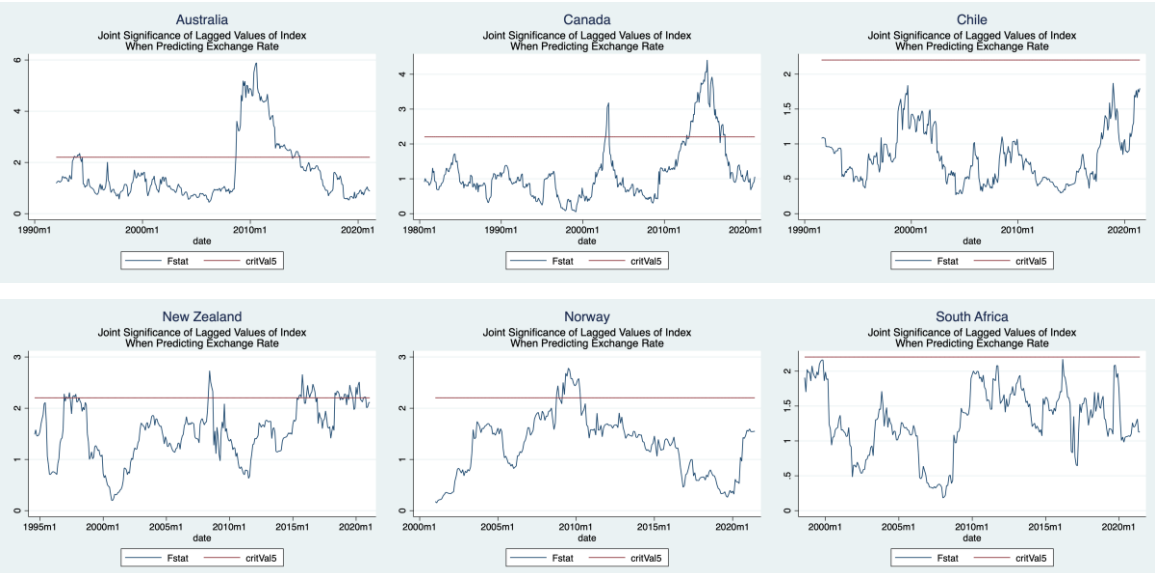
The below graphs should be interpreted against the 5% significance level (red line), given which we would expect 5% of each line to rise above the significance threshold based on mere happenstance. In summary, they suggest that exchange rate information can be used to forecast commodity price movements during some periods of time. Highly interesting is to compare each graph to its counterpart (Graphs VII-XII). These counterparts test the joint significance of commodity index lags in predicting exchange rates.

Graphs I-VI



Notes: The unrestricted models add the six (6) most recent lags of the exchange rate series corresponding to the commodity. The sums of squared residuals for these two sets of window regressions are stored and used to determine the F-statistic for joint significance of the exchange rate lags in each window. This is plotted against the 5% critical value. Window size is 96 periods, i.e., 8 years. The value of F at time t is based on the 8-year window of which t is the last period. Test performed using data from IMF and other sources, see Data Description and Selection.

Graphs VII-XII



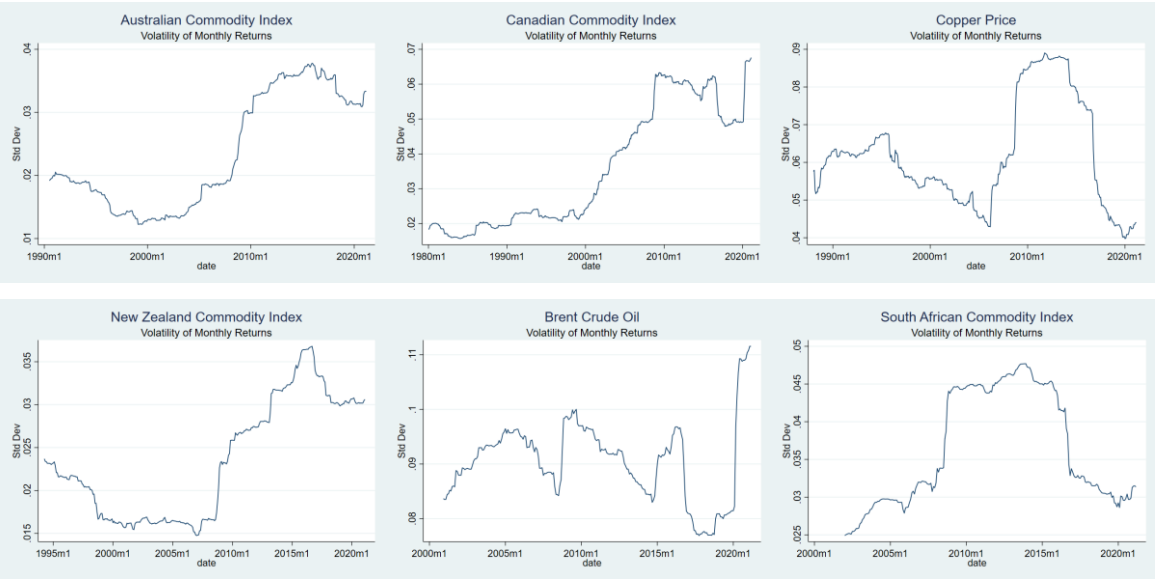
Notes: The restricted model is an exchange rate AR(1) specification, whereas the unrestricted also adds the six (6) most recent lags of the index. Test performed using data from IMF and other sources, see Data Description and Selection.

As compared to the Exchange Rate to Index connection explored in the previous graphs, there is a much lower degree of significance in the Index to Exchange Rate graphs, seemingly less than chance, in fact, for half the pairs. While there is clearly some ambiguity, the connection appears much less plausible in this direction.

5.3 Volatility Analysis

The below graphs represent the volatility of the monthly returns of a select group of commodity prices and indices using the same rolling window-methodology (every point on the blue line represents volatility during past 96 periods). As expected, the volatility varies over time, however it also exhibits strong patterns. This is interesting, given the strong link between volatility and efficient markets. While high volatility is not necessarily the result of a more efficient market, a more efficient market typically exhibits higher volatility (Ross, 1989). As such, Graphs XIV-XVIII are powerful indicators of markets whose efficiencies are varying over time. While the overall picture is ambiguous, the multi-commodity indices of Australia, Canada, and New Zealand are clearly increasing in volatility over time (although a linear regression indicates that the volatility is increasing across the board, see table IV).

Graphs XIV-XVIII



Notes: The graphs display variations in volatility over time, using a Rolling Window Regression framework. Test performed using data from IMF and other sources, see Data Description and Selection.

TABLE IV - Slope of SLR-model Applied to Commodity Price Volatility

	AUS	CAN	CHI	NZ	NOK	SAR
Slope coefficient	**0.0008148 *****	**0.0013092 *****	**0.00015 ****	**0.0006372 *****	0.00002508	**0.0007008 *****

Notes: A star (*) indicates the significance at the 10% level, two stars indicate significance at 5% and three stars at 1% of rejection that the coefficient is 0. Model plots volatility against time as measured in years. Test performed using data from IMF and other sources, see Data Description and Selection.

6. Discussion

In the discussion section, we interpret the results from our Granger-causality tests and Rolling Window Regressions in the context of the literature on the CCH and our research question.

6.1 The Commodity Currency Hypothesis and Granger-causality

The results of our Granger-causality tests point towards the existence of an asymmetric relationship between commodity currencies and commodity prices for most time periods and commodities. The link is asymmetric in the sense that the Granger-causality running from exchange rates to commodity prices is clearly more prevalent in terms of which currency-commodity pair-, time period-, and frequency-specifications it holds for than the Granger-causality running from commodity prices to exchange rates. These results indicate that it would in fact be possible to predict the movements of commodity markets using commodity currencies; there is no evidence to indicate that this connection is somehow disappearing over time (quite the opposite, as our results are clearly more significant during later time periods). We have thus answered our main research question and provided additional evidence in favor of the Commodity Currency Hypothesis.

However, we fail to fully confirm the results of Chen et al. (2010), as the tests performed on quarterly frequency only show Granger-causality running from exchange rates to commodity prices before 2008 for Australia and Chile. For Canada and New Zealand, a possible explanation for why we fail to replicate their results might be that these countries have, since Chen et al. published their study, revised their commodity export indices (retroactively applying the changes to past time periods). This would make the current index a worse fit for true terms of trade the further back from the present day we look. For South Africa, we hypothesise that the differences might in part stem from differences in the commodity data, as we have not been able to determine e.g. which exact kind of coal Chen et al. (2010) employed in their study.

The very strong results post-2008 we believe stem from the relative inefficiency of the commodity markets compared to the FX markets. Our results indicate that the relationship is

stable, telling us that the increased financialisation of commodity markets since the early 2000s has failed to make the commodity markets more efficient on an aggregate level. A plausible explanation for this can be the implementation of new legislation after the financial crisis. We suspect that another important factor was that of increasing co-movement of the commodity market with other markets. Through increased co-movement with other assets, commodity prices became more decoupled from their values as production inputs and consumable goods and price discovery became more inefficient, allowing exchange rates to precede commodity prices.

The literature on the CCH has emphasised the importance of data frequency, and we do find discrepancies in our results based on choice of frequency. However, the effect is present for most countries regardless of whether monthly or quarterly data is employed. This aggregation-indifference is somewhat surprising, as effects observed in monthly data need not necessarily be visible on a quarterly level (whereas any effect observed in quarterly data would be in theory observable also in monthly data) but supports the case that the CCH is a phenomenon robust to choice of frequency and other parameters within the control of the researcher. Furthermore, we cannot in any meaningful way distinguish between those tests performed on index data and those performed on individual commodities, giving us no reason to believe that the choice of commodity aggregation should have a significant impact on results, so long as there is a strong enough link between the commodity and the economy.

The rest of the discussion will be focused on discussing our secondary research question: Given that the CCH still bears relevance, how can we explain the earlier, contradictory, results in the literature?

6.2 Time Variance in the Commodity Currency Connection

The results from our Granger-causality tests are very strong across all countries and commodities but are lacking during certain time periods for certain countries.

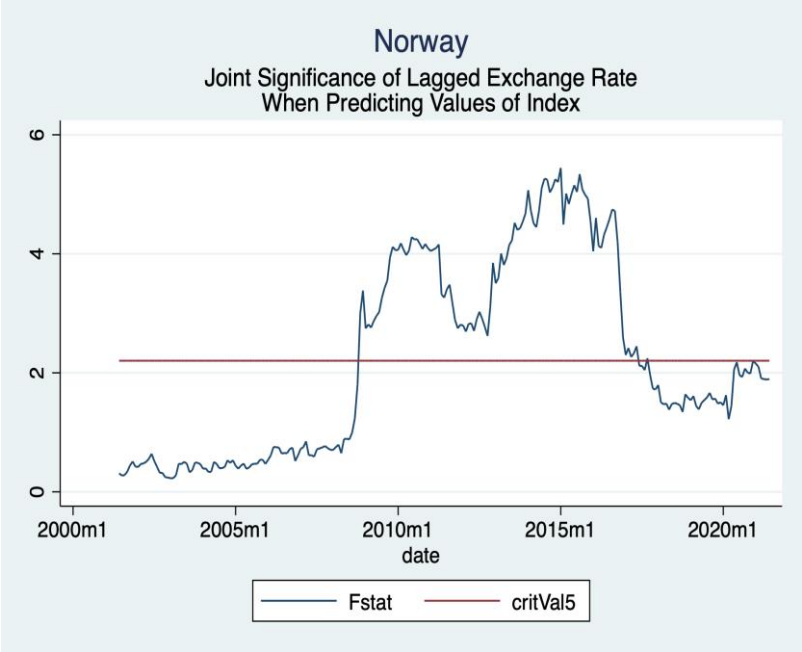
Graphs I-VI, plotting the results of our Rolling Window Regressions, show much more clearly than the Granger-causality tests the extent to which the relationship between exchange rates and commodity prices can be time-variant. While Kato (2012) argued that the financialisation

of commodities made them more predictable by commodity currencies, no study has to our knowledge addressed the issue of time-variance from a more general perspective. Our results indicate that there are specific market conditions (i.e., that currency markets are/become relatively more efficient than commodity markets) which need to be met for exchange rates to be predictive of commodity prices. As no currencies or commodities are alike, it is probable that these conditions are more often met for certain commodity exporting countries than others. The Rolling Window Regressions provide evidence for this.

We hypothesise, based on the comparison of Graphs I-VI to Graphs VII-XII from the results section, that periods of strong predictivity running from exchange rates to commodity prices weakly correspond to periods of weak predictivity running from commodity prices to exchange rates and vice versa for each country. We conjecture that the mechanism behind this is that the relative advantage in efficiency of one group over the other is constantly shifting. Based on changes affecting factors such as the importance of the commodity to the country's economy, liquidity of the particular market for the commodity and market imperfections (i.e. introduction/removal of arbitrage-hindering regulation, entry/exit of specific types of traders and speculative bubbles), either currencies or commodities can become more efficient than the other. As an illustration of these phenomena, we provide a practical example below.

6.2.1 Norway Case Study

Graph V



Notes: Test performed using data from IMF and other sources, see Data Description and Selection.

Here, we consider the case of Norway (for the reader's convenience we have above graph V from the Results section). We see quite distinct movements in the 8-year windows ending between ca 2008 and 2017, allowing us to speculate on possible factors behind the rise and breakdown of joint significance of lagged exchange rates, and by association the relationship between exchange rates and commodity currencies in general.[26] The movements we attempt to explain clearly require substantive explanations as they represent significant variations in the joint significance of exchange rate lags in explaining commodity price movements. The role of macro events - general, such as the financial crisis of 2008, or commodity-specific, such as the invasion of Iraq - are not easily interpreted in this framework. While these events certainly influence the predictability of oil prices, it is, crucially, not trivial that they should differentially influence the ability of FX traders and oil traders to predict the oil price. As such, it is possible but by no means certain that they would be visible in Graphs I-XII, and thus the account below will focus on other factors. While this constitutes a highly speculative account of the

[26] This is, however, a perilous exercise, as the F-statistic at one point in the graph incorporates all events in the past eight years. Movements in the F-statistic are thus influenced when particularly meaningful events or trends enter the window, exit from it, or become a more prominent part of it.

relationship, we believe the factors we highlight below are reasonable to consider as explanations for the time variance.

Commodity markets generally underwent a financialisation in the mid 2000s. One of the major effects of financialisation is the increased correlation of the financialised market with other asset classes (Chinn and Coibion, 2014), assumed to impede effective price discovery thereby reducing efficiency. As hedge funds and other actors moved into commodities, primarily seeking diversification benefits, we hypothesise that they would not initially make the same demands for returns. Alternatively, it could simply be that they were not yet experienced enough in these markets to make accurate forecasts. Either way, it would, in aggregate, decrease efficiency in the commodity market. Given that no coinciding financialisation or mass hedge fund entry occurred in the FX market (the efficiency of which therefore remains the same), a relative difference in efficiency arises. As this period of financialisation comes to make up a greater part of the 8-year windows (ones ending around 2008-10), we observe a significant uptick in excess predictive power of exchange rates in these windows due to a comparatively less efficient commodity market.[27]

The subsequent minor downtick (windows ending 2010-12) could have its origin in the new entrants' gradual increased trading strategy and forecasting sophistication. As the novelty of the hedging opportunity provided by the financialised market fades and demand rises for returns, driving efficiency (alternatively it increases as hedge funds gain experience). The advantage of FX traders is somewhat tempered.

The second period of increasing joint significance of exchange rate lags, (windows ending 2012-15) matches very well with the 2008 financial crisis hitting the middle of the eight (8) year window. Presumably due to the economic downturn and the precipitous drop in the oil price, activity in the oil market decreased (measured in terms of open interest[28]). An exodus of money, and thus talent applied to analysis and forecasting, from the market could certainly have lowered the quality of analysis enough to temporarily decrease the relative efficiency of the oil market compared to the market for the Norwegian Krone, strengthening the joint significance of exchange rate lags. Further, regulation was also introduced shortly after the

[27] Indeed, we observe this phenomenon across several commodities.
[28] The number of contracts or commitments outstanding in futures and options trading on an official exchange at any one time.

financial crisis, which hindered arbitrage by penalising larger balance sheets, thereby increasing transaction costs for e.g. financial actors exploiting mispricing (Fleckenstein and Longstaff, 2018). As arbitrageurs (e.g. hedge funds) generally provide market liquidity and thereby contribute to price discovery (Chordia et al, 2008), their disappearance is likely to reduce market efficiency, manifesting itself as increased predictivity of commodities.

The exit of the tumultuous period of 2007-08 from the 8-year window in late 2016 coincides with the disappearance of joint significance and as noted the appearance of joint significance coincides with the 2007-08 period entering the window. This is tentatively consistent with the analysis of Nissanke (2012), who claims that financial investors returned to the markets closely after the financial crisis, again improving the market efficiency by improving for example price discovery and liquidity.

A rise in the joint significance of exchange rate lags for windows ending around 2008 and fall in joint significance for windows ending around 2017 appears in the Rolling Window Regression graphs for all countries but South Africa. The Graphs I and III for Australia and Chile even display the same two-hump structure as the Graph V for Norway. This has two tentative implications. Firstly, that the factors described for the case of Norway hold some analogous explanative power for the other countries as well. Secondly, the entry and exit of the 2007-08 crisis from the 8-year window seems to be privileged in terms of its importance for joint significance of exchange rate lags compared to other events, periods of deviations,[29] or trends in the time series (especially for Norway which does not experience significance for any other time periods). However, there is significant variance between all the windows which contain the 2007-08 period. The 2007-08 crisis can therefore not on its own account for all significance in the time series.

We believe that these kinds of accounts can be instructive, in that they provide the reader with plausible explanations as to why the relative efficiency of the two markets may vary over time. It is, however, also clear that there are many more factors which influence the relative efficiency which we have yet to describe, as we cannot explain all variation in the graphs. These factors may be country-specific or commodity-specific or both, for example the introduction of national restrictions on commodity trading, or the industrialisation over time of

[29] E.g., temporary regulations restricting on trading activity.

the country in question. Better determining these factors is an interesting topic for further research.

6.3 Comments on The Methodology

In our study, we have employed a time series-analysis framework. Throughout the paper, we have had the work of Chen et al. (2010) in mind, while choosing to disregard some of their more advanced tests (for example, various robustness tests and a Granger-causality test allegedly robust to structural breaks) as we found them to be outside the scope of this study. In essence, we believe that the tests we have chosen to perform are robust enough to provide us with a reasonable assurance that our results are reliable. However, this is not to say that there is no room for improvement.

We also performed several Rolling Window Regressions, which is a departure from the methodology of Chen et al. (2010) and a possible improvement upon their study. There is no standard way known to us of how to interpret a series of several hundred consecutive such regressions taken together. While each regression and its F-statistic individually are easily interpreted, the graphs as a whole lack a statistic to suggest what confidence one should assign the collective result and are in a sense merely indicative. This is a clear weakness of the methodology employed. However bluntly, they do allow us to observe the relationship in a more detailed way than tests employed in previous research and we conclude that they are an important addition to the toolkit - provided they are interpreted with due caution.

The use of Rolling Window Regression also allows us to more clearly observe something analogous to Granger-causality arising and breaking down in greater detail. As the Granger-causality tests report the probability that the coefficients of a VAR-model are jointly zero (0), a strong significance in even a small portion of the data set might yield a significant result overall. This may then be interpreted as evidence in support of the prevalence of an economic phenomenon over the whole time period (that is, Granger-causality throughout), revealing a weakness in the Granger-causality tests; a methodology often employed in the literature. In essence, by employing both we are able to better understand our results from the Granger-causality tests.

As we have mentioned, there is also some concern regarding the use of data. We have ventured to employ as wide of a range of data as we could so as to minimise the effect of any one concern, however every result by itself can of course be called into question. Our treatment of structural breaks in the data, while systematic, can also be criticised for being less-than-rigorous. Improving on our methodology would involve employing tests to control for heteroscedasticity and autocorrelation,[30] as well as using a test for Granger-causality robust to structural breaks.

To further improve on our study, it would be beneficial to perform some further robustness tests. Examples of such tests are tests for exogeneity of exchange rate determination and robustness to exchange rates in other base currencies (Yen, Pound Sterling). As these tests when done in other studies have generally yielded results that confirm our results (i.e. the exogeneity assumption holds and results are robust to different currency bases), and our scope is limited, we have decided to omit them. Other ways to test the robustness of our study would be to include more countries. There are many countries whose currency heavily depends on export of primary commodities, such as Brazil and Burundi, and could be employed in further studies. Finally, performing tests for Granger-causality out-of-sample (that is, testing the hypothesis on data not used for modelling the VAR-model) would yield more conclusive evidence in favor of the CCH.

6.4 Practical Relevance and Further Research

By default, we expect that any enduring predictive capability in the marketplace will be exploited and subsequently fade away.[31] Given the extensive research done on the Commodity Currency Hypothesis (and a reasonably efficient market), pure arbitrage opportunities should already have been exhausted. However, even during perfect market conditions the Efficient Market Hypothesis does not rule out all financial forecasting (Timmerman and Granger, 2004), only the directly exploitable. While trading strategies based on exploiting the CCH may not confer abnormal returns, its real importance may instead lie in its use as a tool to help

[30] For example, the Newey-West procedure to provide more accurate standard errors for the regression in the presence of autocorrelation and heteroscedasticity is widely used in the literature (Chen et al., 2010). This is especially important when employing higher frequency data (Bork et al., 2014).
[31] Given that transaction costs and other trading restrictions are not prohibitively large (Timmerman and Granger, 2004).

companies and central banks improve production planning and inflation control measures by improving their forecasts of the prices of certain commodities. The time-variant nature of currencies' predicting advantage is likely to make this an unreliable approach, but its potential justifies further efforts and further research should pursue this.

For the CCH to be applicable, one must first conclusively determine whether or not the relationship between commodity currencies and their respective commodities actually exists, which has yet to be done. In this sense, our study is valuable as it supports the notion of an asymmetric Granger-causal relationship running from commodity currencies to commodity prices.

A final note is one on the results of our volatility analysis. We do not find any connection between the clear trends of increasing volatility over time displayed by the commodity indices of Australia, Canada, New Zealand, and Norway and the time-variant results of our Rolling Window Regressions based on the tests we have performed. However, these trends of increasing commodity volatility are significant enough to merit further investigation of the effect of volatility on the Commodity Currency Hypothesis. Methods beyond the scope of this study may yet find important and interesting results.

7. Conclusion

Commodity prices are rising anew. Given the importance of commodities, especially for developing economies, the Commodity Currency Hypothesis is one of continued relevance. Albeit theoretically attractive, the hypothesis has not to this day been conclusively proven to be true, with numerous studies arguing for, as well as against, its existence. Among those who find evidence for the connection, there is a discussion whether the link is stronger from exchange rates to commodities or vice versa. As the practical use of a proven link between currencies and commodities might be immense, not least as a way to improve inflation control, production planning and food safety, it is likely that the field will remain relevant despite the apparent difficulty of finding conclusive evidence.

In our paper, we have conducted tests that strengthen the belief that the exchange rates of commodity currencies can be used to predict movements on commodity markets. We have also shown that the opposite relation can exist, albeit to a much lesser extent. These results are consistent with a large portion of the literature (e.g. Chen et al., 2010) on the subject.

Further, our results indicate that the relationship between commodity currencies and commodity markets is to a large extent time-variant in ways which do not follow deterministic trends (based on the results of Graphs I-VI). This is a novel result, as the existing literature has almost exclusively focused on the binary question of whether the relationship exists or not. The nature of time-variance in the relationship between currencies and commodities is one of the main findings and contributions to the literature of our study, as it adds a layer of complexity to the question. Movements in our Rolling Window Regression graphs do not seem to be random, but rather dependent on trends, events, and periods of deviation. As such, there should be structural reasons explaining the behaviour of the two markets. We hypothesise, while not directly investigating, that such structural elements might be regulatory action, changes to liquidity, types of traders present etc. all affecting market efficiency. By studying this quality further researchers may gain more information about how price setting and price discovery in commodity markets works.

To conclude, this study contributes to the existing literature by providing evidence in favour of the Commodity Currency Hypothesis, as presented by Chen et al. (2010), while presenting a

more detailed picture of the phenomenon, and simultaneously suggesting areas for further research.

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APPENDIX A: Commodity Index Providers

Country	**Website**
Australia	https://www.rba.gov.au/statistics/tables/xls/i02hist.xls?v=2021-05-16-21-45-22
Canada	https://www.bankofcanada.ca/rates/price-indexes/bcpi/
New Zealand	https://www.anz.co.nz/about-us/economic-markets-research/commodity-price-index/

APPENDIX B: Commodities Exported

Australia	**Canada**	**New Zealand**
Wool	Coal	Lamb
Beef and veal	Oil	Beef
Wheat	Natural Gas	Wool
Barley	Gold	Skins
Canola	Silver	Venison
Sugar	Nickel	Wholemilk Powder
Cotton	Copper	Skimmilk Powder
Milk powder	Aluminium	Butter
Lamb and mutton	Zinc	Cheese

Aluminium	Potash	Casein
Lead	Lead	Apples
Copper	Iron	Kiwifruit
Zinc	Pulp	Logs
Nickel	Lumber	Sawn Timber
Iron ore	Newsprint	Wood Pulp
Metallurgical coal	Potatoes	Hoki (Fish)
Thermal coal	Cattle	Orange Roughy (Fish)
LNG	Hogs	Mussels
Crude oil	Wheat	Aluminium
Alumina	Barley	
Gold	Canola	
Copper ore	Corn	
	Finfish	
	Shellfish	

Chile	**Norway**	**South Africa**
Copper	Oil	Gold
		Coal
		Platinum

APPENDIX C: Granger-causality Analysis, Results

TABLE BI - Granger-causality test using **quarterly** data (1 lag)

`Index → Exchange Rate`

	AUS	CAN	CHI	NZ	NOR	SAR
-2007Q4	0.489	0.386	0.424	0.818	0.505	0.646
2008Q2-20Q4	0.152	0.811	0.252	0.248	0.695	0.279
Entire period	0.358	0.448	0.619	0.298	0.866	0.334

*Notes: The table reports the p-values for testing the null of no Granger-causality from **commodity indices** to **exchange rates**, using quarterly data and one lag. Note the lack of significance in any time period.*

TABLE BI - Granger-causality test using monthly data (6 lags)

`Exchange Rate → Index`

	AUS	CAN	CHI	NZ	NOR	SAR
-2007Q4	**0.09***	0.354	0.72	0.225	0.868	0.714
2008Q2-20Q4	**0.000*****	**0.000*****	**0.007*****	**0.001*****	**0.000*****	**0.000*****
Entire period	**0.000*****	**0.000*****	**0.036****	**0.001*****	**0.000*****	**0.002*****

Notes: The table reports the p-values for testing the null of no Granger-causality from exchange rates to commodity indices.