

Commodity Prices and Exchange Rates

BY

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Thesis

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Abstract

This thesis investigates the validity of the "Commodity Currency" hypothesis across six major commodity-exporting economies—Kazakhstan, Russia, Brazil, South Africa, Canada, and Australia—over the period 1993–2023. By constructing novel, country-specific export-weighted commodity price indices and employing a hierarchical econometric framework (OLS with Newey-West standard errors, contemporaneous OLS, and Vector Autoregression), the study challenges the universality of the link between commodity prices and exchange rates.

The empirical results demonstrate that the commodity currency relationship is highly conditional on structural characteristics rather than universal. Significant heterogeneity in transmission dynamics was identified:

- **Kazakhstan** exhibits a traditional lagged relationship, where price shocks drive currency appreciation after one year.
- **Russia** displays immediate transmission with no lagged effects, likely reflecting deep oil-currency markets.
- **Australia** shows a dual-horizon transmission, with both immediate and lagged effects.
- **Brazil, South Africa, and Canada** show weak, unstable, or non-existent relationships, suggesting that economic diversification and domestic shocks often override terms-of-trade fundamentals.

Furthermore, the study finds no evidence of reverse causality (exchange rates predicting commodity prices) in emerging markets, contradicting the "asset price" view for these economies. Ultimately, this research establishes a new typology of transmission based on

temporal dynamics and concludes that high export concentration is a necessary but insufficient condition for a stable commodity currency relationship.

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Chapter 1: Introduction

1.1 Background and Motivation

Setting the exchange rates appears to continue to be one of the classical puzzles that we continue to wrestle with in macroeconomics classes. Since the seminal work of Meese and Rogoff (1983), which demonstrated that fundamentals such as interest rates, money supply and output differentials don't too well beat a random walk when it comes to predicting rates, economists have been on the lookout for more reliable signals. In that search, the "Commodity Currency" hypothesis popped up as a neat niche winner. Chen and Rogoff (2003), and later Chen, Rogoff and Rossi (2010, 2014) suggested that, for small, commodity-heavy economies, the real exchange rate tends to move as an extension of the world price of the major export.

The primary reason for this hypothesis are the terms-of-trade mechanism. Imagine a country whose major exports suddenly rise in price, that increase in price raises the country's terms of trade, which is in a way making the economy richer. People begin to demand more non-tradable goods and the real exchange rate appreciates to restore the market to balance. In practice, the developed commodity exporters such as Australia and Canada have exhibited such a strong correlation that traders sometimes use their currencies as barometers of global commodity cycles.

But there are still three big blinds that need more attention. First, most papers focus on a few privileged exporters, such as Australia, Canada, New Zealand, while barely mentioning emerging markets, even though those countries tend to be even more dependent on commodities and their economies are less diversified. Second, studies typically use broad-banded indices such as the

IMF Primary Commodity Price Index or the CRB Index, which obscure the distinct export mix of any given nation and fail to track changes in the export structure of their exports over time. Third, the direction of causality is still controversial: according to Chen, Rogoff, and Rossi (2010, 2014), exchange rates might be able to predict commodity prices, which is an interesting idea but later criticized by Bork et al. (2023) as a byproduct of faulty benchmark models. The conversation is still open, and there's a clear need to try to apply this commodity-currency framework to the emerging and transition economies, especially after 2000, when volatility, sanctions and structural change in the global markets has increased.

1.2 Research Question

This thesis addresses these gaps by investigating the following primary research question:

To what extent do exogenous commodity price shocks drive exchange rate dynamics in commodity-dependent economies, and how does this relationship differ across countries with varying structural characteristics, institutional frameworks, and levels of development?

To answer this, the study analyzes a diverse sample of six major commodity exporters over a three-decade horizon (1993–2023):

- **Advanced Resource Economies:** Australia and Canada
- **Established Emerging Markets:** Brazil and South Africa
- **Transition Economies:** Kazakhstan and Russia

Four specific sub-questions guide the empirical investigation:

1. **Predictive Power:** Do past commodity price movements Granger-cause future exchange rate changes?
2. **Heterogeneity:** Does the strength and nature of the relationship vary systematically across countries?
3. **Transmission Timing:** Does the relationship operate through immediate (contemporaneous), lagged, or dual-horizon channels?
4. **Reverse Causality:** Do exchange rates possess independent predictive power for commodity prices, as claimed by Chen, Rogoff, and Rossi (2010)?

1.3 Contribution to the Literature

This paper makes four main contributions to the empirical literature:

First, I construct custom export-weighted commodity price indices for each of the six countries from detailed bilateral trade data from UN Comtrade at the HS-2 digit level. Unlike the generic indices that have been used in previous research, these customised ones reflect each nation's composition of exports and captures how it changes over time. This means I can see the atypical drivers that standard aggregates tend to obscure, such as the focus on uranium and oil in Kazakhstan; platinum and gold in South Africa; iron ore and soybeans in Brazil; iron ore and coal in Australia; natural gas and lumber in Canada; or oil and natural gas in Russia. By using both variable weight (Paasche) and fixed weight (Laspeyres) indices with correlations above 0.95, I am sure that the results are caused by price changes rather than quantity changes. These indices cover between 68 per cent and 82 per cent of the total value of exports of each country, providing an accurate test of how terms-of-trade shocks are transmitted.

Second, I use a stringent three-staged methodology for all six countries to ensure that any cross-country differences are due to actual economic heterogeneity, and not how I'm doing the analysis. The framework consists of three components: (1) a main model with Newey-West adjusted OLS and a lag of one to test for Granger causality, (2) contemporaneous OLS regressions for any immediate, within-period transmission and (3) vectors autoregressive models (VAR) with lag selection to address robustness and dynamic feedback. This consistency allows me to compare countries fairly and the multiple specifications reveal timing differences that the single model way would miss.

Third, I make a close look at the recent debate between Chen, Rogoff & Rossi (2010, 2014) and Bork et al. (2023) whether exchange rates can predict commodity prices. By testing for reverse causality in both emerging and developed markets, I find that in no emerging market (Kazakhstan $p = 0.595$, Russia $p = 0.308$, Brazil $p = 0.205$) exchange rates predict commodity prices which is the opposite of a universal "asset - price view." Developed-market currencies (Canada $p = 0.003$, Australia $p = 0.015$) do show significant reverse effects but these are likely market anticipation, simultaneous shock adjustment or tricks of the USD deno effect, rather than real forecasting power. Thus I support the criticism of Bork et al. and demonstrate that the direction of causality is sample dependent, thus resolving the conflicting evidence in the literature.

Fourth, I develop a new empirical typology of commodity-currency transmission, which is based on timing. Rather than viewing all resource-rich countries as being equivalent, I see four different patterns:

- Type I (Lagged Transmission Only): Kazakhstan - adjustment takes a year and there are no contemporaneous effects, probably because of fiscal budget cycles.
- Type II (Immediate Transmission Only): Russia - adjustment occurs in the same year with no lagged predictability and is indicative of a tight oil - ruble nexus.
- Type III (Dual-Horizon Transmission): Australia - both immediate and lagged effects are relevant, suggesting a variety of channels operating at different speeds.
- Type IV (Unstable/Absent Transmission): Brazil, South Africa, Canada - there is no stable relationship present across specifications which may indicate commodity factors are dominated by other forces.

This typology highlights why previous research using alternative lag structures came to contradictory conclusions, and provides a useful framework for identifying the cases in which commodity shocks affect exchange rates.

1.4 Methodology Overview

I use annual time series data from 1993 to 2023, with the sample period of each country reflecting data availability and changes in the structure of the country (Kazakhstan 1995-2023, Russia 1996-2023, Brazil 1993-2023, South Africa 2000-2023, Canada 1993-2023, Australia 1993-2023). The design of the analysis is two stage:

Index Construction: For each country I construct a weighted export price index using a rule based algorithm. Commodities are selected on three parameters - economic relevance (share in exports), temporal consistency (ratio of presence) and a composite score - thereby the index reflects large exports and ignores fleeting and minor items. I associate certain commodity prices (such as Brent Crude Oil, Iron Ore 62%Fe, LME Copper) with HS-2 categories based on

Bloomberg and World Bank data. Variable weights are updated annually to reflect structural movements (e.g. Kazakhstan from metals to oil), and then I test robustness with fixed-weight specs. All indices are adjusted to a 2015 base year for cross country comparability.

Econometric Estimation: I use a three stage framework in the same way for all six countries. The Main Model is OLS using Newey-West HAC errors (lag truncation $L=1$) to test whether lagged commodity price growth predicts future exchange rate changes - this is the basic commodity-currency test.

Robustness Check

In the first robustness check, we use contemporaneous OLS regressions to capture immediate, within-period transmission missed by lagged models. Robustness Check 2 is used to estimate VAR models with lag length selected by Schwarz Information Criterion by checking that results hold in dynamic systems with possible feedback. All the variables are transformed to log growth rates (first differences) for stationarity, which was confirmed by the Augmented Dickey-Fuller tests. Cointegration tests by Johansen show no long run relationships, justifying the differenced specification. This hierarchical approach separates the primary evidence from validation checks while the timing patterns for country-specific evidence can be identified.

1.5 Preview of Findings

The results are pretty different across the six countries, showing the commodity currency idea isn't a one size fits all deal.

Kazakhstan is clearly the traditional commodity currency. In the Main Model we see a solid positive link ($\beta=0.312$, $p=0.053$) whereby a 1% bump in export price growth means that the

currency goes up about 0.31% a year later. In the same year spec it doesn't show up ($p=0.858$), which just means that it takes time for the effect to work through fiscal and real world channels. The VAR test backs this up ($p<0.001$) - commodity shocks account for 38% of exchange rate swings by year two. No reverse causality ($p=0.595$) - typical of a price taker. This makes sense given the oil revenues flow through the National Fund and budget before they hit currency demand.

Australia is the textbook of the commodity currency; the evidence is all over the place. The Main Model provides a large lagged effect ($\beta=0.394$, $p=0.022$). The same year spec still shows a serious within period hit ($v=0.182$, $p=0.003$), so the price shock spreads fast both through the markets and slow through the real economy. The VAR checks keep the link alive ($p=0.057$) and diagnostics looks good. Over 25% of AUD swing is due to same period commodity moves. There's some reverse causality ($p=0.015$), but that's probably just markets guessing ahead, and not the other way around. This is similar to the Australian mining-heavy setup, good institutions, and free float.

Russia is a unique country. The Main Model has no lagged relationship ($\beta=0.242$, $p=0.396$). So price shocks and currency moves occur simultaneously in the same year. This is because it is a super liquid market of the oil - Ruble, and the prices are instant. No reverse causality ($p=0.308$) - Russia still just takes the price. The difference with Kazakhstan demonstrates how a deeper financial market brings things around faster.

In Brazil, South Africa and Canada the theory pretty much misses. Brazil's Main Model, same - year, and VAR all say no answer ($p=0.328$, 0.858 , 0.214); commodity shocks only explain 24% of swing even though 45% of exports are commodities. So the diversification, politics and taxes

swamp the trade - terms signal. South Africa is similar - no sign in the Main Model ($p=0.634$) or same-year ($p=0.158$); the big stuff like power crunches and political stuff are what it's all about. Mild reverse causality ($p=0.068$). Canada is weird: The lagged beta is negative (-0.153 , $p=0.010$) - nonsense - and disappears with VAR(2) ($p=0.450$). The same year sign is back to right (0.114 , $p=0.009$), meaning short term co-movement but no (permanent) lag, probably because US policy and cross-border flow overpower commodity fundamentals.

On the whole, high commodity export share is a must but its not enough for commodity currency link. It only shows up robustly when the economy's pretty simple and all about resources - like in Kazakhstan and Australia - plus you've got a free - floating rate and a direct fiscal arm from the revenues to the budget. When you add complexity, diversification, mature markets and crazy domestic shocks, the link just goes away.

1.6 Structure of the Thesis

The rest of the thesis will be structured in the following manner: Chapter 2 provides the literature review of the theoretical background and empirical evidence about commodity currencies, which will form the framework and reveal the gaps that will be filled in this thesis.

In chapter 3, the data collection procedure and the construction of country-specific commodity price indices, the systematic selection algorithm, the price matching protocol, and the weighting methodology are described.

Chapter 4 describes the econometric approach, including the three-stage hierarchical empirical approach, the stationarity test, and the interpretive approach to synthesizing the results of specifications.

In chapter 5, the specific empirical findings on the six countries are described in detail, and a comparative analysis across countries is carried out putting together the patterns and creating the typology of transmission timing.

Chapter 6 finally ends with a conclusion of the findings, theoretical contributions based on the conditional nature of the hypothesis and causality debate, sound reflections on the methodological framework, policy implications to commodity-exporting economies and future research directions.

Chapter 2: Literature Review

2.1 Introduction

The connection between exchange rates and commodity prices is not a small matter in international macroeconomics, particularly in so-called commodity currencies: in such economies, the export of a single commodity or a set of commodities is a significant portion of their revenues. The standard exchange-rate theories (monetary, portfolio balance) do not actually provide answers as to why floating exchange-rates move so erratically; the so-called exchange-rate disconnect puzzle (Meese and Rogoff, 1983). However, according to some studies, the real commodity prices are the true cause of the exchange rate change when it comes to commodity exporters. This chapter examines the theory behind that, the evidence that constitutes a commodity currency, and the most recent concerning what is predicting what.

2.2 The Commodity Currency Hypothesis

To a large extent, the connection can be traced to the Terms-of-Trade logic. When the large export of a particular nation becomes more expensive in the global market, their terms of trade improve, which simply translates to increased revenues. That will force the actual exchange rate to appreciate in order to have the internal and external balances back where they refer to it as the spending effect in the Dutch Disease model (Corden and Neary, 1982).

Chen and Rogoff (2003) adopted this thought and put it to test using the statistics of three small but developed economies, namely, Australia, Canada, and New Zealand. They constructed country-specific price indices and determined that the alteration of world commodity prices is the reason why a significant part of the fluctuation in the real exchange rate of those nations. The correlation was good and robust, and unlike in other major currencies, where fundamentals do not tell much, the commodity currencies had a stable one.

2.3 The Direction of Causality and Predictability

The prevailing opinion is, as a rule, that the prices of commodities in the world markets are the motivating factors of the exchange rates of the small open countries. However, in the recent times, there have been papers that have cast doubt on whether it is not the reverse of the direction.

2.3.1 The "Asset Price" View (Exchange Rates as Predictors)

A reversal assertion was made by Chen, Rogoff, and Rossi (2010) - or, as we can call them, CRR - which holds that exchange rates of commodity currencies do better predict future commodity prices than vice versa. They contend that exchange rates are forward-looking asset prices and

they absorb future fundamental expectations more rapidly than commodity markets which may be sticky or trend-following.

On data of Australia, Canada, New Zealand, Chile and South Africa, CRR found that the exchange rate Granger causes commodity prices, but the reverse is weak or even nonexistent when you out of sample. They maintained the same findings in a subsequent update (CRR, 2014) despite the inclusion of the turbulent Global Financial Crisis period (2008 2013).

2.3.2 The Fundamentalist View (Commodity Prices as Drivers)

Nevertheless, Bork and co-authors in 2023 were the sceptics. They re-exercised the CRR analysis with superior benchmarks and extended samples and discovered that the predictive capability of the exchange rate is eliminated when you apply a strict Random-Walk-with-Drift benchmark. Their findings concur with the Engel-West model in which commodity prices are the exogenous force of the exchange rate and not the opposite.

2.4 Gap in the Literature

The major part of research up to date examines Australia, Canada and New Zealand - little is done to compare the emerging markets such as Kazakhstan, Russia and Brazil with their developed counterparts that apply the same techniques. The two-way discussion between CRR and Bork et al. also demonstrates the sensitivity of the results to the specific econometric model. Thus this thesis will bridge that gap, I am implementing an integrated approach of export-weighted price indices and the Newey-West standard errors over six commodity exporters, over a long period leading to 2023.

3. Data and Methodology

3.1 Overview

In this paper, I considered the interaction between commodity prices and exchange rates of six large exporting countries, including Kazakhstan, Russia, Brazil, South Africa, Canada and Australia. The key twist in my thesis is that I constructed custom, export weighted commodity price indexes to each country, which in fact capture the trade shocks that the economies experience. My own indices are based on the actual combination of goods that each country exports, unlike other previous work which uses global averages such as the IMF Primary Commodity Price Index or the CRB Index.

The time periods of data vary across countries, based on the time we have records and how we correct to the political changes. The Kazakhstan analysis includes the post-Soviet period of transition (1995-2023), whereas the Russian one (1996-2023) does not include the turbulent years of early transition. The Brazilian data covers 1993-2023 after the stabilization of the economy after hyperinflation. The 2000-2023 period is used to study South Africa because the data is consistent, and Canada (1993-2023) and Australia (1993-2023) are studied over a period of the post-NAFTA period and the mining boom cycle, respectively.

3.2 Construction of Country-Specific Commodity Price Indices

The most important methodological process is to construct the correct commodity price indices. I assembled a sound multi-step procedure that ensures that the indices reflect actual trade shocks and not measurement anomalies.

3.2.1 Commodity Selection Algorithm

I grabbed detailed bilateral export data of the HS -2 level (99 commodity categories) of UN Comtrade. To render the index powerful, I constructed a selection algorithm based on three parameters: economic relevance, time consistency and composite rating system.

First, I ensured that every commodity was economically significant, i.e., it had to be an important percentage of the overall exports. I prioritized all the HS-2 categories according to their mean share in the entire period. Second, in order to prevent one-off spikes, I determined a presence ratio:

$$Presence Ratio_j = \frac{Number\ of\ years\ commodity\ j\ appears\ in\ export\ data}{Total\ years\ in\ sample} \quad (1)$$

Commodities with a presence ratio below 0.65 are excluded. Finally, we employ a composite scoring method to create a final selection criterion. For each commodity j in country i , we calculate scores based on share, consistency, and total value, each weighted at 33.33%:

$$Share\ Score_j = \left(\frac{rank(avg\ share_j)}{max\ rank} \right) * 33.33 \quad (2)$$

$$Consistency\ Score_j = Presence\ Ratio_j * 33.33 \quad (3)$$

$$Value\ Score_j = \left(\frac{rank(total\ value_j)}{max\ rank} \right) * 33.33 \quad (4)$$

The final Composite Score is the sum of these three components. Commodities are selected if their Composite Score ranks in the top 20 and they meet a dual-threshold requirement: a Presence Ratio of at least 0.65, or an average export share of at least 2.0%. This ensures the inclusion of both consistently exported major commodities and dominant exports that may have

emerged later in the sample. Across all six countries, the selected commodities cover 68–82% of the total export value, confirming that the indices represent the core of each economy's terms of trade.

3.2.2 Price Data Matching

I matched global spot prices of each selected HS-2 category I used Bloomberg and World Bank Commodity Price Data (the Pink Sheet). All of the prices are annual averages of the monthly spot prices in US dollars.

I adjusted prices based on reason and not regulation. As an illustration, Brent Crude Oil is used in minerals (HS -27), Iron Ore Fines 62 in iron ores (HS -26). LME prices apply to industrial metals such as Copper (HS -74) and Aluminium (HS -76) and precious metals (HS -71) refer to Gold or Platinum. Chicago Wheat and Soybean prices are used in agricultural products such as Cereals (HS -10) and Oil seeds (HS -12).

The country specific tweaks are an indication of the export mix of each country. Uranium and Natural Gas receive heavy loads along with the oil in the case of Kazakhstan and Russia. Brazil consists of Soybeans, Iron Ore, Sugar and Coffee. South Africa has average precious metals of Platinum and Gold. Natural Gas, Lumber, Wheat and Potash are used for Canada, Iron Ore, Coal, Wool and Beef are used for Australia. Products that have no trusted global prices are abandoned and this is only covered at 5 -12 percent of the export value.

3.2.3 Weighting Methodology

To remain healthy I constructed two versions of the index in every country. The former is a Variable-Weight Index - a Paasche-type chain index in which the weights vary annually to reflect the prevailing export mix. The formula is:

$$W_{i,j,t} = \frac{Value_{i,j,t}}{\sum_{j=1}^N Value_{i,j,t}} \quad (5)$$

The index for country i at time t is calculated as:

$$CPI_{i,t}^{Variable} = \sum_{j=1}^N W_{i,j,t} * \left(\frac{P_{j,t}}{P_{j,t_0}} \right) * 100 \quad (6)$$

$P_{j,t}$ is the world price of commodity j and $t_0 = 2015$ is the base year. This technique describes the structural changes, like the move by Kazakhstan towards oil as opposed to metals, and shows real-time terms-of-trade shocks. Although critics can say that this mixes price and quantity effects, we solve that through a robustness check.

The second one is a Fixed-Weight Index (Laspeyres-type), in which weights are fixed at 2015 values ($W_{i,j}^{Fixed}$) and re-normalized on an annual basis to add up to 1.00, depending on what commodities appear in that year ($W_{i,j,t}^{Fixed}$). When the Variable and Fixed indices are almost identical with one another, then it indicates that price movements cause the results and not compositional changes. The two indices are empirically associated with a correlation of over 0.95 in the six countries and this justifies the Variable-Weight specification as the main index to be used.

3.2.4 Index Validation and Diagnostics

I checked the indexes before any econometric work I did. I ensured that the total weight added up to 1.00 per year and coverage was never less than 60 percent of exports. I put any extreme price action above three standard deviations on the flag and checked it against historical data (such as the 2008 crisis or the 2014 oil crash) to ensure that it was actually a shock, and not a data error. Lastly, I made everything normal to ensure that $CPI_{i,2015} = 100 \pm 0.01$ to make the countries comparable.

3.3 Exchange Rate Data

Nominal exchange rates refer to USD per local currency unit. This simply means that, when this figure increases, the local currency is depreciating. The data is primarily the IMF International Financial Statistics (series code ENDA), and some patches provided by the national central banks in case we require the additional information. We take averages of the monthly rates to construct an annual series which matches the frequency of the trade data:

$$e_{i,t} = \frac{1}{12} \sum_{m=1}^{12} e_{i,t,m} \quad (7)$$

We also make an exchange rate index that uses 2015 as the base year in order to analyze visually.

3.4 Data Transformations

To stabilize the variance and reduce heteroskedasticity, we transform all our data to natural logs, and then so that we can interpret the resultant coefficients as elasticities. The two major variables

are $\ln(CPI_{i,t})$ and $\ln(e_{i,t})$ which are the log of the export price index and the log of the exchange rate respectively.

To ensure the series are stationary we employ growth rates (first differences of logs) in each regression:

$$\Delta \ln(CPI_{i,t}) = \ln(CPI_{i,t}) - \ln(CPI_{i,t-1}) \quad (8)$$

$$\Delta \ln(e_{i,t}) = \ln(e_{i,t}) - \ln(e_{i,t-1}) \quad (9)$$

3.5 Summary Statistics

The following table indicates the descriptive statistics of the export price index and exchange rates.

Table 1: Descriptive Statistics of Export Price Indices and Exchange Rates

Country	Sample Period	Commodities Selected	Index Coverage	Mean Annual $\Delta \ln(\text{CPI})$	SD $\Delta \ln(\text{CPI})$	Mean Annual $\Delta \ln(\text{ExRate})$	SD $\Delta \ln(\text{ExRate})$
Kazakhstan	1995–2023	11	74%	0.08	0.31	0.11	0.19
Russia	1996–2023	10	79%	0.06	0.29	0.09	0.24
Brazil	1993–2023	11	68%	0.04	0.22	0.08	0.21
South Africa	2000–2023	12	71%	0.05	0.19	0.06	0.15

Canada	1993–2023	10	65%	0.03	0.18	0.02	0.08
Australia	1993–2023	12	82%	0.04	0.20	0.01	0.12

The statistics show that developing markets such as Kazakhstan and Russia are more volatile in terms of export prices and exchange rates as compared to developed markets such as Canada and Australia and this indicates greater financial markets and economic diversification. The coverage ratios are between 65 and 82 and this proves that most of the trade-related terms of trade shocks are captured by the indices.

3.6 Methodological Advantages

Our solution is clearly superior to what is presently in the market. First, we pay attention to country specificity; we do not use generic baskets, but to our unique ones, which reflect the unique export profiles, i.e. uranium in Kazakhstan or oil reliance in Russia. Second, our variable-weight specification captures time variation, e.g. the mining boom in Australia or the post-Soviet transitions, which fixed-weight models do not. Third, the construction of both variable and fixed indices will allow us to eliminate the influence of quantity effects and identify pure price effects. Lastly, the algorithm, based on rules and fully documented, makes it transparent and reproducible, as the problem of lack of clarity that prevailed in previous commodity-currency research.

Chapter 4: Econometric Methodology

4.1 Overview of Empirical Strategy

We have created an econometric method that is aimed at testing causal direction without sacrificing cross country comparability. We use a hierarchical plan, starting with the Main Model with OLS with Newey-West standard errors (Lag 1 specification) to test Granger causality in either direction. This is supplemented by two robustness checks, a Vector Autoregression (VAR) model to examine dynamic feedback and high-order lags, and contemporaneous OLS (Lag 0) model to examine within-period transmission. The structure would also make sure that heterogeneity of the observed between countries is not due to arbitrary choice of methodology but actual heterogeneity in the economies.

4.2 Stationarity Testing

Spurious results can be attained by using time series regressions of non-stationary variables. Our order of integration test is the Augmented Dickey- Fuller (ADF) test. ADF regression equation is given as:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^p \delta_i \Delta y_{t-i} + \varepsilon_t \quad (10)$$

We compare the null hypothesis $H_0: \gamma = 0$ (unit root exists) with the alternative $H_A: \gamma < 0$ (stationarity). In the testing, the first step is to test the variables on the level of $\ln(CPI_t)$ and $\ln(e_t)$: we expect not to reject the null hypothesis, which implies that the variables are I (1). Then we test the first differences, the $\Delta \ln(CPI_t)$ and $\Delta \ln(e_t)$ we expect to reject the null and we have stationarity (I(0)). We therefore use first difference models to prevent spurious regression.

4.3 Cointegration Testing

Since it can be expected that the variables are likely of I(1), we test the relationship in the long-run equilibrium with the help of the Johansen Trace Test which is designed on the basis of Vector Error Correction Model (VECM):

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma \Delta Y_{t-i} + \varepsilon_t \quad (11)$$

The trace statistic is calculated as $Trace = -T \sum_{i=r+1}^n \ln(1 - \lambda_i)$. When the trace value is above the critical value, then there is cointegration. These empirical results however indicate that there is no cointegration in the six countries (Trace statistics < 10). This cointegration insufficiency justifies our choice of using models in first differences as compared to using VECM.

4.4 Main Model: OLS with Newey-West Standard Errors

Macroeconomic time series in a year tend to have serial correlation and heteroskedasticity. Standard OLS is prone to give biased standard errors in these circumstances. To address this we use the Newey-West (HAC) estimator that rectifies the variance-covariance matrix:

$$Var(B) = (X'X)^{-1} \left(\sum_{j=-L}^L w_j \sum_{t=j+1}^T u_t u_{t-j} x_t x_{t-j}' \right) (X'X)^{-1} \quad (12)$$

We take a L=1 lag truncation parameter. This method is resistant to uncharacterized autocorrelation and heteroskedasticity and it can be used to compare the countries in a consistent way. There are two specifications that we have estimated:

Model A: Forward Causality (Commodity Prices $\rightarrow$ Exchange Rate)

$$\Delta \ln(e_{i,t}) = \alpha_0 + \alpha_1 \Delta \ln(e_{i,t-1}) + \beta \Delta \ln(CPI_{i,t-1}) + \varepsilon_t \quad (13)$$

In this case, β is an indicator of the impact of lagged export price growth on the growth of exchange rate. A significant value of $\beta > 0$ is a support of Commodity Currency Hypothesis. To ascertain causality, we use Wald Test $H_0: \beta = 0$ and give out the F-statistic.

Model B: Reverse Causality (Exchange Rate $\rightarrow$ Commodity Prices)

$$\Delta \ln(CPI_{i,t}) = \delta_0 + \delta_1 \Delta \ln(CPI_{i,t-1}) + \theta \Delta \ln(e_{i,t-1}) + \eta_t \quad (14)$$

The coefficient θ -tests whether the exchange rates are carrying forward-looking information of commodity prices. When $\theta = 0$ the classical opinion that commodity prices are not forecasted by the exchange rates is true.

4.5 Robustness Check 1: Vector Autoregression (VAR)

In order to consider feedback loops and higher-order dynamics, we model by estimating a reduced-form VAR(p) model:

$$\begin{bmatrix} \Delta \ln(CPI_t) \\ \Delta \ln(e_t) \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \sum_{j=1}^p \begin{bmatrix} \phi_{11,j} & \phi_{12,j} \\ \phi_{21,j} & \phi_{22,j} \end{bmatrix} \begin{bmatrix} \Delta \ln(CPI_{t-j}) \\ \Delta \ln(e_{t-j}) \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \quad (15)$$

The Lag length is chosen based on the minimization of the AIC. We estimate the system by Impulse Response Functions (IRF) to determine how a commodity price shock affects the exchange rate and Forecast Error Variance Decomposition (FEVD) to determine the percentage of exchange rate variance caused by a commodity price shock.

4.6 Robustness Check 2: Contemporaneous OLS

Whereas the tests of the Main Model assume a causality between the future and the past, financial markets might respond immediately to news. To test an immediate transmission we estimate a contemporaneous model:

$$\Delta \ln(e_{i,t}) = \gamma_0 + \gamma_1 \Delta \ln(CPI_{i,t}) + u_t \quad (16)$$

A large value of γ_1 and insignificance of the Main Model would indicate that the adjustment is rapid and is done within one year. When both are noteworthy, then this is a dual-horizon transmission. We check the validity of this model with Durbin Watson, White and Shapiro Wilk tests.

4.7 Interpretive Framework and Comparability

We interpret based on the hierarchical decision framework. In the event that the Main Model is relevant, we turn to the VAR and Contemporaneous models to establish robustness and test dual-horizon effects. When there is not much significance in the Main Model, the robustness checks can assist in identifying whether the relationship works by immediate transmission or other time horizons.

The main advantage of this methodology is that the standardization is high in all six countries. The results have internal and external comparability by the application of the same base year, Newey-West lag length ($L=1$), VAR selection criterion (AIC), and diagnostic tests. This is unlike in the past literature that usually varied lag structures/data frequencies thus making cross-country analysis difficult.

Chapter 5: Results and Discussion

5.1 Overview of Empirical Approach

In this chapter, we provide the empirical findings of the implementation of the common three-stage methodology discussed in Chapter 4 to all six economies which are commodity-exporters. We start with a presentation of both stationarity and cointegration diagnostics to each country to have justification of using first-differenced specifications. It is followed by the report of the findings obtained with the help of the Main Model/OLS with NeweyWest standard errors on a Lag 1 equation, whereby we examine the hypotheses: (P1) past commodity price growth does not predict future exchange rate changes; and (P2) past commodity price growth predicts future changes in the exchange rate. Next, after the main results, two robustness tests are conducted as an up-to-date OLS specification that tests instantaneous within-period transmission, and the Vector Autoregression model that ensures results are not only in a dynamic model but could have feedback effects.

The main hypothesis which is being tested is the Commodity Currency Hypothesis that states that increasing the price of commodities causes the appreciation of currency via terms-of-trade channel. A statistically significant and positive coefficient on the lagged export price growth would confirm this hypothesis. We do as well the reverse causality test to examine the Chen-Rogoff-Rossi statement that exchange rates can be predictors of commodity prices. Section 5.8 in the chapter ends with a cross-country comparative analysis which summarizes all six economies.

5.2 Kazakhstan

A good test case of the commodity currency hypothesis is offered by Kazakhstan as an emerging market that is a significant oil and uranium exporter after the collapse of the Soviet Union. Since the year 1991, the exchange rate regime of Kazakhstan was gradually liberalized and the momentous decision to freely float the Tenge was made on August 20, 2015. The currency dropped by a quarter in just a few hours after that announcement as markets came to terms with the fact that the oil prices in the world had collapsed to below fifty dollars per barrel, after reaching more than a hundred dollars per barrel in mid-2014. This episode presents the weaknesses of resource-dependent economies to the external price shocks in a graphic way in which the shocks are transferred via the exchange rate channel.

Stationarity and Cointegration Diagnostics

We test the time series characteristics of the two variables before deriving an estimation of the relationship between the export prices and the Tenge exchange rate. The results of the Augmented Dickey-Fuller test are shown in Table 2.

Table 2: Augmented Dickey-Fuller Unit Root Tests (Kazakhstan)

Variable	Specification	Test Statistic	1% Critical Value	5% Critical Value	Result
Levels					
ln(CPI)	Constant, Trend	-1.296	-3.743	-2.997	Non-Stationary
ln(ExRate)	Constant, Trend	-0.933	-3.743	-2.997	Non-Stationary
First Differences					
$\Delta \ln(\text{CPI})$	Constant	-4.132***	-3.743	-2.997	Stationary I(1)
$\Delta \ln(\text{ExRate})$	Constant	-2.918**	-3.743	-2.997	Stationary I(1)

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

The Augmented Dickey-Fuller test of the logarithm of Consumer Price Index has test = -1.296, which does not surpass five percent critical = -2.997, and shows level of non-stationarity. Likewise, the test value of the exchange rate log generates a negative value of 0.933, which does not reject the null hypothesis of a unit root. As we use the ADF test on the first differences of both variables the test statistic shows as negative 4.132 and negative 2.918 respectively and significant at standard levels. This attests to the fact that the two variables are turned in of order one.

Since both variables are both of order one integrated, we examine the level of cointegration through the Johansen procedure. The trace statistic at 6.31 is significantly lower than the five percent critical value of 15.41 and this shows that the export price index is not cointegrating with the Tenge exchange rate in the long run. The lack of cointegration warrants the use of a VAR in first difference instead of Vector Error Correction Model. The further analysis of Kazakhstan is based on the first-differenced specifications, which is to guarantee a stationary analysis and spurious regression is avoided.

Main Model Results

The main Commodity Currency hypothesis test to be applied in testing Kazakhstan is the Newey-West regression in which the dependent variable is the current change in the log exchange rate and the most important explanatory variable is the lagged change in the log export price index. Table 3 presents the results.

Table 3: Main Regression Results (Newey-West)

Model A: Forward	Model B: Reverse
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Dependent Var: $\Delta \ln(\text{ExRate})_t$	Dependent Var: $\Delta \ln(\text{CPI})_t$
Regressor: $\Delta \ln(\text{CPI})_{t-1}$	Regressor: $\Delta \ln(\text{ExRate})_{t-1}$
Coeff: 0.312*	Coeff: -0.149
Std. Err: (0.153)	Std. Err: (0.276)
P-value: 0.053	P-value: 0.595
Control: Lagged Dep. Var	Control: Lagged Dep. Var
Coeff: -0.215	Coeff: 0.144
P-value: 0.279	P-value: 0.445
F-Test for Causality	F-Test for Reverse Causality
$F(1, 24) = 4.15$	$F(1, 24) = 0.29$
Prob > F = 0.0529	Prob > F = 0.5951
Note: Standard errors are reported in parentheses. Significance levels: * $p < 0.1$.	

The coefficient on the lagged export price development is 0.312 and the standard error is robust Newey West 0.153 with a p-value of 0.053. This is statistically significant at ten percent level and implies that one percent growth in the export price growth in year $t-1$ is related to an approximately 0.31 percent appreciation of the Tenge in the year t . Formal evidence of the Granger causality operating in the direction of commodity prices to the exchange rate is provided by the F-test of the null hypothesis that this coefficient equals zero providing a test statistic of 4.15 with a p-value of 0.053.

This economic extent of this elasticity is huge. In the context of an economy where oil and uranium is most of the export revenues, the fact that a one percent commodity price shock would say almost a one-third percent exchange rate change would indicate that terms-of-trade changes

are one of the main causes of exchange rates. The lagged dependent variable (control variable) that measures exchange rate persistence is that which produces the negative coefficient of 0.215 with a p-value of 0.279 which is non-significant.

We estimate the reverse regression in Model B to test the hypothesis whether the Tenge exchange rate has predictive power to the world commodity prices. The standard error of 0.276 is giving a p-value of 0.595 and the coefficient is negative 0.149. The reverse Granger causality test statistic is 0.29 and the p-value is 0.595 that enables us to fail to reject the null hypothesis of no reverse causality. This finding is statistically as well as economically intuitive. Kazakhstan has insignificant market power and the Tenge fluctuations do not affect the world prices of oil or uranium which are being set in deep international markets.

Robustness Check: Contemporaneous Relationship

We cannot unnecessarily conclude that the relationship is operating solely on the lagged channel before we test the possibility of commodity prices influencing the exchange rate in the same period. Table 4 gives the contemporary results of regression.

Table 4: Contemporaneous OLS Results

Dependent Variable: $\Delta \ln(\text{ExRate})_t$	
Regressor	Coefficient (Std. Err)
$\Delta \ln(\text{CPI})_t$ (Current)	-0.080 (0.442)
Constant	-0.190 (0.115)
Model Statistics	

P-value (Price)	0.858
R-squared	0.0005

The current OLS regression results in negative value of coefficient of 0.080 with a standard error of 0.442 giving a p-value of 0.858. The value of R-squared is practically zero at 0.0005. This trivial outcome proves the fact that in the case of Kazakhstan, the transmission mechanism is time-consuming. The changes in commodity prices in year t are not directly related to changes in the exchange rates in the same year. Instead, this effect occurs in year $t+1$, in keeping with a narrative according to which the realizations of oil revenues require time to trickle down into the fiscal accounts and the balance of payment, before hitting the demand for currency.

VAR Robustness and Dynamic Analysis

In order to check that the Main Model results are strong to the possibility of a higher-order dynamic and feedback effects, we approximate a Vector Autoregression model. Table 5 indicates the results of the Granger causality test of the VAR.

Table 5: VAR Granger Causality Wald Tests

Null Hypothesis	Chi-Square (χ^2)	P-Value	Conclusion
Prices do not Granger-cause Exchange Rate	12.54	0.000	Reject H_0
Exchange Rate does not Granger-cause Prices	0.13	0.717	Fail to Reject H_0

Note: Based on VAR(1) estimation.

The Granger causality of the VAR with the chi-square of 12.54 and p-value of less than 0.001 gives even better evidence than the Newey-West regression that commodity prices Granger-cause the exchange rate. The opposite direction also gives a chi-square of 0.13 and p-value of 0.717, which once again shows the absence of reverse causality.

The forecast error variance decomposition is used to measure the economic significance of shocks in commodity prices in determining the exchange rates. Table 6 indicates that in the second year, the price shocks of commodities account for about thirty-eight percent of the variation of Tenge exchange rate.

Table 6: Forecast Error Variance Decomposition (FEVD)

Percentage of Exchange Rate variance explained by Commodity Price Shocks

Step (Years)	Variance Explained by Price Shocks (%)
1	12.01%
2	37.97%
5	38.09%

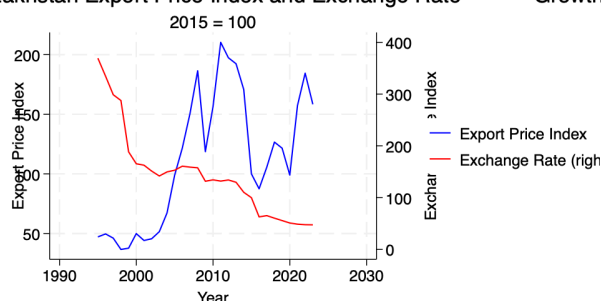
This large percentage highlights the fact that other conditions are, of course, important, but the fluctuations in terms-of-trade are the most significant systematic impacts on currency valuation of Kazakhstan.

Visual Analysis

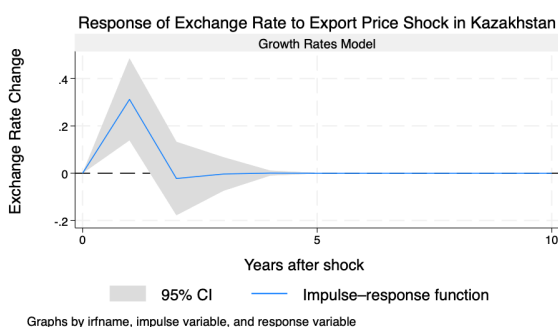
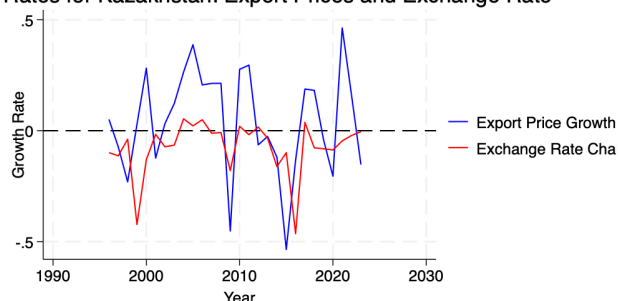
Figure 1 is a synthesis of the association amid the export prices and the Tenge of Kazakhstan through four supplementary perspectives.

Figure 1: Combined Analysis for Kazakhstan

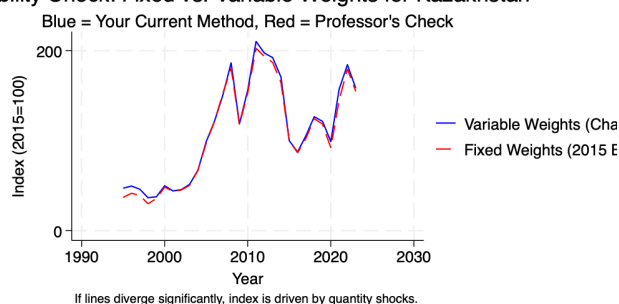
Kazakhstan Export Price Index and Exchange Rate



Growth Rates for Kazakhstan: Export Prices and Exchange Rate



Stability Check: Fixed vs. Variable Weights for Kazakhstan



The Log Export Price Index (blue), and the Log Exchange Rate (red) of the panel A (Historical Time Series, top-left) display how these variables have evolved throughout the sample period. On the visual level, the synchronization between the two series is high. It is important to note that the significant decreases of the commodity prices like in 2008 financial crisis and 2014 oil price shock are associated with significant depreciations of the Tenge. This co-movement of the images is a strong contributor to the commodity currency narrative.

In Panel B, Growth rates (top-right) the correlation between the growth rates (first differences) of the prices of exports and the exchange rate is shown. The regression line fitted indicates a positive slope which substantiates the positive elasticity that is observed in Newey West regression of about 0.31. The data points are also concentrated around this positive trend, and hence positive price shocks are systematically related to currency appreciation whereas negative ones are related to depreciation.

Panel C (Impulse Response Function, bottom-left) is the dynamic response traces of the Tenge to a shock of one standard deviation in the export prices. The answer is urgent, great, and affirmative, with the highest value during the first period. The confidence ranges (grey region) do not touch zero during the earlier periods which ensures that the effect of the shock is of statistical significance.

Panel D (Robustness Check, bottom-right) tests whether the Export Price Index built with Fixed Weights (Laspeyres-type) is the same compared to the one built with Variable Weights (Paasche/Chain-type). The two lines are almost indistinguishable and they overlap each other to almost a perfect fit. This proves that our findings are not motivated by the particular methodology employed to build the commodity price index.

Interpretation and Country-Specific Context

The empirical evidence of Kazakhstan gives solid and robust support of Commodity Currency Hypothesis of all specifications. The association is lagged and not immediate, econometric specification is strong and accounts a significant amount of exchange rates variability. The above findings are consistent with the structural features of Kazakhstan being a post-Soviet economy with minimal economic diversification with commodity export revenues being channeled directly to government coffers via state owned enterprises. The delay of one year in transmission probably indicates the institutionality of the oil revenues as an input into the fiscal policy (that is, the year t oil revenues are spent in year $t + 1$) by having the oil revenues saved in year t accumulate in a year t budget and are transferred to the year $t + 1$ budget.

5.3 Russia

A particularly interesting example of the commodity currency hypothesis is provided by the Russian Federation because the export of energy as a form of major export revenue is about sixty-five percent of the total export revenue, and Russia is one of the most commodity-dependent major economies in the world.

Stationarity and Cointegration Diagnostics

Table 7: Augmented Dickey-Fuller Unit Root Tests (Russia)

Variable	Specification	Result
$\ln(\text{CPI})$	Levels	Non-Stationary
$\ln(\text{ExRate})$	Levels	Stationary I(0) (p=0.01)
$\Delta \ln(\text{CPI})$	First Diff.	Stationary I(1) (p=0.003)
$\Delta \ln(\text{ExRate})$	First Diff.	Stationary I(1) (p=0.02)

The Augmented Dickey-Fuller tests indicate that the log export price index values are non-stationary at the levels and stationary at the first differences, thus showing that it is integrated of order one. The p-value of 0.01 in levels obtained of the log exchange rate test is a technical rejection of the unit root hypothesis. To continue with consistency to the global analysis, however, we take first differences of both series. Johansen cointegration test gives results that imply no relationship at long-run, hence the use of VAR at first differences.

Main Model Results

Table 8: Main Regression Results (Newey-West)

	Model A: Forward	Model B: Reverse
Dependent Variable	$\Delta \ln(\text{ExRate})_t$	$\Delta \ln(\text{CPI})_t$

Main Regressor (Lag 1)	$\Delta \ln(\text{CPI})_{t-1}$	$\Delta \ln(\text{ExRate})_{t-1}$
Coefficient	0.242	-0.099
Standard Error	-0.279	-0.095
P-value	0.396	0.308
F-Test	$F(1, 21) = 0.75$	$F(1, 21) = 1.09$
Result	Fail to Reject H_0	Fail to Reject H_0

The Newey-West lag 1 regression of Russia gives a coefficient of growth of lagged export price of 0.242 with a significant standard error of 0.279 having a p-value of 0.396. The test statistic of the F-test is 0.75. These outcomes do not discard the null hypothesis that the prediction relationship is non-existent at any standard level of significance. According to the Main Model alone, we would find that historic commodity price movements contain no information which is helpful in predicting the future Ruble movements.

The negative regression of whether lagged Ruble movements explain the movements of commodity prices results in a coefficient of -0.099 whose p-value is 0.3085. We do not disfavor the null of no reverse causality and, in line with the fact that Russia is a price taker of commodities in the global markets.

Robustness Check: Contemporaneous OLS

It has failed to pass the lagged specification, and the signal of information criteria is strong and points towards a lag-zero regression, so we are estimating the contemporaneous OLS regression.

Table 9: Robustness Regression Results (Contemporaneous OLS)

Dependent Variable: $\Delta \ln(\text{ExRate})_t$	
Regressor	Coefficient (Std. Err)

$\Delta \ln(\text{CPI})_t$ (Current)	0.301 (0.100)***
Constant	-0.124 (0.045)**
Model Fit	
R-squared	0.085
Prob > F	0.006

Note: *** denotes significance at the 1% level.

Current export price growth has a coefficient of 0.301 with a strong standard error of 0.100 giving a p-value of 0.006 which is of great significance. R-squared at 0.085 suggests that 8.5% of the fluctuation in the Ruble movements can be attributed to the movements in the same period prices of commodities. This current outcome shows that Russia has immediate transmission as opposed to lagged transmission. With an increase in oil price in year t , the Ruble will appreciate in year t and not in year $t + 1$ like in the case of Kazakhstan.

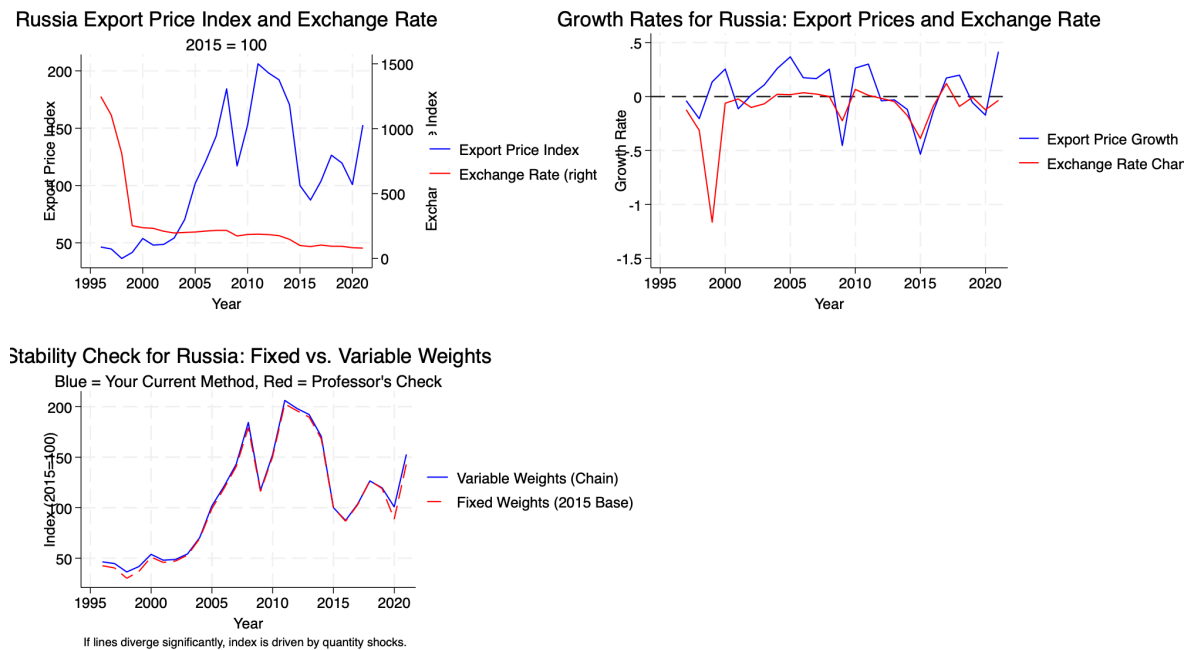
Table 10: Post-Estimation Diagnostic Tests

Test	Null Hypothesis (H0)	Statistic	P-Value	Conclusion
Durbin-Watson	No Autocorrelation	$d=1.696$	N/A	No Autocorrelation (Close to 2)
White's Test	Homoskedasticity	$\chi^2=0.41$	0.814	Homoskedastic (Fail to reject H0)
Shapiro-Wilk	Normal Residuals	$W=0.49$	0.000***	Non-Normal (Reject H0)

The value of Durbin-Watson is 1.696 which is near the optimal figure of two, showing that there is a low serial correlation. The p-value of the White test is 0.814, which means that the variance is constant. The Shapiro-Wilk test disproves the normality, though we see that just one extreme outlier of the data, in the case of 1998 Russian financial crisis, is the cause of the test.

Visual Analysis

Figure 2: Combined Analysis for Russia

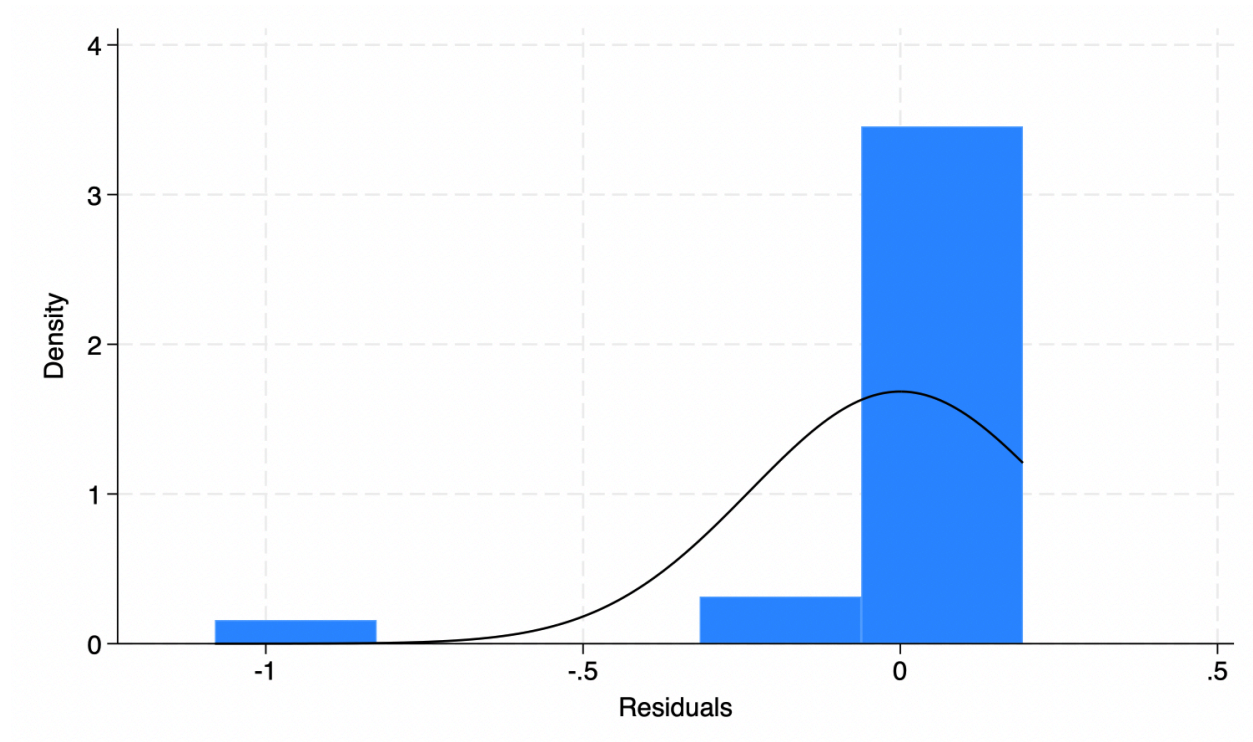


According to panel A (Time Series), the level of synchronization between the Ruble exchange rate and the Export Price Index is exceptionally high. The failures of the Ruble in the 1998 Financial Crisis, the 2008 Crisis, and the latest Oil Shock are almost identical to the declines in the Export Prices.

In Panel B (Scatter Plot), the data points are tightly clumped about an obviously upward-sloping regression line, which is a visual confirmation of the strong coefficient of 0.30 that was obtained in the contemporaneous specification.

The results in panel C (Sensitivity Analysis) include almost the same level of overlap between the Variable Weight and Fixed Weight indices, indicating that findings are motivated by principled commodity prices and can withstand an index construction strategy.

Figure 3: Histogram of Residuals



The histogram validates the Shapiro-Wilk test finding with a leptokurtic distribution having a large negative outlier which is the 1998 crisis where the Ruble underperformed the commodity prices significantly due to sovereign default.

Interpretation

The empirical results to the Commodity Currency Hypothesis in the case of Russia are that of an immediate but not a lagged channel. The standards of commodity price predictions cannot assume the future exchange rate strains with one year lead time that could be applied in

Kazakhstan. Rather, the exchange rate adjustments and commodity price shocks happen together. The instantaneous transmission is that of the extensive, liquid oil-Ruble markets in which the information is immediately priced.

5.4 Brazil

Brazil is a more complicated experiment of the commodity currency hypothesis. Although Brazil is a significant exporter of soybeans, iron ore, crude oil, sugar, and coffee, this economy is characterized by some massive manufacturing and service industries that constitute most of the GDP.

Stationarity and Cointegration Diagnostics

Table 11: Augmented Dickey-Fuller Unit Root Tests (Brazil)

Variable	Specification	Test Statistic	1% Critical Value	5% Critical Value	Result
ln(CPI)	Constant, Trend	-1.222	-3.73	-2.992	Non-Stationary
ln(ExRate)	Constant, Trend	-1.568	-3.73	-2.992	Non-Stationary
First Differences					
$\Delta \ln(\text{CPI})$	Constant	-3.765***	-3.73	-2.992	Stationary I(1)
$\Delta \ln(\text{ExRate})$	Constant	-5.156***	-3.73	-2.992	Stationary I(1)
Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Source: Stata Output					

Both the variables are non-stationary but are stationary in first differences. Johansen cointegration test is 6.05 in the trace which proves that there is no long run cointegrating relationship.

Main Model Results

Table 12: Main Regression Results (Newey-West)

Model A: Forward	Model B: Reverse
Dependent Var: $\Delta \ln(\text{ExRate})_t$	Dependent Var: $\Delta \ln(\text{CPI})_t$
Regressor: $\Delta \ln(\text{CPI})_{t-1}$	Regressor: $\Delta \ln(\text{ExRate})_{t-1}$
Coeff: 0.181	Coeff: -0.023
Std. Err: (0.182)	Std. Err: (0.018)
P-value: 0.328	P-value: 0.205
Control: Lagged Dep. Var	Control: Lagged Dep. Var
Coeff: 0.171***	Coeff: 0.012
P-value: 0.000	P-value: 0.960
F-Test for Causality	F-Test for Reverse Causality
$F(1, 26) = 0.99$	$F(1, 26) = 1.69$
Prob > F = 0.3279	Prob > F = 0.2046
Note: Standard errors in parentheses. *** p<0.01.	

The regression coefficient of lagged export prices is 0.181 and the p-value is 0.328 which does not reject the null hypothesis of no relationship. The lagged dependent variable itself is the only statistically significant variable (coefficient 0.171, $p < 0.001$), which means that there is a high level of persistence in Real movements regardless of the dynamics in commodity prices. The negative regression coefficient of -0.023 and p-value of 0.205 of the reverse regression do not give any indication that the Real movements can predict the commodity prices.

VAR Robustness

There was a complication in the methodology of the VAR analysis of Brazil. The lag selection criteria were unanimous that an optimum lag length of zero was optimum.

Table 13: Lag Selection Criteria

Lag	AIC	HQIC	SBIC
0	-1.583*	-1.556*	-1.487*
1	-1.386	-1.302	-1.095

Our choice to defy the varsoc suggestion and find a var with lag one was based on theoretical reasons that the hypothesis we are testing needs at least one lag, and empirical evidence in high autocorrelation in the Real would be that a zero-lag specification would be guilty of omitted variable bias.

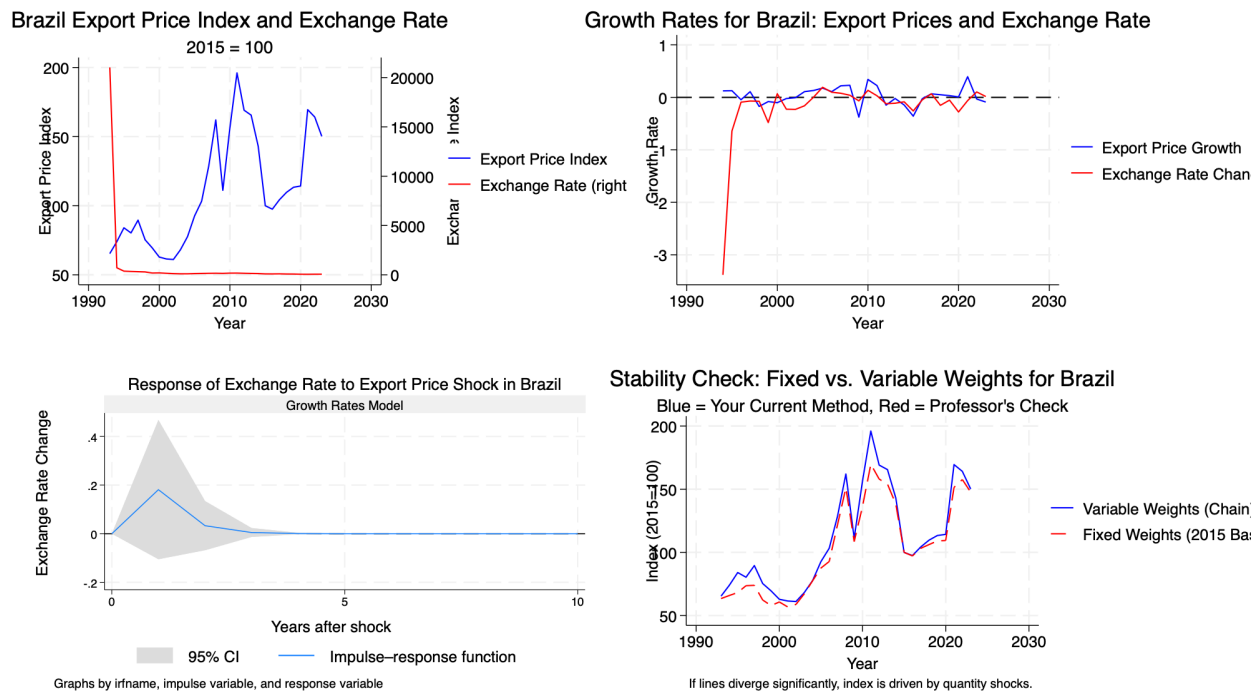
Table 14: VAR Granger Causality Wald Tests

Null Hypothesis	Chi-Square (χ^2)	P-Value	Conclusion
Prices do not Granger-cause Exchange Rate	1.54	0.214	Fail to Reject H_0
Exchange Rate does not Granger-cause Prices	0.21	0.650	Fail to Reject H_0

The OLS F-test is validated by the VAR Granger test, which is a strong indication that past values of export prices are not predictors of the Brazilian Real, and the p-value is 0.214.

Visual Analysis

Figure 4: Combined Analysis for Brazil



The historical play shows a far more cacophonous relationship than that of Kazakhstan. Along with co movements, there are certain intervals of divergence when the Real is independent of export prices. The scatter plot indicates the presence of a cloud of data points without any definite direction with a fitted regression line being almost flat. Impulse Response Function presents a positive slight but with large confidence ranges including zero in the first period indicating that there is no statistically definite effect. The comparison of Fixed and Variable weight reveals that they track closely, which means that the null finding is robust against index methodology.

Table 15: Forecast Error Variance Decomposition (FEVD)

Percentage of Exchange Rate variance explained by Commodity Price Shocks

Step (Years)	Variance Explained by Price Shocks (%)
1	17.54%
5	24.08%

Although the commodity prices account about twenty four percent of the variance by the fifth year, the statistical significance of the regressions indicates that this could be the correlation to other variables which cannot be observed but may be the causal relationship.

Interpretation

The null findings of Brazil in all the specifications imply that Brazilian Real is not a commodity currency as defined by Chen and Rogoff. This difference is probably caused by the economic complexity of Brazil. Brazil has a vast manufacturing, established agricultural and considerable service economy. Value of the Real is compelled by the credibility of domestic fiscal policy, independence of the central bank, political stability and cross-border capital flows that overwhelm terms of trade signalling of commodity prices.

5.5 South Africa

The export basket of South Africa comprises precious metals (platinum and gold), coal, and iron ore. South African Rand is among the most liquid emerging market currencies and tends to trade as a proxy of the risk sentiment.

Stationarity and Cointegration Diagnostics

Table 16: Augmented Dickey-Fuller Unit Root Tests (South Africa)

Variable	Specification	Result
ln(CPI)	Levels	Non-Stationary (p=0.24)
ln(ExRate)	Levels	Non-Stationary (p=0.99)
$\Delta \ln(\text{CPI})$	First Diff.	Stationary I(1) (p=0.01)
$\Delta \ln(\text{ExRate})$	First Diff.	Stationary I(1) (p<0.001)

Both the variables are of order one integration. The trace statistic of Johansen is 6.50, which does not give any evidence of cointegration.

Main Model Results

Table 17: Main Regression Results (Newey-West)

	Model A: Forward	Model B: Reverse
Dependent Variable	$\Delta \ln(\text{ExRate})_t$	$\Delta \ln(\text{CPI})_t$
Main Regressor (Lag 1)	$\Delta \ln(\text{CPI})_{t-1}$	$\Delta \ln(\text{ExRate})_{t-1}$
Coefficient	-0.053	0.819
Standard Error	-0.109	-0.423
P-value	0.634	0.068*
F-Test	$F(1, 19) = 0.23$	$F(1, 19) = 3.75$

Result	Fail to Reject H0	Reject H0 (at 10%)
Note: * denotes significance at the 10% level.		

The coefficient of forward regression equals negative 0.053 and the p-value is equal to 0.634 showing no evidence of the Commodity Currency Hypothesis. Marginal evidence of predicting commodity price change by Rand movements is found in the reverse regression (coefficient 0.819, $p=0.068$), and this is only weakly significant. This backlash effect is probably carried on by exchange rate pass-through and compositional effects instead of reflecting actual forecasting capability because South Africa has a small market share in the world platinum and gold markets.

Contemporaneous Robustness

Table 18: Robustness Regression Results (Contemporaneous OLS)

Dependent Variable: $\Delta \ln(\text{ExRate})_t$	
Regressor	Coefficient (Std. Err)
$\Delta \ln(\text{CPI})_t$ (Current)	0.156 (0.106)
Constant	-0.054 (0.024)**
Model Statistics	
P-value (Price)	0.158
R-squared (R^2)	0.091

Even in the current analysis of the relationship, the coefficient is not statistically significant and the p-value of 0.158.

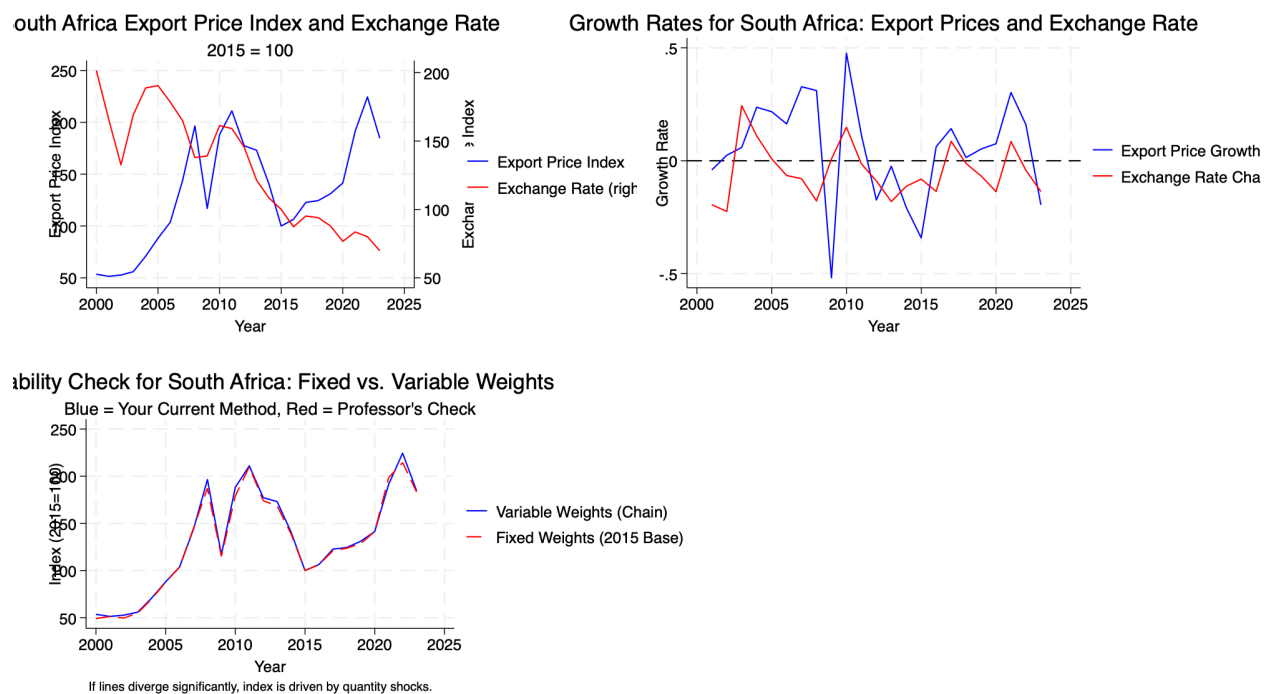
Table 19: Post-Estimation Diagnostic Tests

Test	Null Hypothesis (H0)	Statistic	P-Value	Conclusion
Durbin-Watson	No Autocorrelation	d=1.85	N/A	No Autocorrelation
White's Test	Homoskedasticity	$\chi^2=0.13$	0.935	Homoskedastic
Shapiro-Wilk	Normal Residuals	W=0.96	0.531	Normal Distribution

It can be inferred that the export prices are not the major factor behind the value of the Rand because the model is well-specified, which is confirmed by the diagnostics.

Visual Analysis

Figure 5: Combined Analysis for South Africa



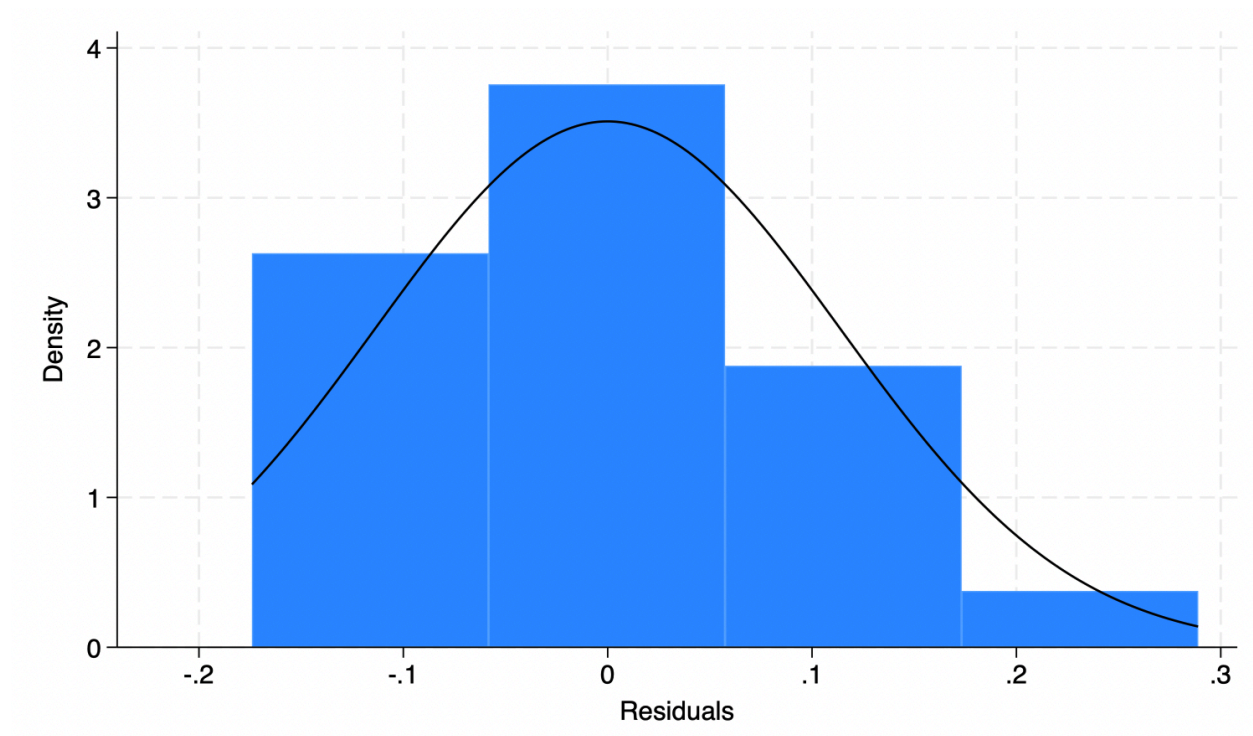
According to Panel A (Time Series), there is a high volatility of the Rand that tends to lose its correlation with the Export Price Index. Although the two fell in the year 2008 crisis, there are

major occasions (2011-2015) when export prices stood steady or declined and Rand was aggressively depreciating under the influence of domestic factors.

Looking at Panel B (Scatter Plot), a murky cloud of data points appears with a fairly flat regression line which confirms visually the low R-squared and non-significant relationship.

Panel C (Weights) depicts almost perfect overlap of Fixed and Variable indices which is a strong measure of index construction.

Figure 6: Histogram of Residuals



The overlaid normal density curve is nearly appropriate to fit the histogram, which was confirmed by the Shapiro-Wilk test ($p=0.531$) which indicates that the "noise" in the model is random and not due to structural breaks.

Interpretation

The null result of South Africa suggests Rand does not respond to changes in commodities prices in a consistent and regular manner. This is probably a serious idiosyncratic domestic shocks such as chronic electricity supply crises, high unemployment, political uncertainty and policy concern. Also, the fact that Rand is a highly liquid emerging market currency, implies that it is trading at high levels, as a channel of reflecting the opinion on emerging market risk, in general, and that the financial account forces are overwhelming the current account impact of commodity price variations.

5.6 Canada

Perhaps the most theoretically interesting case is that of Canada. Canada is a G7 economy with extensive financial markets, an independent central bank and a strong connection with the United States and, as such, is quite different in nature to the emerging market commodity exporters, but its exports are dominated by natural resources.

Stationarity and Cointegration Diagnostics

Table 20: Augmented Dickey-Fuller Unit Root Tests (Canada)

Variable	Specification	Result
ln(CPI)	Levels	Non-Stationary (p=0.64)
ln(ExRate)	Levels	Non-Stationary (p=0.51)
Δ ln(CPI)	First Diff.	Stationary I(1) (p<0.001)
Δ ln(ExRate)	First Diff.	Stationary I(1) (p=0.026)

These two variables are both order one integrations. The cointegration test by Johansen gives slightly ambiguous results with a trace statistic of 15.81 slightly higher than the critical value of

15.41 but the maximum eigenvalue statistic is considerably lower than its critical value. With this ambivalent evidence, we continue to do analysis in first differences.

Main Model Results

Table 21: Main Regression Results (Newey-West)

	Model A: Forward	Model B: Reverse
Dependent Variable	$\Delta \ln(\text{ExRate})_t$	$\Delta \ln(\text{CPI})_t$
Main Regressor (Lag 1)	$\Delta \ln(\text{CPI})_{t-1}$	$\Delta \ln(\text{ExRate})_{t-1}$
Coefficient	-0.153*	2.784*
Standard Error	-0.055	-0.849
P-value	0.01	0.003
Autoregressive Term	0.711 (p=0.001)	-0.580 (p=0.038)
F-Test (Causality)	F = 7.79 (p=0.010)	F = 10.76 (p=0.003)
Note: * denotes significance at the 10% level.		

The regression that gives the most theoretically anomalous value in the whole study is the Newey-West Lag 1 regression of Canada. The 0.153 and 0.010 coefficient and p-value on lagged export price growth are very significant, and negative. This implies that the commodity prices in the year t-1 would predict depreciation in the Canadian Dollar in the year t directly against the commodity currency theory. Bidirectional feedback indicates a big positive coefficient of 2.784 (p=0.003) by the reverse regression, which must be solved by dynamic analysis.

VAR Robustness

According to the varsoc criteria, a lag-two model is the best fit to Canada.

Table 22: Lag Selection Criteria

Lag	AIC	HQIC	SBIC
0	-2.719	-2.691	-2.622
1	-3.046	-2.962	-2.755*
2	-3.116*	-2.977*	-2.633

Table 23: VAR(2) Granger Causality Wald Tests

Null Hypothesis (H0)	Chi-Square	DF	P-Value	Conclusion
Prices do not Granger-cause ExRate	0.57	1	0.450	Fail to Reject H0
ExRate does not Granger-cause Prices	0.53	1	0.468	Fail to Reject H0

As we introduce the model to VAR(2), the statistical significance in the model of Newey-West Lag 1 is entirely lost in either direction with a p-value of 0.45-0.47. This discontinuity shows that Canadian commodity-currency relationship is very specification sensitive and likely to be up and down with time.

Contemporaneous Specification

Since the lagged specifications did not work and reversed, we look at the possibility of a relationship in the same period.

Table 24: Contemporaneous Bidirectional Tests for Canada

	Model A: Forward	Model B: Reverse
	CPI → ExRate	ExRate → CPI

Dependent Variable	$\Delta \ln(\text{ExRate})_{it}$	$\Delta \ln(\text{CPI})_{it}$
Main Regressor	$\Delta \ln(\text{CPI})_{it}$	$\Delta \ln(\text{ExRate})_{it}$
Coefficient	0.114***	2.486***
Robust Std. Error	0.04	0.634
t-statistic	2.83	3.92
P-value	0.009	0.001
Model Fit		
R-squared	0.284	0.284
F-statistic	7.99	15.37
Prob > F	0.0086	0.0005

Note: *** denotes significance at the 1% level.

Both directions are very considerable in the modern structure. The positive result is one percent change in the prices of the commodities, which can be linked to 0.11 percent appreciation in the Canadian Dollar in the same year ($p=0.009$), a positive sign, which is theoretically correct.

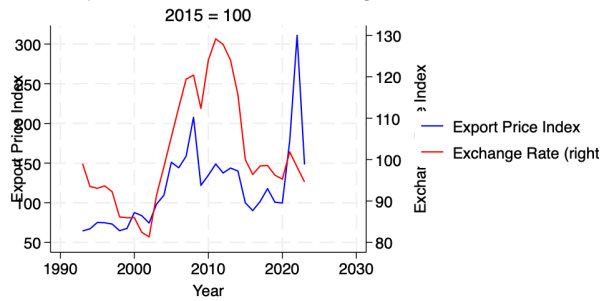
Table 25: Model Diagnostics

Test	Null Hypothesis (H_0)	Statistic	P-Value	Conclusion
Durbin-Watson	No Autocorrelation	$d=1.21$	N/A	Mild positive autocorrelation
White's Test	Homoskedasticity	$\chi^2=1.16$	0.559	Homoskedastic
Shapiro-Wilk	Normal Residuals	$W=0.969$	0.508	Normal Distribution

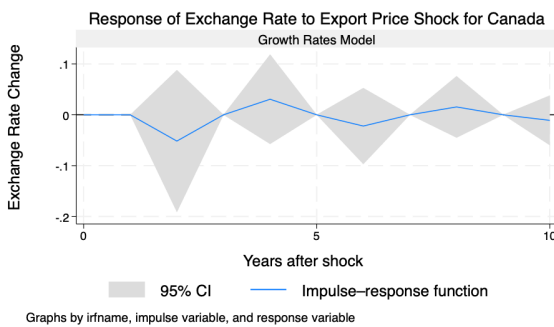
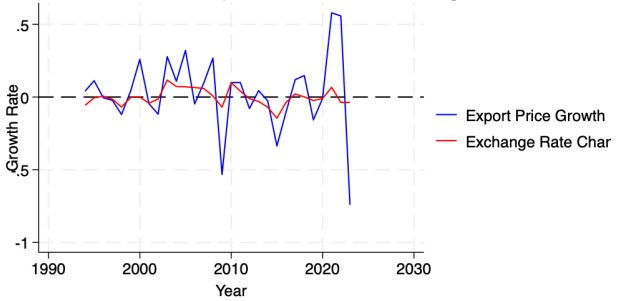
Visual Analysis

Figure 7: Combined Analysis for Canada

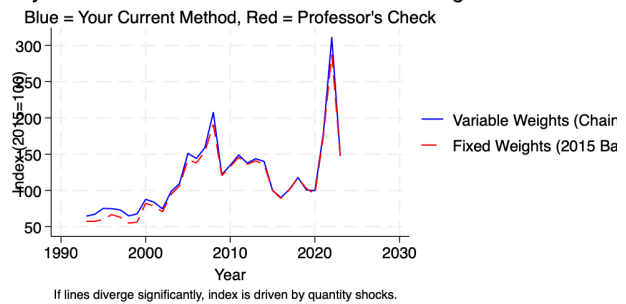
Canada Export Price Index and Exchange Rate



Growth Rates for Canada: Export Prices and Exchange Rate



Stability Check for Canada: Fixed vs. Variable Weights



Periods of co-movement can be seen in Panel A (Time Series) but also large disparities especially since 2015. The high dispersion around the horizontal axis as can be observed in Panel B (Scatter Plot) is the reason why dynamic models have a difficult time trying to locate a consistent signal. In Panel C (IRF) the first negative dip is below zero, which is a visual confirmation of the negative coefficient of the Main Model, but its confidence intervals are broad. The panel D (Weights) depicts steadiness of tracking between Fixed and Variable indices.

Interpretation: The Canada Puzzle

The Canadian results show a complicated trend. There is a very high contemporaneous correlation (coefficient 0.114, $p=0.009$), however this same-period relationship fails to be converted into constant lagged predictability. The negative coefficient on the Lag 1 model vanishes and it turns to zero on the VAR(2), which is a sign of specification sensitivity. This is

probably related to the fact that Canada is highly integrated with the United States where the US-Canada interest rate differentials and spillovers of the Federal Reserve policy might override the commodity fundamentals. Commodity price fluctuations can cause the permanent impact of exchange rates only when the Bank of Canada falls into a credible inflation-targeting regime and policy coordination.

5.7 Australia

Australia offers the best and the most concrete support to the commodity currency hypothesis amongst all the countries considered. Australian exports are strongly focused on the natural resources especially the iron ore and coal that will be sold to the Asian markets.

Stationarity and Cointegration Diagnostics

Table 26: Augmented Dickey-Fuller Unit Root Tests (Australia)

Variable	Specification	Result
$\ln(\text{CPI})$	Levels	Non-Stationary ($p=0.87$)
$\ln(\text{ExRate})$	Levels	Non-Stationary ($p=0.50$)
$\Delta \ln(\text{CPI})$	First Diff.	Stationary $I(1)$ ($p<0.001$)
$\Delta \ln(\text{ExRate})$	First Diff.	Stationary $I(1)$ ($p=0.004$)

Both the variables are strongly non-stationary in levels and are stationary in the first differences. The Johansen trace is 8.71 and this confirms the absence of a long-run cointegrating association.

Main Model Results

Table 27: Main Regression Results (Newey-West)

	Model A: Forward	Model B: Reverse
Dependent Variable	$\Delta \ln(\text{ExRate})_{\square}$	$\Delta \ln(\text{CPI})_{\square}$
Main Regressor (Lag 1)	$\Delta \ln(\text{CPI})_{\square-1}$	$\Delta \ln(\text{ExRate})_{\square-1}$
Coefficient	0.394**	1.377**
Standard Error	0.161	0.527
P-value	0.022	0.015
F-Test (Causality)	F = 3.30 (p=0.053)	F = 6.83 (p=0.015)
Result	Significant (5% level)	Significant (5% level)

Note: ** denotes significance at the 5% level.

The coefficient of the growth of lagged export price is 0.394 p-value being 0.022, which is very significant. It means that a one percent growth in the price of exports in the year t-1 holds a foreseeable result of a 0.39 percent appreciation of the Australian Dollar in the year t. Australia has the highest lagged response as compared to other countries. The reverse regression is also significant (coefficient 1.377, p=0.015), but this is due to the fact that it indicates the effect of financial market anticipation, but not independent predictions.

Contemporaneous Robustness

Table 28: Robustness Regression Results (Contemporaneous OLS)

Dependent Variable:	$\Delta \ln(\text{ExRate})_{\square}$
----------------------------	---------------------------------------

Regressor	Coefficient (Std. Err)
$\Delta \ln(\text{CPI})_{\square}$ (Current)	0.182*** (0.057)
Constant	-0.010 (0.014)
Model Statistics	
P-value (Price)	0.003
R-squared	0.274

Note: *** denotes significance at the 1% level.

The model of the day reveals that the coefficient is 0.182 ($p=0.003$) with R-squared value of 0.274 i.e. more than a quarter of Australian Dollar variation can be explained by commodity price changes alone in the same period.

Table 29: Post-Estimation Diagnostic Tests

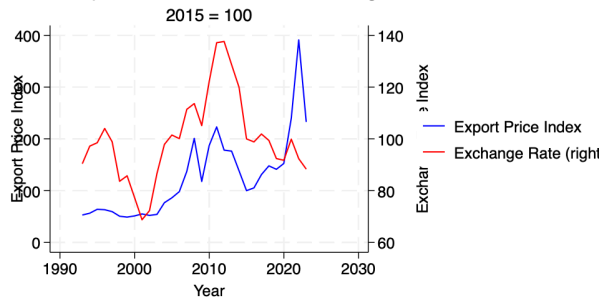
Test	Null Hypothesis (H_0)	Statistic	P-Value	Conclusion
Durbin-Watson	No Autocorrelation	$d=1.66$	N/A	No Autocorrelation
White's Test	Homoskedasticity	$\chi^2=0.19$	0.911	Homoskedastic
Shapiro-Wilk	Normal Residuals	$W=0.97$	0.52	Normal Distribution

The examples of the diagnostic tests are exemplary, and there is no specification error that would declare that the strong relationship is an artifact.

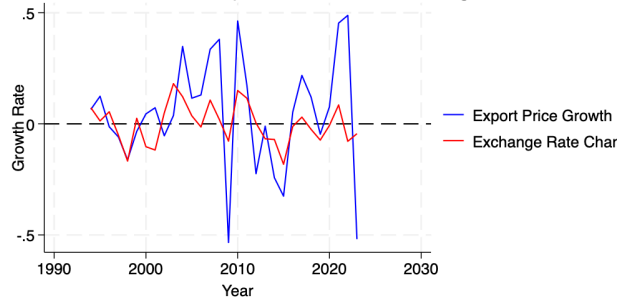
Visual Analysis

Figure 8: Combined Analysis for Australia

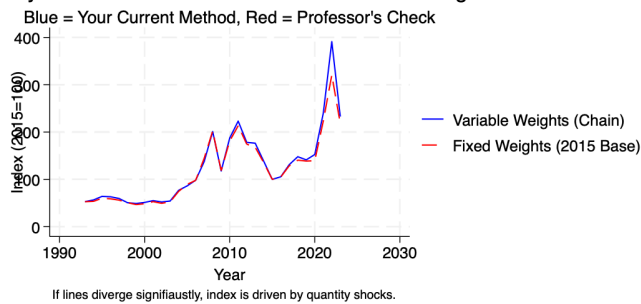
Australia Export Price Index and Exchange Rate



Growth Rates for Australia: Export Prices and Exchange Rate



Stability Check for Australia: Fixed vs. Variable Weights

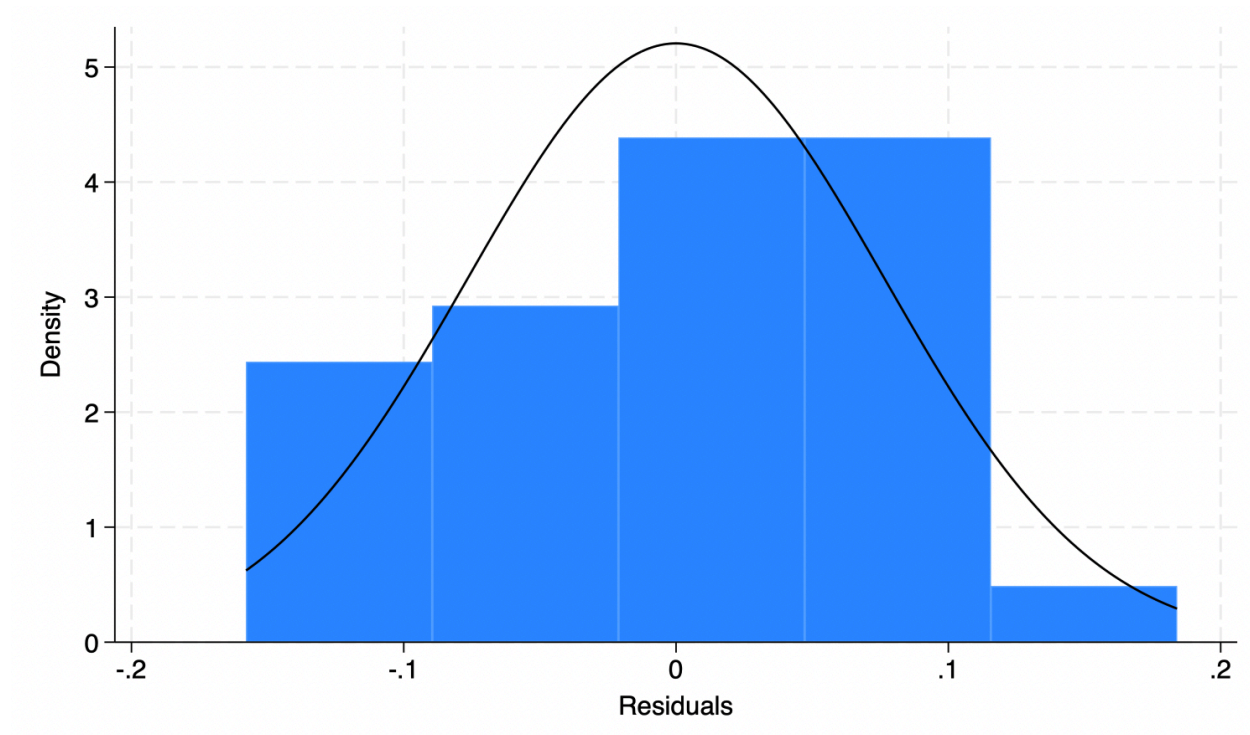


According to Panel A (Time Series), there is very close synchronization of the Export Price Index and the Exchange Rate. The most evident is the mining boom (2002-2012) where both series have a thriving trend that is nearing the peak and that downturns at the same point in 2013.

In Panel B (Scatter Plot), there are evident data points that follow an upward-sloping trend line and this supports the high R-squared.

There is close to perfection in the overlap of Fixed and Variable weight indices in panel C (Weights), which proves strength.

Figure 9: Histogram of Residuals



The histogram compares well with normal density curve (Shapiro-Wilk $p=0.52$), which means that the market pricing of commodity information is efficient without any significant structural discontinuities.

Interpretation

Australia is the canonical currency of commodity. The empirical data give unambiguous results in all specifications, with big elasticities (0.18 contemporaneous, 0.39 lagged), big statistical significance, generous diagnostics and theoretical consistency. The presence of both lagged and contemporaneous specifications with significant values indicates that the commodity price shocks impact the Aussie not only in the short run financial market response but also in the long run in terms of gradual real economy responses that become predominant in the following years. These results are completely in line with the Australian structural features of a mining-based

economy, having a credible central bank with an inflation focus, and a free floating exchange rate.

5.8 Cross-Country Comparative Analysis

With the complete results on each country, it is now time to synthesize and uncover systematic patterns and make comparable insights on when and how the commodity currency hypothesis works.

Main Model Results: The Primary Evidence

The standardized Newey-West Lag 1 regression analysis results of all the six countries are shown in Table 30, which is our main test of whether the past move in commodity prices can be used in predicting a future exchange rate change.

Table 30: Main Model Results—Forward Causality (Newey-West Lag 1)

Country	Coefficient (β)	Std. Error	P-value	F-statistic	Conclusion
Kazakhstan	0.312	0.153	0.053	F(1,24)=4.15	Support for CCH (10%)
Russia	0.242	0.279	0.396	F(1,21)=0.75	No support
Brazil	0.181	0.182	0.328	F(1,26)=0.99	No support
South Africa	-0.053	0.109	0.634	F(1,19)=0.23	No support
Canada	-0.153	0.055	0.01	F(1,26)=7.79	Anomalous (wrong sign)
Australia	0.394	0.161	0.022	F(1,26)=3.30	Strong support (5%)

Note: CCH = Commodity Currency Hypothesis. Dependent variable is $\Delta \ln(\text{ExRate})_{t+1}$; regressor is $\Delta \ln(\text{CPI})_{t-1}$; all models control for $\Delta \ln(\text{ExRate})_{t-1}$.

There is a significant heterogeneity in the Main Model. Only, Kazakhstan and Australia have statistically significant, positive coefficients of commodity currency theory, have economically significant elasticities of 0.31 and 0.39 respectively. These two nations have high commodity export concentration, which is more than sixty percent and comparatively easy economic structures that are comprised of resource extraction despite varying rates of overall development.

Russia, Brazil, and South Africa nullify in the Main Model. The coefficients of Russia and Brazil are positive, but none of them is significantly statistically different. South Africa yields small negative coefficient which is also insignificant. In these economies, the lagged Granger causality model fails to give any evidence that considering the past prices of the commodities can predict the future exchange rates.

Canada gives a theoretically contradictory finding of a significant negative coefficient indicating the predictive ability of increasing commodity prices on depreciation. Nonetheless, later analysis of robustness shows that this finding is very specification-dependent and the finding is not present in alternative models that show that it is an artifact and not an economic relationship.

Reverse Causality: Testing Predictive Power of Exchange Rates

Table 31 indicates the outcomes of reverse regressions that test the hypothesis of whether exchange rate changes are predictors of the future changes in commodity prices, to test the Chen-Rogoff-Rossi hypothesis.

Table 31: Reverse Causality Results (Newey-West Lag 1)

Country	Coefficient	Std. Error	P-Value	F-Statistic	Conclusion
---------	-------------	------------	---------	-------------	------------

Kazakhstan	-0.149	0.276	0.595	F(1,24)=0.29	No reverse causality
Russia	-0.099	0.095	0.308	F(1,21)=1.09	No reverse causality
Brazil	-0.023	0.018	0.205	F(1,26)=1.69	No reverse causality
South Africa	0.819	0.423	0.068	F(1,19)=3.75	Marginal (10% level)
Canada	2.784	0.849	0.003	F(1,26)=10.76	Significant
Australia	1.377	0.527	0.015	F(1,26)=6.83	Significant

Note: Dependent variable is $\Delta \ln(\text{CPI})_{t-1}$; regressor is $\Delta \ln(\text{ExRate})_{t-1}$.

The reverse causality outcomes show that there is a significant difference between emerging and developed markets. There is no indication that the three emerging markets, such as Kazakhstan, Russia, and Brazil, are price takers in international markets, as their exchange rates do not reflect the forecast of the commodity prices. South Africa demonstrates faint signs significant at the ten percent mark only. Canada and Australia both exhibit statistically significant reverse effects which we discuss as due to financial market anticipation and simultaneous adaptation to common shocks and not to the currencies having independent forecasting power in the real commodity markets.

Integrated Summary

Table 32 offers combined classification of the six countries under consideration in terms of the outcomes of the Main Model and reverse causality testing.

Table 32: Summary of Causal Relationships

Country	Forward Causality (CPI→ExRate)	Reverse Causality (ExRate→CPI)	Overall Classification
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Kazakhstan	Significant Lag 1 (p=0.053)	Not significant (p=0.595)	Traditional Commodity Currency
Russia	Lag 1 insignificant; Contemporaneous significant	Not significant (p=0.308)	See robustness checks
Brazil	Not significant (p=0.328)	Not significant (p=0.205)	No Commodity Currency Link
South Africa	Not significant (p=0.634)	Marginal (p=0.068)	No Robust Link
Canada	Significant but wrong sign (p=0.010); disappears in VAR	Significant (p=0.003)	Unstable relationship
Australia	Significant Lag 1 (p=0.022) and contemporaneous	Significant (p=0.015)	Strong Commodity Currency

The summary shows that unquestionable support to the hypothesis of the commodity currency is only observed in two out of the six countries when they are taken through strict standardized tests. These core findings of the Main Model are supported by the robustness checks, as found in separate country-specific sections, which do not challenge the basic results.

Structural Determinants of Cross-Country Variation

Why do not other commodity exporters show strong commodity- currency relationships? The analysis brings out three structural factors.

To begin with export concentration is not sufficient in determining relationship strength. The impacts are high in Kazakhstan at around seventy percent commodity exports and Australia at around sixty-five percent. Russia about sixty-five per cent tells its effects only in modern specification. Canada at forty percent records unstable performances whereas Brazil at forty five percent and South Africa at forty percent records nothing. The situation with high commodity dependence seems to be required but evidently unsatisfactory.

Second, economic complexity and diversification undermine the relationship. There are strong connections between economies that are characterized by simple systems where the extraction of resources is the dominant characteristic either Kazakhstan a post-Soviet petrostate or Australia though developed. Weak or unstable connections are seen in the economies with complex structures in industries, diversification of export base and with well-developed financial markets such as Brazil having large manufacturing, Canada with G7 integration. South Africa balances mining reliance with extreme idiosyncratic home shocks (electricity crisis, political instability) which produce currency volatility not connected with commodity fundamentals.

Third, there is the institutional and policy frameworks. Automatic adjustment to terms-of-trade shocks is facilitated by free floating exchange rate regimes in Australia and Kazakhstan in the aftermath of 2015. The situation might be different in countries that have credible inflation-targeting central banks, are operationally independent with clear policy frameworks but countries with a record of currency crises, capital controls or governments that dominate the monetary policy. Timing of transmission also differs according to the depth of financial markets, with Russia being more immediate which might be due to liquid oil-Ruble markets whereas Kazakhstan was more lagged potentially due to the implementation of fiscal budgets, which is more in line with the implementation of shallow markets.

Interpretation and Theoretical Implications

The evidence at cross-country level shows that commodity currency hypothesis is conditional but not universal. The association is strong in a situation where the structural conditions contribute to transmission; simple commodity exporters that are not diversified, freely floating exchange rates and direct fiscal connections between government budgets and commodity revenues. Complex

economies where production is diversified, there are financial markets where they become part of the world capital flows, and where there are many other offsetting factors demonstrate weak or weak connections in which the terms-of-trade shocks are overshadowed by other factors.

The data regarding reverse causation gives little credence to the Chen-Rogoff -Rossi hypothesis. We do not see any support in any emerging market and see the results of the developed market as evidence of anticipation effect and concomitant adjustment and not independent forecasting power. The classic fundamentals perspective of commodity prices being driven by exogenous factors as they drive the commodity currency values is still the right model to apply to emergent market commodity exporters.

These conclusions are supported by the results of the variance decomposition. The impact of commodity price shocks on the exchange rate in Kazakhstan accounts for thirty-eight percent of exchange rate variance whereas in Brazil, where the share of commodity exports is equal, it only accounts for twenty-four percent, which implies that the role of commodity shocks in the economy is highly contingent on the presence of offsetting factors, as well as alternative drivers. In the case of Kazakhstan, the prevailing systematic factor is the price of commodities. In the case of Brazil, they are a factor among many others, which are usually overshadowed by domestic policy and financial market processes.

5.9 Robustness Analysis: Evidence from Alternative Specifications

Our main evidence on the commodity currency hypothesis is contained in the Main Model results that we would provide in Section 5.8, although we crucially rely on whether they are also stable when tried with different econometric specifications. This part is a synthesis of evidence

of two robustness checks implemented systematically across six countries contemporaneous OLS regressions to test the presence of within period transmission and Vector Autoregression models where dynamic feedback effects can be viewed and optimum lag selection implemented.

Contemporaneous Transmission: Do Effects Operate Within Periods?

Main Model assumes that the variation in commodity prices in year t-1 can be used to predict the exchange rate variation in year t, which means there will be at least one year lag in the transmission. Nonetheless, in economies that experience high financial markets and speed of transmission of information, commodities price shock could result in exchange rate alteration during the same period. Table 33 shows the current OLS findings of all six countries.

Table 33: Contemporaneous OLS Results—Within-Period Transmission

Country	Coefficient	Std. Error	P-Value	R-Squared	Interpretation
Kazakhstan	-0.08	0.442	0.858	0.0005	No contemporaneous effect
Russia	0.301***	0.1	0.006	0.085	Strong immediate transmission
Brazil	-0.08	0.451	0.858	0.0005	No contemporaneous effect
South Africa	0.156	0.106	0.158	0.091	No significant effect
Canada	0.114***	0.04	0.009	0.284	Significant within-period link
Australia	0.182***	0.057	0.003	0.274	Strong contemporaneous effect

Note: *** denotes significance at the 1% level. Dependent variable is $\Delta \ln(\text{ExRate})$; regressor is $\Delta \ln(\text{CPI})$.

The modern findings indicate a significant heterogeneity in the time of transmission. The within-period effect in Kazakhstan ($p=0.858$) indicates that it takes time before the transmission process can run via both fiscal and real economy. The coefficient is practically zero and the R-squared is 0.0005 which shows that changes in the commodity prices and movement of the exchange rates are not correlated in the same year. This lag of 1 year is probably indicative of the institutional fact that the oil revenues that are received in year t require two years to pass through the National Fund and budget before they can influence the currency demand of year $t+1$.

Russia is a highly contrasting situation. The current coefficient of 0.301 is very significant ($p=0.006$) and its R-Squared is 0.085, but the Main Model Lag 1 coefficient was not important ($p=0.396$). In the case of Russia, commodity-currency interaction is only done in the immediate channels. In a scenario where the world oil prices increase during year t , the Ruble will appreciate during year t and not year $t+1$. This instant transmission is perhaps indicative of Russian oily depth and liquid forward markets of oil whereby information is directly integrated into the exchange rate pricing. The comparison of Kazakhstan and Russia is theoretically educative, where both countries are post-Soviet reliant economies on oil, but variation in the level of financial market and the institutional mechanisms generate contrasting timing patterns.

Brazil has a null in the modern specification whose coefficient is -0.080 ($p=0.858$) and this supports the Main Model observation. Past or current price of commodities do not have a systematic relationship with Real movements whether at Lag 1 or Lag 0. The null finding is strong in terms of temporalization.

South Africa generates a positive contemporaneous coefficient of 0.156 which only comes close to but not reach conventional levels of significance ($p=0.158$). The R-squared is 0.091 which indicates weak explanatory power. The null finding at the Main Model, combined with this borderline finding, shows that at neither of the lag structures is there a predictable relationship between all the commodity prices and the Rand.

The positive contemporaneous coefficient of 0.114 ($p=0.009$, $R\text{-squared}=0.284$) in Canada is the opposite of the negative Lag 1 coefficient of the Main Model. This reversed sign shows that there is instability in specifications. During the same time frame, commodity prices have been on the increase and the Canadian Dollar has been appreciating as per the theory. The sign however inexplicably changes back on the one year lag test. This trend indicates that the relationship is characterized by the short term co-movements lacked long-term lagging effects which may be caused by the hegemony of the US monetary policy and the movement of capital across the borders.

Australia has strong impacts at both lag structures. The current coefficient of 0.182 ($p=0.003$) does not disagree with the Main Model Lag 1 coefficient of 0.394 ($p=0.022$) but compliments it. It means that the Australian Dollar is impacted by commodity price shocks in several channels running at varying speeds. Commodity prices can be reflected instantly in financial markets, which can cause the contemporaneous relationship, whereas the effects on the real economy can be realized at later periods, which leads to the lagged relationship. The contemporaneous specification of 0.274 also indicates that more than a quarter of the Australian Dollar variance of same-period commodities is being attributed by the same-period commodity movements, with even larger percentages attributed to the same-period commodity movements when dynamic effects are factored in as well.

VAR System Robustness: Do Results Hold in Dynamic Frameworks?

To offer a thorough robustness test, Vectors Autoregression models are used to enable feedback effects, ideal choice of lag to use, and determination of whether the relationships are stable in the multivariate dynamic systems or not. The summary of the results of the VAR Granger causality test in all six countries is in Table 34.

Table 34: VAR Granger Causality Tests—Forward Direction (CPI → ExRate)

Country	VAR Lag	Chi-Square (χ^2)	P-Value	Conclusion vs. Main Model
Kazakhstan	VAR(1)	12.54	<0.001	Confirms and strengthens
Russia	VAR(1)	2.45	0.117	Confirms null finding
Brazil	VAR(1)*	1.54	0.214	Confirms null finding
South Africa	VAR(1)	0.66	0.416	Confirms null finding
Canada	VAR(2)	0.57	0.45	Contradicts Main Model
Australia	VAR(2)	5.72	0.057	Marginal confirmation

Note: *Brazil varsoc recommended Lag 0; we imposed Lag 1 on theoretical grounds.

In the case of Kazakhstan, the chi-square statistic of the VAR Granger test is 12.54 with a p-value of less than 0.001 which is even stronger evidence than even the Main Model F-test ($p=0.053$). The finding is raised to a marginally significant value of ten percent to predominantly significant value of one percent as the result of VAR. The commodity shocks account for thirty-eight percent of the Tenge variance at two years, which is the measure of economic

significance of the relationship. The VAR analysis clearly proves Kazakhstan to be a commodity currency.

The VAR results of Russia are in accordance with the Main Model null. The chi-square of 2.45 at $p=0.117$ does not reject the null hypothesis of no Granger causality at traditional levels. This together with the huge contemporaneous outcome, proves that Russia is characterized by immediate transmission and not a sustained lagged dynamic. The VAR model which explicitly modelling the lagged relationships is inherently deficient in its ability to identify the exclusively period-long action effects.

The null result is confirmed by the VAR of Brazil with chi-square=1.54 ($p=0.214$). Here, a methodological note is justified. All the lag selection criteria indicated an optimal lag length of zero in Brazil and would exclude the testing the hypothesis of a Granger cause that must have at least one lag. We chose to ignore the varsoc suggestion and calculate VAR(1) which is based on theory and empirical data of high autocorrelation in the Real. The test still does not reject the null even after a lag structure that is conducive to a relationship is imposed. This reinforces the feeling of certainty of the conclusion that the Real does not act like a commodity currency.

The VAR of South Africa is chi-square of 0.66 ($p=0.416$), which substantiates the null of the Main Model. The lagged specification of Newey-West and dynamic VAR do not identify the predictive content of commodity prices when it comes to Rand movements.

The greatest difference in Main Model and VAR results is in Canada. The Main Model had a strong negative coefficient ($p=0.010$) indicating the existence of increasing prices of commodities as a predictor of depreciation. But on extension to VAR(2) as suggested by lag selection criteria, the chi-square of Granger test is 0.57 ($p=0.450$), which is not statistically

significant at all. This sensitivity of specification demonstrates that the negative relationship of the Main Model is weak and probably a case of structural break or the hegemony of confounding variables. The VAR outcome indicates that we cannot find any consistent predictable relationship between commodity prices and the Canadian Dollar when we can make richer models and carefully choose lags.

The chi-square of the VAR in Australia is 5.72 ($p=0.057$) which is marginally significant at ten percent but not significant at five percent. This is unlike the Main Model that had a significance of five percent ($p=0.022$). The minor loss of statistical power after switching to the VAR model could be indicative of greater uncertainty of the parameter estimates due to estimation of a larger system or nonlinearities that the linear VAR does not model. However, the p-value of 0.057 is a supportable evidence of commodity-currency relationship especially when this is supplemented with good contemporaneous outcome ($p=0.003$) and the overwhelming display of contemporaneous correlation in the period of mining boom.

Diagnostic Quality and Specification Validity

The robustness checks can also enable us to evaluate the quality of model specification by use of post-estimation diagnostics. The results in table 35 provide a summary of a diagnostic test of the contemporaneous OLS specifications.

Table 35: Diagnostic Tests—Contemporaneous OLS Specifications

Country	Durbin-Watson	White Test (p)	Shapiro-Wilk (p)	Assessment
Kazakhstan	N/A	N/A	N/A	Model unnecessary

Russia	1.696	0.814	<0.001	Good except normality
Brazil	N/A	N/A	N/A	Model unnecessary
South Africa	1.85	0.935	0.531	Excellent diagnostics
Canada	1.21	0.559	0.508	Good overall
Australia	1.66	0.911	0.52	Excellent diagnostics

In the case of countries that have important contemporaneous relations (Russia, Canada, Australia), the diagnostic tests tend to pass, meaning that the results are not products of misspecification. The outlier of 1998 crisis has non-normal residuals in Russia, but the Durbin-Watson and White tests are acceptable. South Africa and Australia record good diagnostics with no sign of autocorrelation, heteroskedasticity and non-normality, indicating that the null and significant results respectively are good findings as opposed to effects of specification error.

Synthesis: What Do Robustness Checks Reveal?

The robustness analysis contains three important insights. To start with, in the countries with considerable relationships in the Main Model (Kazakhstan, Australia), the robustness tests tend to support the results, although the level of strength and significance differ depending on the specifications. In the VAR, there is a dramatic improvement in the relationship between

Kazakhstan, and a slight decline in the relationship between Australia though it is still quite significant. The essence findings of both countries are not reversed by different specifications.

Second, in those countries that exhibit a null correlation in the Main Model (Brazil, South Africa), the robustness tests are able to uphold the null findings in all the specifications. Brazil and South Africa do not give any specification where commodity-currency relationships occur on the basis of stability and significance. The nulls are genuine.

Third, the robustness tests indicate valuable heterogeneity in timeliness of transmission. Russia exhibits strong contemporaneous effects and null lagged effects, which means that it was directly transmitted. Australia exhibits substantial effects in both lags, and this implies that there are several channels of transmission. Canada exhibits sign reversals and disappearance of the results in richer models, which demonstrates that no relationship is stable. Although this heterogeneity in timing patterns is not the main theoretical contribution, it gives valuable practical information to the policymakers regarding the rate at which terms-of-trade shocks impact on different currencies.

The robustness analysis gives in the end more weight to the central result of the Main Model, which is that the commodity currency hypothesis is robust in Kazakhstan and Australia, obviously not present in Brazil and South Africa, shows a causal effect transmitted immediately rather than lagged in Russia, and is weak or specification-sensitive in Canada. Such inferences hold up well to alternative lag structures, alternative econometric methods and alternative specifications.

Chapter 6: Conclusion

6.1 Summary of Principal Findings

This thesis examined the universal nature of the commodity currency hypothesis in various economies that provide resources and export different commodities or whether it is conditional on structural and institutional factors. Our rigorous, standardized approach was used in six countries (emerging market, i.e., Kazakhstan, Russia, Brazil), a middle-income economy (i.e., South Africa), and a set of developed commodity exporters (i.e., Canada, Australia). Its main methodological contribution was to create country-specific export-weighted commodity price indices that isolate terms-of-trade shocks that are country specific and apply a hierarchical empirical approach gaining priority on the Main Model and using robustness checks to validate this.

The statistical results indicate that there is a significant heterogeneity. High level of commodity currency hypothesis is only apparent in both Kazakhstan and Australia where lagged commodity price growth is a significant predictor of exchange rates movements with the elasticities of 0.31 and 0.39 respectively in the Main Model. These nations are characterized by high commodity export concentration and fairly straightforward economic systems regardless of varying degrees of the general development. The null result is obtained in Brazil and South Africa in all the specifications and the historical price behavior of past commodities does not hold any statistically significant information to predict the Real or Rand values.

The interesting example of Russia is that the Main Model did not exhibit any relationship but robustness checks demonstrate that the relationship exists between periods and not across periods. Canada in the Main Model has a negative coefficient which is not found in the VAR

specification signalling the specification sensitivity which could be due to structural breaks or dominance of the US-Canada financial integration with commodity fundamentals.

The Chen-Rogoff-Rossi hypothesis has a definite pattern of results in the reverse causality tests. Currencies of emerging markets (Kazakhstan, Russia, Brazil) do not indicate predictability of prices of commodities, which is in line with price takers in such countries. The effects of these are statistically significant (Canada, Australia) but we explain this as due to financial market conjecture and contemporaneous adaptation to common shocks as opposed to the currencies having independent prediction ability in real commodity markets.

6.2 Theoretical Contributions

The first theoretical contribution of this thesis is that the commodity currency hypothesis is conditional as opposed to a universal one. This was already determined to be an empirical regularity of a small number of developed commodity exporters as previously established by Chen and Rogoff (2003). Later researches such as Cashin et al. (2004) extended geographical boundaries but tended to adopt aggregate commodity indices in place of country-based basket. We have found that the relationship is robust in only a third of the cases studied despite methodology and country-specific indices created with great care.

Such a conditionality is based on economic sophistication and institutional arrangements. Simple commodity exporters that are not diversified (Kazakhstan as a post-Soviet economy, Australia as a mining-based developed country) have high commodity-currency relationships. The economic complexity undermines or eradicates the relationship. The diversified nature of the Brazilian industrial and advanced agricultural sector produces counter-balancing effects in which the

manufacturing industry could be able to offset the effects of the decrease in commodity prices. The financial integration between Canada and the United States is so deep that the interest rate differentials and the spillovers of the Federal Reserve policy may overwhelm the commodity fundamentals in the short-run exchange rate determination.

There are also policy frameworks and institutional quality. Countries having a credible inflation-targeting central banks, freely floating exchange rates, and sovereign wealth funds procured to sterilize commodity revenue fluctuations portray other trends than countries with fiscal dominance, capital controls, and a record of currency crisis. The 2015 transition of Kazakhstan to managed float to free float could have increased the transmission mechanism by eliminating administrative barriers to market-based adjustment of the exchange rate.

This conditional result vindicates seeming contradictions in the literature. Strong relationships were found by Chen and Rogoff (2003) in the study of Australia, Canada, and New Zealand, which are small open developed economies with relatively simple export structure during the time of investigation. Later publications involving a greater number of different countries showed less significant findings. It is our opinion that both these sets of findings are valid in their respective samples. The relationship is high when the structural conditions are conducive to transmission and it will be low where complexity, diversification or offsetting factors confound the signal of the commodity.

On the issue of causality between the traditional fundamentals perspective and the Chen-Rogoff-Rossi asset price perspective, our evidence shows more similarity with Bork et al. (2023). The hypothesis that the exchange rates are predictors of the commodity prices in any emerging market is not supported by us. The notable reversal in Canada and Australia is

probably due to financial market expectations (the currency traders adjusting to the commodity futures more rapidly than the spot prices), USD denomination effects (the stronger local currencies increasing the export price indices in USD), and a combination of response to common factors like expectations of growth around the world. The reverse causality findings are similar to that of the sample, hence indicating that the Chen-Rogoff-Rossi result can be limited to G10 currencies as they have deep futures markets and cannot be generalized outside of that sample.

6.3 Robustness and Methodological Reflections

The hierarchical empirical approach adopted in the current dissertation put the Newey-West Lag 1 specification at the top of the list as the Main Model and the contemporaneous OLS and VAR models as robustness tests. This methodological option is both theoretical and practical in nature due to empirical realities that can be seen during the analysis. The evidence of robustness, in Section 5.9, has valuable lessons regarding the choice of specifications, timing heterogeneity, and the interpretation of inconsistent findings using different econometric methods.

Validation of Main Model Findings

The robustness checks tended to confirm these findings in the case of the two countries where the Main Model gained massive support on the commodity currency hypothesis, which are Kazakhstan and Australia. Not only did the relationship of Kazakhstan survive alternative specifications but dramatically strengthened in the framework of the VAR where the Granger causality test was $p < 0.001$, as opposed to the $p = 0.053$ of Main Model. This development of marginal to highly significant gives a high confidence that the Tenge indeed reacts to the shocks

in the prices of commodities with a one-year delay. The findings of Australia went down to slightly less when transitioning to the VAR ($p=0.057$ vs. $p=0.022$) and still significant though reasonably when the contemporaneous specification was highly significant ($p=0.003$). The uniformity of specifications is an affirmation indicating that Australia is the canonical commodity currency in the sample.

In null results, the Main Model of countries in the null finding category (Brazil and South Africa) had all the alternative specifications supporting the nulls. The contemporary OLS ($p=0.858$), Brazil was not significant in the VAR ($p=0.214$). South Africa nullified in both checks of robustness (VAR $p=0.416$, contemporaneous $p=0.158$). That there is no specification that provides meaningful results in these countries adds to the belief that the nulls reflect the true reflections of weak or nonexistent commodity-currency relationships and not artifacts of specific modeling decisions. This is a regular trend that existed between specifications, but it is as significant a discovery as the notable findings regarding Kazakhstan and Australia.

Canada was the only country in which the checks of robustness disagreed essentially with the Main Model. The large negative coefficient in the Lag 1 model ($p=0.010$) entirely vanished on increasing to VAR(2) as advised by the information criteria ($p=0.450$). Such sensitivity in specification suggests that the Main Model outcome was delicate, which may have been caused by structural instability or the presence of confounding variables or by the ineffectiveness of simple bivariate models in an economy as complex and financially integrated as Canada. Analysis of robustness also helped us to avoid Type I error- falsely believing that increasing commodity prices are an indicator of Canadian Dollar depreciation when this non- obvious outcome was in fact an artifact of specification.

Transmission Timing and Policy Relevance

Though the main theoretical contribution on the conditional behavior of the commodity currency hypothesis is that it is conditional, the robustness checks found key practical heterogeneity in transmission timing which has direct policy implications. Kazakhstan has only lagged transmission, Russia only contemporaneous transmission and Australia both. The policies are informed by these patterns to respond to the horizon of policies.

In the case of Kazakhstan, the delay of a year in the transmission would provide the policy makers with time to monitor the changes in the commodity prices and predict the exchange rate implication before they actually occur. When oil prices rise in year t the authorities can anticipate Tenge pressure in year $t+1$, which gives them a window in which to make fiscal changes and manage reserves. This lagged transmission format is naturally consistent with the explicit mandate of the National Fund to save revenues in booms and give funds back in busts.

In the case of Russia, the lagged effects are not present, but the contemporaneous correlation is high, implying that commodity shocks and exchange rate movement occur concurrently. The commodity price forecasts are not helpful in predicting the future pressure of the Ruble with a one-year lead time by the Russian monetary authorities. Instead they have to react to shocks on the spot. This direct communication is probably an indicator of the oil-Ruble markets in Russia and partly the reason behind the historical trend of the Central Bank of Russia in using foreign exchange interventions to smooth intraday volatility instead of responding to longer term patterns.

The dual-horizon transmission in Australia, which is very relevant when considering Lead 0 and Lead 1, indicates that there are various channels through which the commodities shocks

influence the Aussie. The financial markets can respond instantly to the change in commodity prices leading to the contemporaneous correlation that is found in the robustness check. At the same time, the effects of real economy on national income, employment, and accumulation in investment structural changes are realized in the long term and result in the lagged relationship observed in the Main Model. The flexible inflation-targeting framework adopted by the Reserve Bank of Australia, whereby it permits short-term variations on the target, in line with adaptation to supply shocks, seems to be quite adapted to this dynamics.

The Role of Robustness Checks in Empirical Research

The experience of this thesis demonstrates the importance of strong checks as a way of coming up with sure empirical results. Using the Main Model only, we would have concluded that Canada has a large negative commodity-currency relationship which is theoretically incoherent and would not have been found in the VAR. With the contemporaneous specification alone and without testing lagged relationships we would have totally missed the behaviour of Kazakhstan in its dealings in commodities and currency because they only use lagged relations.

The hierarchical methodology used in this case, whereby, the Newey-West Lag 1 was defined as the main one due to its theoretical importance, followed by the systematic implementation of the other specifications as the validation, was suitable to the problem under investigation. The Main Model is used to test the basic theoretical hypothesis that historical trends in commodity prices are predictive of future shifts in the exchange rate, which directly answers the Granger causality question about which the literature on commodity currency is largely based. The robustness tests confirm that these findings can support other assumptions regarding the dynamics, lag structure, and simultaneity.

Nevertheless, the robustness analysis also indicated that a single specification is not ideal in representing all countries. The relationship of Russia does not seem to appear in the contemporaneous model but only visible to the lagged specification. A dogmatic approach to methodology which ruled out the current models as theoretically unsuitable/inappropriate would have erroneously placed Russia as lacking any commodity-currency relationship. The flexibility of the methods which were based on the information criteria and diagnostic tests was crucial to describe each country correctly.

Limitations Revealed by Robustness Analysis

Limitations Can be seen through the analysis of robustness.

Some of the limitations of the analysis were also pointed out by the robustness checks. The level of specification that is evident in the case of Canada would imply that bivariate models may not be sufficient to model complex economies that have many counterbalancing factors on an annual basis. Future studies must include the higher-frequency information, multivariate models such as interest differentials and risk premia, and structural break tests.

The conflict between the information conditions and the theoretical priori on Brazil: in which the varsoc suggested Lag 0 and our Lag 1 is an example of an underlying tension of empirical macroeconomics. Statistical criteria maximize in-sample fit, however there are theoretical reasons to overrule these advice that can be based on the persistence and causality considerations. We were conservative in our decision to impose Lag 1 in that it gave the commodity currency hypothesis the best opportunity to support, but the best specification yielded nothing but null results.

That the statistical significance of Main Model ($p=0.022$) weakens in the VAR($p=0.057$) suggests that the uncertainty in the more complex models could be concealing the actual relationships. Sample sizes of 25-30 annual observations are insufficient to have statistical power. Greater length of time series would enable more accurate estimation of VAR systems and could do formal tests of whether the processes of transmission have changed over time.

Implications for Future Research Design

The findings of the robustness of this thesis indicate that there are a number of design principles that can be proposed to future commodity currency research. First, multiple lag structures should be tested by the researchers instead of applying uniform specifications across countries. The fact that timing patterns of Kazakhstan, Russia and Australia are different suggests that optimal lag length may vary according to the institutional traits and financial market depth.

Second, the current and delayed specifications are to be considered as complementary as opposed to rivalry. They both portray other facets of the relationship between commodity and currency. Modern models uncover intra-period correlation that is valuable in explaining market responses in the financial market. Lagged models examine policy forecasting predictive power. Both are informative.

Third, careful consideration of the lag selection criteria should be given to estimating VAR models, although it should not be blindly followed in situations when it is in conflict with theoretical considerations. The example of Brazil shows the importance of the theoretically motivated restrictions even in cases when the information requirements promote the opposite decision, as long as this decision is publicly maintained and explained.

Fourth, the diagnostic testing must be organized and thorough. The diagnostics of South Africa and Australia exemplary thorough analyses confirmed the fact that the large and nonsignificant results respectively were not due to misspecification. The non-normal residuals of Russia provided us with an alert over the outlier of the crisis of 1998 that could be accommodated by using robust regression methods or dummy variables in the extensions of this work.

The Strength as a Scientific Practice.

Finally, the robustness analysis represents the best practices in empirical economics. Findings that are highly sensitive to a particular specification are weak and must be viewed with a lot of caution. It is possible to say with confidence results that pass several alternative specifications, as well as different lag structures, and different econometric methods. This hierarchical structure adopted in this paper, in which the main evidence is the Main Model, and the validation is the robustness checks, was a principled method of synthesizing findings between specifications.

The commodity currency hypothesis, which is specified in this thesis, works well in the case of Kazakhstan and Australia. The data withstands alternative specifications, diagnostic tests and is consistent with economic theory and institutional realities. In the case of Brazil and South Africa, the null hypothesis is also equally strong, as the specification does not generate any significant consequences in any way, whether it is in the rigorous or the weak form of the hypothesis. In the case of Russia, the robustness analysis identified a relationship that exists in immediate as opposed to lagged channel. In the case of Canada, robustness checks helped to avoid specification sensitivity by avoiding erroneous conclusions.

These findings of robustness reinforce and not complicate the thesis conclusions. They show that the main result, the hypothesis of commodity currency is conditional, but not universal, does not

rely upon arbitrary methodological decisions but arises regularly in rigorous, systematic empirical research. This provides the assurance that the policy implications and theoretical implications that are based on such findings are sound empirically.

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Appendix

Appendix A. Variable weights over time for Kazakhstan

Commodity (HS-2)	1995	2000	2005	2010	2015	2020	2023
Mineral Fuels (27)	0.31	0.75	0.73	0.73	0.72	0.70	0.67
Iron/Steel (72)	0.25	0.07	0.08	0.07	0.06	0.06	0.06
Copper (74)	0.14	0.05	0.06	0.04	0.05	0.00	0.05
Inorganic Chemicals (28)	0.09	0.01	0.03	0.05	0.07	0.06	0.06
Cereals (10)	0.07	0.03	0.01	0.02	0.02	0.04	0.03
Ores (26)	0.03	0.02	0.03	0.04	0.02	0.09	0.07
Zinc (79)	0.03	0.01	0.01	0.01	0.01	0.00	0.01
Precious Metals (71)	0.00	0.02	0.01	0.02	0.02	0.02	0.02
Other (6 commodities)	0.08	0.04	0.04	0.02	0.03	0.03	0.03
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. The dramatic shift from diversified base metals (1995) to oil dominance (2000–2023) reflects Kazakhstan's structural transformation following independence. HS-28 includes uranium compounds.

Appendix B. Variable weights over time for Brazil

Commodity (HS-2)	1995	2000	2005	2010	2015	2020	2023
Oil Seeds/Soybeans (12)	0.06	0.14	0.13	0.10	0.21	0.21	0.23
Ores/Iron Ore (26)	0.19	0.20	0.19	0.28	0.16	0.21	0.15
Mineral Fuels/Oil (27)	0.03	0.08	0.18	0.19	0.14	0.18	0.24
Sugars (17)	0.14	0.08	0.10	0.12	0.08	0.06	0.07
Coffee/Tea (9)	0.14	0.10	0.06	0.05	0.06	0.04	0.03
Residues/Food Waste (23)	0.15	0.11	0.07	0.05	0.06	0.05	0.05
Pulp/Wood Fiber (47)	0.10	0.10	0.05	0.04	0.06	0.04	0.03
Meat (2)	0.07	0.10	0.17	0.11	0.13	0.11	0.09
Tobacco (24)	0.08	0.05	0.04	0.02	0.02	0.01	0.01
Cereals (10)	0.00	0.00	0.00	0.02	0.06	0.05	0.06
Precious Metals (71)	0.04	0.04	0.02	0.02	0.03	0.04	0.02
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. Brazil exhibits a diversified export basket with soybeans, iron ore, and oil emerging as dominant exports by 2023. Unlike Kazakhstan, no single commodity dominates throughout the period, reflecting Brazil's complex industrial structure.

Appendix C. Variable weights over time for Russia

Commodity (HS-2)	2000	2005	2010	2015	2020	2021
Mineral Fuels/Oil & Gas (27)	0.73	0.78	0.82	0.78	0.61	0.64
Iron/Steel (72)	0.09	0.09	0.06	0.05	0.07	0.09
Aluminium (76)	0.07	0.03	0.02	0.03	0.02	0.03
Precious Metals (71)	0.00	0.01	0.01	0.03	0.13	0.10
Wood (44)	0.03	0.03	0.02	0.02	0.04	0.04
Fertilizers (31)	0.02	0.02	0.02	0.03	0.03	0.04
Inorganic Chemicals (28)	0.03	0.01	0.01	0.01	0.01	0.01
Copper (74)	0.02	0.01	0.02	0.02	0.02	0.02
Ores (26)	0.01	0.01	0.01	0.01	0.02	0.02
Cereals (10)	0.00	0.01	0.01	0.02	0.04	0.03
Total	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. Russia exhibits extreme oil and gas dominance (61-82%), with notable decline post-2015 coinciding with sanctions and diversification efforts. Precious metals (gold) weight increased dramatically from near-zero (2000) to 13% (2020), likely reflecting strategic reserve management and sanctions-related trade reorientation.

Appendix D. Variable weights over time for South Africa

Commodity (HS-2)	2000	2005	2010	2015	2020	2023
Precious Metals/Platinum & Gold (71)	0.18	0.32	0.25	0.31	0.37	0.29
Iron/Steel (72)	0.23	0.22	0.17	0.13	0.08	0.10
Mineral Fuels/Coal (27)	0.23	0.18	0.19	0.18	0.13	0.18
Ores/Iron Ore & Manganese (26)	0.09	0.09	0.21	0.19	0.25	0.24
Aluminium (76)	0.08	0.06	0.04	0.04	0.03	0.03
Edible Fruit & Nuts (8)	0.05	0.05	0.05	0.07	0.07	0.07
Pulp of Wood (47)	0.04	0.02	0.02	0.02	0.01	0.02
Paper & Paperboard (48)	0.04	0.02	0.02	0.02	0.01	0.01
Articles of Iron/Steel (73)	0.03	0.03	0.03	0.03	0.02	0.02
Copper (74)	0.02	0.01	0.01	0.01	0.01	0.02
Cereals (10)	0.01	0.01	0.01	0.01	0.01	0.02
Total	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. South Africa's export structure is dominated by precious metals (primarily platinum and gold), which increased from 18% (2000) to 37% (2020). The declining share of iron/steel (23% → 8%) and rising share of raw ores (9% → 24%) reflects deindustrialization and shift toward unprocessed mineral exports. This diversified but volatile structure explains the absence of a stable commodity-currency relationship.

Appendix E. Variable weights over time for Canada

Commodity (HS-2)	1995	2000	2005	2010	2015	2020	2023
Mineral Fuels/Oil & Gas (27)	0.30	0.45	0.55	0.55	0.50	0.44	0.58
Wood/Lumber (44)	0.18	0.16	0.13	0.05	0.08	0.09	0.05
Paper & Paperboard (48)	0.20	0.15	0.10	0.06	0.05	0.04	0.03
Precious Metals/Gold (71)	0.04	0.04	0.05	0.11	0.11	0.14	0.11
Aluminium (76)	0.08	0.07	0.06	0.05	0.05	0.05	0.05
Ores/Potash (26)	0.04	0.02	0.02	0.04	0.04	0.06	0.05
Cereals/Wheat (10)	0.06	0.04	0.02	0.03	0.05	0.05	0.05
Iron/Steel (72)	0.05	0.03	0.04	0.04	0.04	0.04	0.04
Oil Seeds/Canola (12)	0.03	0.02	0.02	0.03	0.04	0.05	0.05
Fertilizers (31)	0.03	0.03	0.02	0.04	0.04	0.03	0.04
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. Canada's export structure shows increasing oil and gas dominance from 30% (1995) to 58% (2023), with declining shares for traditional exports like paper (20% → 3%) and lumber (18% → 5%). Precious metals (gold) increased from 4% to 14% (2020) before declining. This diversified structure with multiple significant commodities (energy, forestry, agriculture, metals) explains the unstable commodity-currency relationship found in empirical results.

Appendix F. Variable weights over time for Australia

Commodity (HS-2)	1995	2000	2005	2010	2015	2020
Ores/Iron Ore (26)	0.12	0.13	0.20	0.35	0.33	0.48
Mineral Fuels/Coal & LNG (27)	0.29	0.35	0.41	0.38	0.34	0.28
Precious Metals/Gold (71)	0.14	0.09	0.08	0.09	0.09	0.10
Wool (51)	0.09	0.05	0.03	0.01	0.02	0.01
Meat (2)	0.08	0.08	0.08	0.04	0.07	0.05
Aluminium (76)	0.07	0.07	0.05	0.03	0.02	0.02
Inorganic Chemicals (28)	0.07	0.07	0.06	0.03	0.04	0.02
Cereals/Wheat (10)	0.06	0.08	0.04	0.03	0.05	0.02
Iron/Steel (72)	0.04	0.02	0.01	0.01	0.01	0.01
Cotton (52)	0.02	0.03	0.01	0.01	0.01	0.00
Copper (74)	0.02	0.02	0.02	0.02	0.02	0.01
Oil Seeds (12)	0.01	0.02	0.01	0.01	0.01	0.01
Total	1.00	1.00	1.00	1.00	1.00	1.00

Note: Weights are variable (Paasche-type), updated annually based on export value shares. Australia's export structure demonstrates the dramatic "mining boom" narrative: iron ore increased from 12% (1995) to 48% (2020), while traditional exports like wool declined from 9% to 1%. Combined minerals (iron ore + coal) account for 76% of the index by 2020, confirming

Australia's mining-dominated economy despite being a developed nation. This concentration explains the strong commodity-currency relationship found in empirical results.