Journal of International Money and Finance 130 (2023) 102745

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Commodity price effects on currencies

Wenhao Wang [a,*], Yin-Wong Cheung [b]

[a] *School of Finance, Shandong University of Finance and Economics, China*
[b] *Department of Economics, University of California, Santa Cruz, USA*

ARTICLE INFO

Article history:
Available online 24 September 2022

Keywords:
Commodity Currencies
Sectoral Commodity Prices
The US Dollar Effect
The Global Financial Crisis, Macro Variables

ABSTRACT

Using quarterly data on four commodity-exporting countries, we examine the explanatory power of real commodity prices to predict real effective exchange rates, paying particular attention to the separate roles of varied sectoral commodity prices during alternative time periods. We determine that the commodity price effect is nonuniform across countries and commodity sectors and varies over time. The use of fixed-weight price indexes or nominal exchange rates and commodity prices yields heterogeneous commodity price effects. Furthermore, the pattern of commodity price effects is influenced by the presence of macroeconomic conditions, effects of crises, and exchange rates of leading trading partners. These empirical results highlight the challenges associated with explaining diverse currency behaviors across different time periods using a single commodity-price-based exchange rate model. In addition, these findings suggest policymaking assuming stable commodity price effects difficult.

© 2022 Elsevier Ltd. All rights reserved.

1. Introduction

Seminal studies of Meese and Rogoff (1983a, b) illustrate the difficulties in modeling and forecasting exchange rate movements. Subsequent analyses usually affirm the general conclusion of the aforementioned studies; in particular, identifying a model that explains and predicts all currencies for all time periods is challenging (Cheung, et al., 2005; Cheung, et al., 2019; Engel, et al., 2019; Rossi, 2013).

While a general specification was difficult to establish, Chen and Rogoff (2003) and Cashin, et al. (2004) employed the least squares or dynamic least squares regression method and reported a positive relationship between commodity prices and exchange rates. These authors suggested that the Balassa–Samuelson framework is in accordance with the empirical positive commodity price effect. Furthermore, a commodity currency is referred to as the currency of a commodity-exporting country that pro-cyclically fluctuates with commodity prices. Subsequent studies reported varying degrees of commodity price effects, employing alternative estimation techniques and data samples. For instance, Chen, et al. (2010) and Clements and Fry (2008) adopted the Granger causality technique and demonstrated that commodity prices merely affect exchange rates.[1]

---

* Corresponding author.
E-mail addresses: andrew_wang9007@sdufe.edu.cn (W. Wang), cheung@ucsc.edu (Y.-W. Cheung).

[1] Studies on commodity exchange rates and commodity prices have evolved to include (a) both developed and developing countries (Bodart, et al., 2012, 2015; Cashin, et al., 2004; Coudert, et al., 2015), (b) country-specific aggregate commodity price indexes to commodity specific price indexes (Bodart, et al., 2012; Ferraro, et al., 2015; Zhang, et al., 2016), (c) the feedback between commodity currencies and commodity prices (Chen, et al., 2010; Clements and Fry, 2008, Zhang, et al., 2016), (d) the effects of structural determinants on the strength of commodity currency and commodity price relationship (Bodart, et al., 2012, 2015; Chen and Lee, 2018), and e) forecasting performance, links to carry trade, volatility, and equity returns (Ayres, et al., 2020; Byrne, et al., 2019; Chaban, 2009; Chen, et al., 2010; Ready, et al., 2017b).

https://doi.org/10.1016/j.jimonfin.2022.102745
0261-5606/© 2022 Elsevier Ltd. All rights reserved.

This paper examines the explanatory performance of real commodity prices for real effective exchange rates in a systematic manner, with specific focus on differential roles of various sectoral commodity prices in alternative time periods. We anticipate that owing to varied industrial structures and unique mixes of commodity exports, the commodity currencies of different commodity-exporting countries can respond nonuniformly to different sectoral commodity prices.[2] Dissimilar productivity differentials between commodity and non-commodity sectors in different countries can further contribute to nonuniform responses.

The US dollar is the predominant global currency and the main pricing currency in the global commodity market. The market usually perceives a strong correlation between the US dollar and commodity prices. Thus, the dollar valuation can be a common factor driving commodity currencies and prices; for instance, a strong US dollar can be associated with a weak commodity currency and low commodity price. Anecdotal evidence suggests that the global demand for the US dollar varies over the course of the global financial cycle. The association between the US dollar, commodity currencies, and commodity prices can vary with time. In this study, the US dollar real effective exchange rate is employed to account for the US dollar effect on the links between real commodity price indexes and real effective exchange rates of commodity currencies.[3]

We stipulate that the association between commodity currencies and prices has changed following the 2007–2008 global financial crisis (GFC). During and after the GFC, countries modified their monetary policies and financial market regulations. These modifications, coupled with altered economic conditions, have triggered changes in the global financial market in general and the global commodity market in particular. For instance, Adams and Glück (2015), Ordu, et al. (2018), and Ready, et al. (2017a) noted different behaviors of commodity price indexes before and after the GFC. Commodity financialization gained momentum in the post-GFC era, thereby making commodities a viable asset class for institutional and individual investors (Adams and Glück, 2015; Baker, 2021; Basak and Pavlova, 2016; Henderson, et al., 2015; Ordu, et al., 2018). Different commodities have experienced different degrees of financialization, which, in turn, can affect the link between commodity prices, financial assets, and exchange rates. Against this backdrop, we compare the nexus between commodity currencies and prices before and after the GFC.

We find that commodity prices influence the currencies of Australia, Canada, Norway, and New Zealand. In general, the set of sectoral commodity price indexes offers better explanatory power than the aggregate commodity price index. The effects of sectoral commodity price index differ across countries, sectors, and time periods and are stronger in the post-GFC period than the pre-GFC period. The US dollar effect is not as strong as anticipated; it primarily appears in some cases in the post-GFC period.

The heterogeneous sectoral commodity price effects qualitatively hold up with fixed-weight price indexes, nominal exchange rates, and nominal commodity prices. They are also influenced by the crisis effect, presence of macroeconomic variables, and exchange rates of leading trading partners.

From a modeling perspective, the nonuniform sectoral commodity price effect does not contradict the findings of Meese and Rogoff, which are difficult to explain and forecast exchange rate movements. Heterogeneous and period-specific commodity price effects attenuate the usefulness of a single commodity price model of exchange rate determination for all currencies in all time periods. The heterogeneity of commodity price effects can have significant policymaking implications for the creation and execution of monetary policy and inflation management based on the notion of a stable empirical link between commodity prices and exchange rates.[4]

The following section provides some basic information regarding the empirical exercise. Section 3 presents the basic commodity price and the US dollar effects. Section 4 reports additional analyses that involve fixed-weight commodity price indexes, nominal (instead of real) effective exchange rates and commodity prices, the presence of macroeconomic variables, the role of the GFC period, and the inclusion of leading trading partners' exchange rates. Section 5 provides the concluding remarks.

2. Basic information

The positive response of commodity currencies to commodity price movements is usually illustrated in a setup incorporating the Balassa–Samuelson effect (Cashin, et al., 2004; Chen and Rogoff, 2003).[5] Following this perspective, we can modify the exchange rate model in Patel, et al. (2019) to illustrate the dependence of commodity price effects on "labor intensity" and "commodity productivity." In Appendix A.1, we outline a model that demonstrates the impacts of labor intensity, commodity productivity, and sectoral wage weights on commodity price effects, especially for readers interested in the basic theoretical setup.[6] As these factors can vary across sectors and countries and change over time, heterogeneous commodity price effects can be a common characteristic of empirical data.

---

[2] For instance, Bodart, et al. (2012, 2015) examined the effect of the price of a country's leading commodity export on its currency. However, studies on the differential effects of different sectoral commodity prices on a commodity currency are limited.

[3] Chen, et al. (2010) used GBP-based exchange rates to assess if exchange rates forecasting performance is sensitive to the US dollar effect.

[4] The exchange rate response to commodity price movements can lead to the so-called "Dutch disease," which affects macroeconomic performance (Frankel, 2010).

[5] Alternative explanations based on portfolio balance models and terms-of-trade shocks are offered by Ayres, et al. (2020), Chen (2004), and Coudert, et al. (2015). An improved commodity price enhances the terms of trade of a commodity-exporting country and its currency. The effect and the corresponding increase in income can induce foreign direct investment (in the commodity sector) and increase nontradable prices that further strengthen the commodity currency.

2.1. Commodity-Exporting countries

We conduct a systematic assessment of the influence of commodity prices on real effective exchange rates of Australia, Canada, Norway, and New Zealand, which are small, open developed countries with large commodity export sectors. The seminal study conducted by Chen and Rogoff (2003) focuses on Australia, Canada, and New Zealand. Chen and Rogoff (2003) did not consider Norway owing to its regulated exchange regime at the time they conducted their analysis. The current study includes the Norwegian economy as, since then, it has evolved into a market economy with a floating rate arrangement.

Despite their differences, the economic, social, and institutional structures of these four countries are relatively homogenous compared to those of a large group of developed and developing countries. The heterogeneous commodity price effects presented below are unlikely due to different economic, social, or institutional structures.[7]

During our sample period, these four small, open developed countries practice minimal intervention in their domestic (capital) markets and mainly adopt inflation-targeting monetary policies.[8] The levels of openness of these countries, as measured by the total trade-to-GDP ratio, are between 34.75 % (Australia) and 54.71 % (Canada) in 2019 (Appendix A.2). These countries follow a flexible exchange rate arrangement, and their currencies are traded quite actively in the global foreign exchange (FX) market. The Australian dollar, Canadian dollar, New Zealand dollar, and Norwegian krone are the fifth, sixth, tenth, and fourteenth most globally traded currencies, respectively (Bank for International Settlements, 2019). The FX trading turnover is quite large relative to the size of their economies (Appendix A.2); for instance, the daily FX turnover to total trade ratios and to GDP ratios are in the range of 35.66 % (Canada) to 163.27 % (New Zealand) and 19.51 % (Canada) to 66.84 % (New Zealand), respectively.

Australia, Canada, Norway, and New Zealand are commodity exporters—that is, commodity exports account for a large share of their total merchandize exports. Table 1 presents the average shares of exports from three main commodity sectors of each country in three alternative sample periods. The 3 main sectors include agriculture (38 commodities), energy (3 commodities), and metals (13 commodities), and the aggregate commodity exports are given by the sum of exports from these three sectors.[9] Individual commodities included in these three sectors are listed in Appendix A.3. The three sample periods are as follows: a) the full sample period 1990Q2–2019Q4, b) the pre-GFC period 1990Q2–2007Q2, and c) the post-GFC period 2009Q1–2019Q4. Note that the crisis period 2007Q3–2008Q4 is not included in the pre-GFC and post-GFC periods; however, it will be considered in Section 4.

Commodity exports contribute to more than one-half of the total exports of Australia, Norway, and New Zealand, and about one-third of Canada's total exports. The aggregate commodity export shares have increased following the GFC—Canada's share experiences the largest increase from 29.35 % to 40.12 %, whereas New Zealand's share exhibits only a marginal increase.

Norway's and New Zealand's sectoral commodity exports are led by the energy and agriculture sectors, respectively. These two leading sectors have maintained their positions before and after the GFC, and they account for about one-half of the corresponding total exports. For Australia and Canada, their leading commodity export sectors were the agriculture sector in the pre-GFC period, which shifted to the metals and energy sectors, respectively, in the post-GFC period.

2.2. Data on exchange rates and commodity prices

Our main analysis is based on quarterly data on real effective exchange rates (REERs) and real commodity price indexes (RCPIs) from 1990Q2 to 2019Q4.[10] Data on REERs that measure the overall valuation of a currency (Chinn, 2006) are from the *International Financial Statistics (IFS)* database. For RCPIs, we consider the country-specific real indexes derived from time-varying trade weights. For brevity, we label them RCPIs henceforth. The change in a sectoral RCPI (Δrcp) is calculated from the following equation:

$$\Delta rcp_{i,t} = \Sigma_j \omega_{ij,t} \Delta \ln(P_{ij,t}/MUV_t) \tag{1}$$

---

[6] The relevance of the Balassa–Samuelson effect goes beyond emerging and developing economies. For instance, Balassa (1964) documented the effect using data from 12 developed countries. Cardi and Restout (2015), Cheung and Fujii (2014), Égert, et al. (2003), Hassan (2016), Lothian and Taylor (2008), and Wang, et al. (2016) presented evidence on the Balassa–Samuelson effect and implied price–income relation for developed countries and within a developed country.

[7] Besides Chen and Rogoff (2003), studies that focused on a small set of similar developed commodity-exporting countries include Chaban (2009), Chen and Lee (2018), Chen, et al. (2010,), Ferraro, et al. (2015), and Zhang, et al. (2016).

[8] Australia has adopted the inflation-targeting strategy since 1993M4, Canada since 1991M2, New Zealand since 1990Q1, and Norway since 2001M3.

[9] Similar to most other studies, we do not include the fertilizers sector, which accounts for 0.04% (Australia), 1.08% (Canada), 0.03% (Norway), and 0.04% (New Zealand) of total exports. Further, "copra" under the agriculture sector is not included, as its price was not updated.

[10] Some data are available at a monthly frequency (commodity prices and effective exchange rates), and some at an annual frequency (the MUV index and commodity exports). The quarterly frequency is commonly considered and is adopted in, for example, Chen and Rogoff (2003), Chen, et al. (2010), Clements and Fry (2008), and Ferraro, et al. (2015).

Table 1
Aggregate and Sectoral Commodity Export Shares (%).

		Aggregate	Agriculture	Energy	Metals
Australia	Full	68.90	18.49	22.27	28.14
	Pre-GFC	63.59	23.42	18.56	21.61
	Post-GFC	76.80	12.11	27.07	37.62
Canada	Full	33.91	12.35	14.24	7.32
	Pre-GFC	29.35	13.24	10.23	5.88
	Post-GFC	40.22	11.51	19.35	9.36
Norway	Full	67.93	8.04	53.86	6.03
	Pre-GFC	65.48	7.77	51.22	6.49
	Post-GFC	70.85	9.06	56.55	5.24
New Zealand	Full	51.47	44.53	2.55	4.39
	Pre-GFC	51.50	44.51	2.05	4.94
	Post-GFC	51.75	45.43	2.81	3.51

Notes: The numbers are average export shares during a) "Full"—the full sample period 1990Q2–2019Q4, b) "Pre-GFC"—the pre-GFC period 1990Q2–2007Q2, and c) "Post-GFC"—the post-GFC period 2009Q1–2019Q4 period. See the text for definitions and information on the aggregate and sectoral commodity exports.

where i is the commodity group identifier; i = agriculture, energy, and metals sectors, j is the j-th commodity in the i-th commodity group, $\omega_{ij,t}$ is the time-varying weight of commodity j in group i given by its export value normalized by total export value at time t, $P_{ij,t}$ is the nominal price (index) of commodity j at time t, and MUV_t is the manufactures unit value index at time t.[11] The change in *aggregate* commodity price index is the sum of changes in the three sectoral commodity price indexes. Appendix A.4 contains information about the definitions and sources of these data and other data used in the empirical exercise.

Fig. 1 presents the country-specific REERs and RCPIs: Australia in Fig. 1a, Canada in 1b, Norway in 1c, and New Zealand in 1d. Visually, for each of these countries, in accordance with the 2000 s commodities boom, most series exhibit a higher value and are more volatile in the latter part of the sample period. The GFC appears as a watershed for the properties of these REERs and RCPIs. Further, preliminary data analyses show that REERs and RCPIs are usually I(1) but not cointegrated. Similar noncointegration results for these four countries are reported in Cashin, et al. (2004) and Chen and Lee (2018). Thus, we consider the first differences of these variables in subsequent analyses.

Table 2 presents some basic descriptive statistics of the changes in REERs and RCPIs. There are a few observations. First, these four real exchange rate series display different appreciation and volatility patterns in the three sample periods (column labeled "REER"). Second, the means and standard errors of the changes in RCPIs differ significantly among commodity exporters and between sample periods. They suggest differential RCPI effects across commodity-exporting countries over time.

Third, there is a stark difference between descriptive statistics reported for the pre-GFC and post-GFC periods. For example, the volatility of aggregate and sectoral RCPI changes is generally smaller in the pre-GFC period than the post-GFC period. The increase in volatility is in accordance with the rising popularity of commodity financialization in the post-GFC period (Basak and Pavlova, 2016; Henderson, et al., 2015).

The correlation estimates between changes in a commodity exporter's REER and other variables are presented under the rows labeled "*Corr.*" The magnitudes of these estimates in the post-GFC period are higher than those in the pre-GFC period; the only exception is the Norwegian agriculture sector. Technically, these correlation estimates provide the association between the variables and imply no causal interpretation. As the crisis period 2007Q3–2008Q4 is not included in the pre- and post-GFC subsamples, the increased correlation is most likely not the result of contagion triggered by crisis effects. The strong correlation in the post-GFC period is likely due to the increasing significance of commodity exports (Table 1) and commodity financialization, which induce strong interdependence between commodity currencies and commodity prices.[12]

3. Empirical results

The descriptive statistics presented in the previous section indicate the links between exchange rates and commodity prices. Here, we analyze exchange rate responses to commodity price movements with the following regression equations:

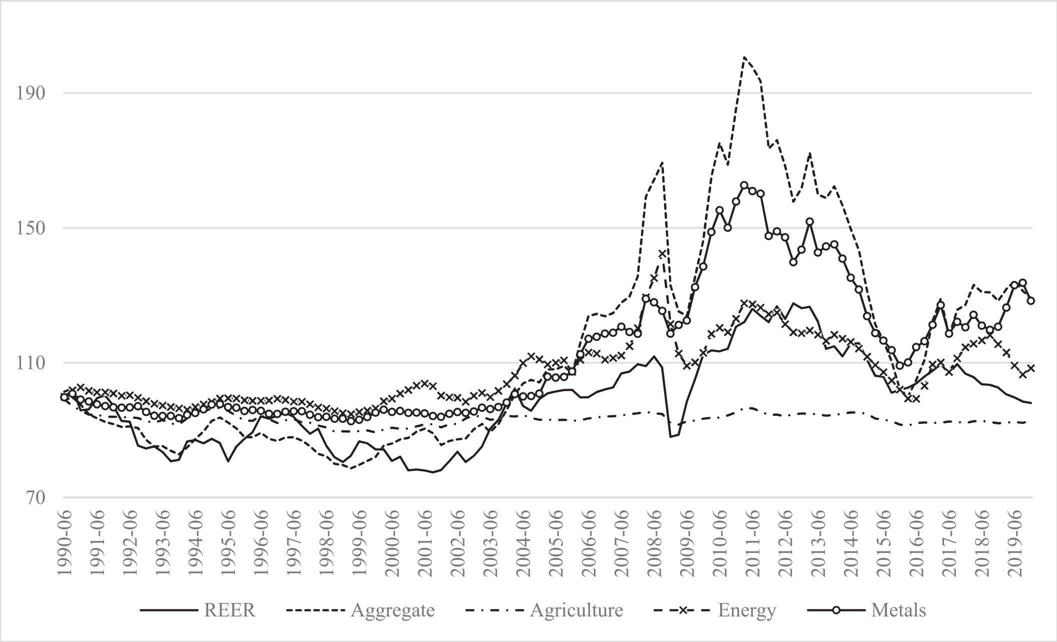
$$\Delta reer_{c,t} = \alpha + \beta \Delta rcp_{aggregate,t} + \varepsilon_t \tag{2a}$$

---

[11] The 54 individual commodity price series are either US dollar-based nominal prices or indexes from the IMF *Primary Commodity Prices* database and the World Bank *Commodities Price Data* (The Pink Sheet). Additionally, we follow Bodart, et al. (2012, 2015), Cashin, et al. (2004), Chen and Lee (2018), and Collier and Goderies (2012) to deflate commodity prices using MUV, which is the index based on a trade-weighted average of the US-dollar export prices of manufactured goods from 15 major developed and emerging countries.

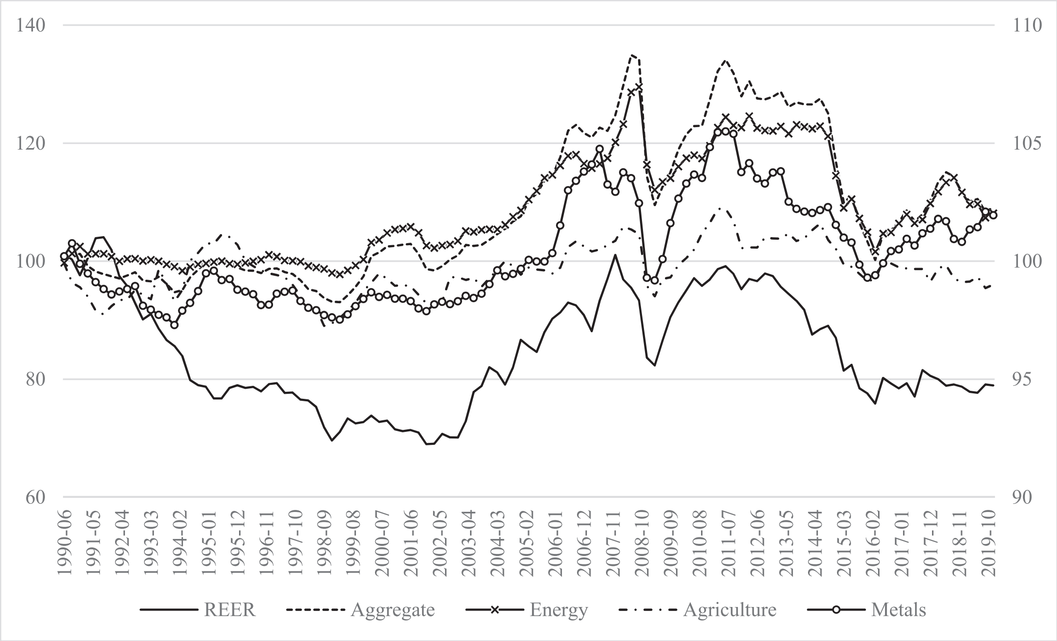
[12] Appendix A.5 shows that the US dollar REER usually exhibits a stronger association with the RCPIs in the post-GFC period than in the pre-GFC period. The plots of these differenced series in Appendix A.5 depict their different behaviors before and after the GFC and the strong comovement during the GFC.

(a) REERs and RCPIs in Australia



Note: All the indexes are normalized to 100 in 1990Q1.

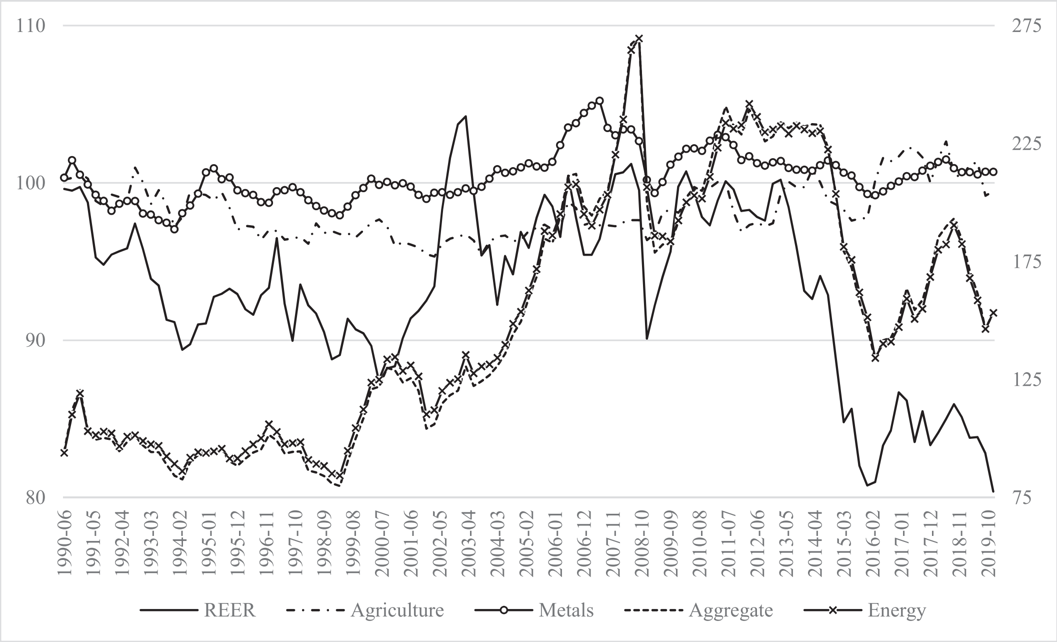
(b) REERs and RCPIs in Canada



Notes: See note to Figure 1a. The scale on the right is for the agriculture and metals price indexes.

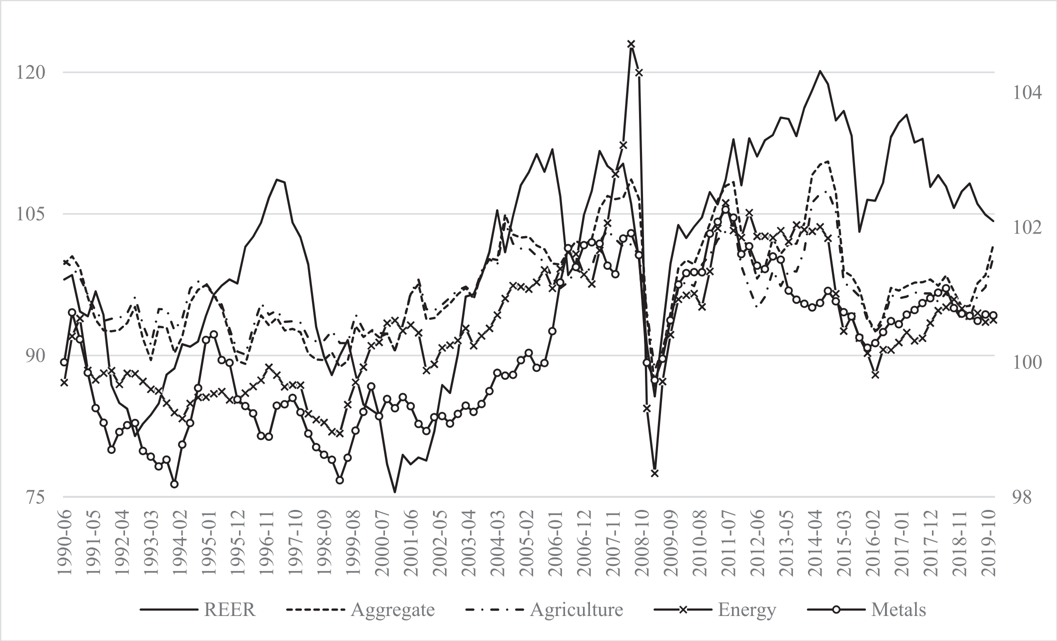
Fig. 1. Country-Specific REERs and RCPIs. Fig. 1a. REERs and RCPIs in Australia. Note: All the indexes are normalized to 100 in 1990Q1. Fig. 1b REERs and RCPIs in Canada. Notes: See note to Fig. 1a. The scale on the right is for the agriculture and metals price indexes. Fig. 1c REERs and RCPIs in Norway Notes: See note to Fig. 1a. The scale on the right is for the aggregate and energy price indexes. Fig. 1d REERs and RCPIs in New Zealand Notes: See note to Fig. 1a. The scale on the right is for the energy and metals price indexes.

(c) REERs and RCPIs in Norway



Notes: See note to Figure 1a. The scale on the right is for the aggregate and energy price indexes.

(d) REERs and RCPIs in New Zealand



Notes: See note to Figure 1a. The scale on the right is for the energy and metals price indexes.

Fig. 1 (*continued*)

$$\Delta reer_{c,t} = \alpha + \beta \Delta rcp_{aggregate,t} + \delta \Delta reer_{us,t} + \varepsilon_t \tag{2b}$$

and.

$$\Delta reer_{c,t} = \alpha + \Sigma_{i=commoditysector} \beta_i \Delta rcp_{i,t} + \varepsilon_t \tag{3a}$$

$$\Delta reer_{c,t} = \alpha + \Sigma_{i=commoditysector} \beta_i \Delta rcp_{i,t} + \delta \Delta reer_{us,t} + \varepsilon_t \tag{3b}$$

Table 2
Descriptive Statistics.

			REER	Aggregate	Agriculture	Energy	Metals	R US$
Australia	Full	Mean	−0.016	0.215	−0.063	0.068	0.210	0.060
		SE	3.701	4.821	0.781	2.566	2.758	2.297
		Corr		0.459	0.394	0.378	0.338	−0.332
	Pre-GFC	Mean	0.096	0.356	−0.083	0.167	0.273	−0.030
		SE	3.190	2.366	0.842	1.212	1.219	2.179
		Corr		0.176	0.170	−0.013	0.236	0.090
	Post-GFC	Mean	0.245	−0.066	0.015	−0.260	0.179	0.185
		SE	3.278	5.853	0.597	2.618	4.000	2.153
		Corr		0.443	0.537	0.256	0.401	−0.601
Canada	Full	Mean	−0.199	0.073	−0.008	0.066	0.016	0.060
		SE	2.723	2.407	0.466	1.753	0.589	2.297
		Corr		0.520	0.249	0.500	0.440	−0.401
	Pre-GFC	Mean	−0.101	0.296	0.007	0.221	0.067	−0.030
		SE	2.478	1.226	0.433	0.830	0.396	2.179
		Corr		0.248	−0.104	0.324	0.205	−0.101
	Post-GFC	Mean	−0.132	−0.106	0.001	−0.167	0.060	0.185
		SE	2.567	2.561	0.419	1.963	0.609	2.153
		Corr		0.665	0.465	0.570	0.640	−0.635
Norway	Full	Mean	−0.183	0.361	−0.004	0.359	0.006	0.060
		SE	2.226	6.464	0.815	5.989	0.542	2.297
		Corr		0.485	0.308	0.455	0.296	−0.323
	Pre-GFC	Mean	−0.053	1.017	−0.040	0.982	0.074	−0.030
		SE	2.053	5.853	0.715	5.401	0.504	2.179
		Corr		0.318	0.362	0.290	0.065	−0.056
	Post-GFC	Mean	−0.259	−0.594	0.072	−0.678	0.012	0.185
		SE	2.089	5.614	0.982	5.304	0.418	2.153
		Corr		0.448	0.200	0.402	0.449	−0.396
New Zealand	Full	Mean	0.035	0.015	0.003	0.005	0.006	0.060
		SE	3.356	2.562	2.098	0.562	0.318	2.297
		Corr		0.312	0.246	0.312	0.338	−0.248
	Pre-GFC	Mean	0.160	0.079	0.030	0.024	0.025	−0.030
		SE	3.288	1.947	1.761	0.230	0.311	2.179
		Corr		0.010	0.002	−0.056	0.088	0.030
	Post-GFC	Mean	0.306	0.179	0.134	0.030	0.016	0.185
		SE	3.227	2.853	2.491	0.391	0.229	2.153
		Corr		0.476	0.406	0.548	0.582	−0.540

Notes: The rows "Mean" and "SE" present the mean and standard errors of the changes in the variables, respectively, listed in the column headings. The row "*Corr*" presents the correlation estimates between changes in the REER and RCPI (or in the US REER) listed in the column headings. The labels "Full," "Pre-GFC," and "Post-GFC" show the results from the full sample period 1990Q2–2019Q4, pre-GFC period 1990Q2–2007Q2, and post-GFC period 2009Q1–2019Q4, respectively.

where $reer_{c,t}$ is the logarithm of a commodity-exporting country's REER, $rcp_{aggregate,t}$ and $rcp_{i,t}$ are the country-specific aggregate and sectoral (i = agriculture, energy, and metals sectors) RCPIs, $reer_{us,t}$ is the logarithm of the US dollar REER, and Δ is the first-difference operator.

Equation (2a) is the canonical bivariate setup for assessing the exchange rate response to commodity price movements (Chaban, 2009; Chen and Rogoff, 2003; Coudert, et al., 2015). The US dollar effect is investigated using (2b). The inclusion of the US dollar REER index is motivated by its role in pricing global commodities and the bivariate correlation estimates as represented in Table 2. The US dollar global prominence is reaffirmed by Gopinath, et al. (2020).

Equations (3a) and (3b) offer insights into the individual roles of sectoral commodity exports. The heterogeneous composition of commodity exports and nonuniform commodity price properties across sectors and over time suggest that the aggregate commodity index may not be a good average measure to capture individual sectoral commodity price effects on exchange rates. Further, we will compare the exchange rate responses in the pre-GFC and post-GFC periods.

The results of estimating (2a), (2b), (3a), and (3b) for the full sample period are presented in Table 3, the pre-GFC period in Table 4, and the post-GFC period in Table 5.[13] For brevity, we have omitted the intercept estimates.

3.1. Results from the Full sample

There are a few observations from Table 3. First, for all four commodity currencies, the estimated coefficient on the change of aggregate RCPI,$\Delta rcp_{aggregate,t}$, is significantly positive (Column 2a); this result indicates that real commodity prices

---

[13] Before conducting these regression analyses, we adopted the Durbin–Wu–Hausman test to assess the endogeneity of commodity prices. About 9 of 12 cases (4 countries and 3 sample periods) yield no significant evidence of endogeneity at the 5% level. The finding is in accordance with the price-taking behavior of these four countries stated in previous studies, including Chen and Rogoff (2003) and Cashin, et al. (2004).

Table 3
Commodity Price Effects with and without Controlling for the US Dollar Effect.

	(2a)	(2b)	(3-i)	(3-ii)	(3-iii)	(3a)	(3b)
Australia							
Aggregate	0.347***	0.296***					
	(0.117)	(0.109)					
Agriculture			1.869**			1.272**	1.145**
			(0.737)			(0.514)	(0.467)
Energy				0.546***		0.310	0.268
				(0.208)		(0.199)	(0.197)
Metals					0.453***	0.230**	0.192*
					(0.160)	(0.114)	(0.105)
R US$		−0.247					−0.231
		(0.209)					(0.218)
Adjusted R^2	0.211	0.223	0.148	0.136	0.107	0.225	0.235
Canada							
Aggregate	0.580***	0.489***					
	(0.079)	(0.103)					
Agriculture			1.459			−0.552	−1.033
			(0.891)			(0.634)	(0.739)
Energy				0.776***		0.618***	0.553***
				(0.132)		(0.152)	(0.156)
Metals					2.035***	1.308**	1.129**
					(0.503)	(0.519)	(0.504)
R US$		−0.165					−0.253
		(0.138)					(0.161)
Adjusted R^2	0.269	0.275	0.054	0.243	0.187	0.281	0.303
Norway							
Aggregate	0.167***	0.147***					
	(0.034)	(0.034)					
Agriculture			0.842***			0.580***	0.527**
			(0.234)			(0.199)	(0.222)
Energy				0.169***		0.141***	0.133***
				(0.038)		(0.035)	(0.035)
Metals					1.216**	0.325	0.267
					(0.568)	(0.393)	(0.373)
R US$		−0.115					−0.070
		(0.100)					(0.104)
Adjusted R^2	0.229	0.233	0.087	0.200	0.080	0.242	0.239
New Zealand							
Aggregate	0.412**	0.335*					
	(0.175)	(0.184)					
Agriculture			0.393*			0.163	0.146
			(0.226)			(0.156)	(0.167)
Energy				1.862***		0.842	0.742
				(0.549)		(0.574)	(0.630)
Metals					3.569**	2.292*	2.208*
					(1.491)	(1.290)	(1.267)
R US$		−0.161					−0.071
		(0.208)					(0.180)
Adjusted R^2	0.093	0.094	0.052	0.090	0.106	0.120	0.114

Notes: The table summarizes the results of estimating (2a), (2b), (3a), and (3b) for the full sample period 1990Q2–2019Q4. Columns 3-i to 3-iii present the individual sectoral RCPI effects. Heteroskedasticity and autocorrelation consistent standard errors are in the parentheses underneath estimates. ***, **, and * indicate significance at the 1%, 5%, and 10% level. See the text for definitions of variables.

and real effective exchange rates are positively correlated. The result aligns with most extant findings; however, the coefficient estimates of $\Delta rcp_{aggregate,t}$ tend to be below the range of 0.5–1 as reported by Chen and Rogoff (2003).[14] The New Zealand dollar specification garners the smallest adjusted R^2 estimate of 9.3 %, whereas the other three specifications yield an estimate of over 20 %.

Second, for individual commodity sectors, changes of RCPIs ($\Delta rcp_{i,t}$ s) mostly have a significantly positive coefficient estimate (Columns 3-i to 3-iii). However, different sectoral RCPIs have coefficient estimates of different magnitudes.

When the three sectoral RCPIs are included, the number of significant RCPIs is reduced to two or one (Column 3a). Some of the significant results reported under Columns 3-i to 3-iii are spurious, and not all of the sectoral RCPIs contain independent information on commodity currencies. Further, the leading commodity export sector is not necessarily the dominant sector or the only sector determining commodity price effects. While the Australian dollar, Canadian dollar, and Norwegian krone respond to the price indexes of their leading commodity export sectors (metals, energy, and energy, respectively), they also respond to another sectoral commodity price index. For the New Zealand dollar, the leading commodity export sector—the agriculture sector—yields no significant commodity price effect in the presence of other sectoral commodity prices (Column 3a). The results raise doubts about primarily focusing on the role of the leading commodity export sector.

---

[14] The range of our estimates is narrower than those presented in Chaban (2009), which has estimates between 0.37 and 1.9 for the Australian dollar, 0.06 and 0.1 for the Canadian dollar, and 0.3 and 0.5 for the New Zealand dollar.

The results indicate that different commodity sectors display different effects, and the significance and magnitude of sectoral RCPI effects vary across countries. The heterogeneous sectoral commodity price effects can be attributed to varying levels of labor intensity, commodity productivity, and sectoral wage weights in different sectors and in different countries, as discussed in Section 2 and Appendix A.1.

Third, the group of sectoral RCPIs, compared with the corresponding aggregate RCPI, tends to offer a better explanatory power in terms of adjusted R^2 estimates (Columns 2a and 3a). The use of aggregate RCPI may not accurately reflect the effects of each sectoral RCPI.

Fourth, the coefficient estimates on $reer_{us,t}$—the variable that captures the US dollar effect—have the anticipated negative sign. While the inclusion of the US dollar variable reduces the estimates of the aggregate RCPI effect, none of the US dollar coefficient estimates are statistically significant.[15]

In sum, while the full sample results are largely in line with the view that commodity currencies and commodity prices comove, they indicate potential gains in considering sectoral instead of aggregate RCPIs.

3.2. Pre-GFC and Post-GFC periods

Tables 4 and 5 present the results obtained from the pre-GFC period (1990Q2–2007Q2) and post-GFC period (2009Q1–2019Q4), respectively. The GFC period is not included here—but considered in the next section—to avoid uncertainty effects caused by extraordinary crisis conditions.

For the pre-GFC sample period, the aggregate RCPI has a statistically significant effect on the Canadian dollar and the Norwegian krone (Table 4, Columns 2a and 2b). The Canadian dollar and the Norwegian krone regressions yield significant sectoral RCPI variables that are similar to those reported in the full sample (Tables 3 and 4, Columns 3b). However, the New Zealand dollar regression presents an extreme case in which neither the RCPI (aggregate or sectoral) variables nor the US dollar variable are statistically significant. Compared with the full sample results, there are fewer significant (sectoral) RCPI variables. The US $reer_{us,t}$ variable is insignificant for all the four cases (Table 4, Columns 2b and 3b). The adjusted R^2 estimates are lesser than the corresponding ones from the full sample regressions (Table 3).

Alternatively, the post-GFC sample presents a few different observations. These commodity currencies respond significantly to the aggregate RCPI (Table 5, Columns 2a and 2b), except the New Zealand dollar in the presence of the US dollar variable. When each individual sectoral RCPI variable enters the regression by itself, they are all statistically significant. However, the significance can disappear in the presence of other sectoral RCPI or US dollar variables (Table 5, 3-i to 3-iii, 3a and 3b). Depending on the currency, the significant sectoral RCPI variables in the composite specification (3b) may or may not be comparable to those in the full sample presented in Table 3.

The RCPI effects are different in the pre- and post-GFC periods, and they tend to be stronger in the latter period. These results are in accordance with the growth of commodity financialization after the GFC that enhances commodity price effects on financial assets and exchange rates (Adams and Glück, 2015; Baker, 2021; Basak and Pavlova, 2016; Henderson, et al., 2015; Ordu, et al., 2018; Ready, et al., 2017a).

The subsample analyses support the result that RCPI price effects are sector- and currency-specific. As previously noted, the heterogeneous effects are consistent with a model that links the RCPI effect to labor intensity, commodity productivity, and sectoral wage weights. Compared with aggregate RCPI, the sectoral RCPIs tend to offer better explanatory power.[16]

The US dollar effect is statistically significant in the post-GFC Australian dollar and Canadian dollar regressions but not in the other two currency specifications. The presence of the US dollar improves the adjusted R^2 estimates by 22.5 % (Australia) and 5.1 % (Canada). As expected, the presence of a significant US dollar effect usually improves the absolute estimated errors. Consider the Australian dollar case in the post-GFC subsample: the omission of the US dollar effect worsens the mean and maximum absolute estimated errors by 6.9 % and 9.7 %, respectively.

The significance of the US dollar can reflect the commodity financialization process and high correlation estimates between the US dollar and these two currencies in the post-GFC period. However, its statistical significance is mostly confined to two currencies in the post-GFC period. The presence of a significant US dollar variable in Table 5 in general reduces the estimated RCPI effect.[17] That is, one might overstate the commodity price effect by ignoring the role of the US dollar.

While the US dollar effect may be a factor in assessing commodity price effects, its significance is relevant only to specific commodity currencies in the post-GFC period. Does the US dollar effect depend on the mix of commodity exports, intensity of commodity financialization, and trade with the US? Further investigation of the factors underlying the interactions

---

[16] In a formal test of the sectoral RCPIs having the same coefficient estimates, the Australian, Canadian, and Norwegian regressions reject the hypothesis of coefficient equality in 7 of 12 cases considered, indicating strong statistical evidence in favor of differential sectoral RCPI effects. The New Zealand regression garners 3 rejections of 12 cases, which is higher than the test size, although the evidence is not as strong as others. A specification with sectoral RCPIs usually offers absolute estimated errors better than the corresponding specification with the aggregate index. Consider the New Zealand case in the post-GFC subsample, the specification with the aggregate index yields the mean and maximum absolute estimated errors that are 11.5% and 23.8%, respectively, larger than those from the specification with disaggregate indexes.

Table 4
Commodity Price Effects: Pre-GFC Period.

	(2a)	(2b)	(3-i)	(3-ii)	(3-iii)	(3a)	(3b)
Australia							
Aggregate	0.215	0.263					
	(0.165)	(0.188)					
Agriculture			0.645			0.458	0.399
			(0.482)			(0.422)	(0.477)
Energy				−0.034		−0.285	−0.270
				(0.301)		(0.236)	(0.276)
Metals					0.619*	0.610	0.754*
					(0.376)	(0.394)	(0.443)
R US$		0.211					0.248
		(0.247)					(0.253)
Adjusted R^2	0.014	0.019	0.014	−0.015	0.042	0.034	0.047
Canada							
Aggregate	0.493**	0.482**					
	(0.235)	(0.239)					
Agriculture			−0.596			−1.367*	−1.607
			(0.750)			(0.792)	(0.987)
Energy				0.967***		0.930**	0.912**
				(0.337)		(0.361)	(0.377)
Metals					1.280**	1.234***	1.143***
					(0.556)	(0.418)	(0.420)
R US$		−0.019					−0.135
		(0.166)					(0.207)
Adjusted R^2	0.048	0.034	−0.004	0.091	0.028	0.128	0.126
Norway							
Aggregate	0.111***	0.116***					
	(0.038)	(0.041)					
Agriculture			1.039***			0.904***	1.144***
			(0.323)			(0.307)	(0.423)
Energy				0.110***		0.082**	0.089**
				(0.040)		(0.039)	(0.040)
Metals					0.264	−0.340	−0.302
					(0.400)	(0.441)	(0.440)
R US$		0.044					0.175
		(0.126)					(0.144)
Adjusted R^2	0.087	0.075	0.118	0.071	−0.011	0.133	0.147
New Zealand							
Aggregate	0.019	0.037					
	(0.177)	(0.205)					
Agriculture			0.004			0.020	0.030
			(0.199)			(0.235)	(0.245)
Energy				−0.805		−1.496	−1.408
				(1.608)		(1.723)	(1.750)
Metals					0.930	1.309	1.349
					(1.425)	(1.447)	(1.482)
R US$		0.054					0.050
		(0.213)					(0.207)
Adjusted R^2	−0.015	−0.029	−0.015	−0.012	−0.007	−0.029	−0.044

Notes: The table summarizes the results of estimating (2a), (2b), (3a), and (3b) for the pre-GFC 1990Q2–2007Q2 period. See notes to Table 3.

between commodity currencies, commodity prices, and the US dollar effect could lead to additional insights on commodity currency dynamics.

The adjusted R^2 estimates from the post-GFC sample (Table 3) are discernibly larger than the corresponding ones in Tables 3 and 4.

4. Additional analysis

In this section, we evaluate the commodity price effect using alternative specifications. We focus on the performance of sectoral RCPIs derived from (3b) in Table 3 or variants of it for the full sample, the pre-GFC period, and the post-GFC period to economize the presentation. Specifically, we discuss a few specifications considered in some extant studies and a few others that have not been widely discussed.

4.1. Fixed weights

First, we consider the commodity price indexes based on fixed weights that are commonly adopted in existing studies.[18] That is, $\omega_{ij,t}$'s in Equation (1) are replaced with ω_{ij}'s, where ω_{ij}'s are the average (over time) shares of individual commodity

Table 5
Commodity Price Effects: Post-GFC Period.

	(2a)	(2b)	(3-i)	(3-ii)	(3-iii)	(3a)	(3b)
Australia							
Aggregate	0.257***	0.141*					
	(0.062)	(0.078)					
Agriculture			2.951***			2.491***	0.943
			(0.764)			(0.927)	(0.892)
Energy				0.321*		−0.001	0.050
				(0.190)		(0.221)	(0.234)
Metals					0.329***	0.203*	0.150
					(0.112)	(0.121)	(0.121)
R US$		−0.747***					−0.616**
		(0.269)					(0.286)
Adjusted R^2	0.199	0.386	0.272	0.043	0.141	0.293	0.359
Canada							
Aggregate	0.660***	0.444***					
	(0.114)	(0.149)					
Agriculture			2.846***			0.522	−0.189
			(0.888)			(0.835)	(0.850)
Energy				0.745***		0.420***	0.362**
				(0.157)		(0.158)	(0.160)
Metals					2.695***	1.880***	1.409**
					(0.495)	(0.548)	(0.562)
R US$		−0.382*					−0.346*
		(0.202)					(0.202)
Adjusted R^2	0.445	0.488	0.197	0.309	0.395	0.471	0.495
Norway							
Aggregate	0.167***	0.126*					
	(0.062)	(0.066)					
Agriculture			0.425**			0.290	0.263
			(0.195)			(0.249)	(0.245)
Energy				0.158**		0.103*	0.097
				(0.070)		(0.062)	(0.063)
Metals					2.243***	1.460**	1.085
					(0.719)	(0.704)	(0.892)
R US$		−0.234					−0.129
		(0.159)					(0.193)
Adjusted R^2	0.183	0.211	0.017	0.142	0.182	0.209	0.200
New Zealand							
Aggregate	0.543***	0.261					
	(0.188)	(0.228)					
Agriculture			0.525**			0.088	0.044
			(0.214)			(0.200)	(0.214)
Energy				4.524***		2.275*	1.902
				(1.171)		(1.334)	(1.473)
Metals					8.213***	5.231**	4.299**
					(2.077)	(2.096)	(2.145)
R US$		−0.584*					−0.245
		(0.301)					(0.268)
Adjusted R^2	0.216	0.290	0.145	0.283	0.323	0.349	0.345

Notes: The table summarizes the results of estimating (2a), (2b), (3a), and (3b) for the post-GFC 2009Q1–2019Q4 period. See notes to Table 3.

exports and are normalized to have a sum of 1. Arguably, compared with the time-varying specification, the fixed-weight specification can better capture the effects of average shares but not of time-varying shares.

Results based on RCPI data with fixed weights are summarized in Table 6. The *italic font* indicates that a variable has a significance classification different from its counterpart under Column 3b in Tables 3, 4, and 5.

In general, the use of RCPI data with fixed weights does not significantly affect the pattern of importance of the sectoral RCPIs and the US dollar index. In the post-GFC period, one additional significant sectoral RCPI variable is reported for Australia (metals) and Norway (energy). One less significant sectoral RCPI (energy) is reported for Canada in the pre-GFC period. While there are variations in the magnitudes of coefficient estimates, the sectoral RCPI and the US dollar effects are qualitatively comparable to those in Tables 3–5.

In sum, the commodity price indexes derived from fixed weights also generate heterogeneous sectoral RCPI and the US dollar effects.

Table 6
Sectoral Commodity Price Effects: RCPI Data with Fixed Weights.

	Australia			Canada		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.323***	0.089	0.176	−0.074	−0.160	−0.065
	(0.119)	(0.150)	(0.120)	(0.091)	(0.128)	(0.111)
Energy	0.014	−0.054	0.003	0.058**	*0.043*	0.059**
	(0.040)	(0.064)	(0.058)	(0.029)	*(0.046)*	(0.030)
Metals	0.114**	0.194**	*0.106***	0.123***	0.108***	0.145***
	(0.048)	(0.098)	*(0.053)*	(0.039)	(0.031)	(0.048)
R US$	−0.058	0.247	−0.419*	−0.233	−0.066	−0.399*
	(0.210)	(0.236)	(0.232)	(0.161)	(0.194)	(0.228)
Adjusted R^2	0.306	0.039	0.417	0.265	0.045	0.508
	Norway			New Zealand		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.053***	0.094***	0.020	0.057	−0.045	0.030
	(0.020)	(0.029)	(0.023)	(0.090)	(0.104)	(0.126)
Energy	0.072***	0.045**	*0.068***	−0.014	−0.016	−0.003
	(0.020)	(0.021)	*(0.033)*	(0.023)	(0.034)	(0.044)
Metals	0.020	−0.028	0.044	0.174***	0.078	0.210**
	(0.024)	(0.032)	(0.050)	(0.061)	(0.084)	(0.086)
R US$	−0.022	0.174	−0.092	−0.090	0.054	−0.349
	(0.105)	(0.138)	(0.187)	(0.184)	(0.219)	(0.276)
Adjusted R^2	0.273	0.173	0.235	0.136	−0.041	0.338

Notes: The table summarizes the results of estimating (3b) using RCPI data with fixed weights. The columns labeled “Full,” “Pre-GFC,” and “Post-GFC” show the results from the full sample period 1990Q2–2019Q4, pre-GFC period 1990Q2–2007Q2, and post-GFC period 2009Q1–2019Q4. See notes to Table 3.

Table 7
Sectoral Commodity Price Effects: Nominal Exchange Rates and Commodity Prices.

	Australia			Canada		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	1.166**	0.583	0.524	−0.671	−0.886	−0.370
	(0.489)	(0.526)	(0.819)	(0.568)	(0.729)	(0.873)
Energy	0.216	−0.374	0.031	0.496***	0.764**	0.331**
	(0.217)	(0.267)	(0.234)	(0.161)	(0.318)	(0.164)
Metals	*0.170*	*0.745*	0.138	1.045*	0.995**	1.371**
	(0.108)	*(0.494)*	(0.117)	(0.561)	(0.490)	(0.644)
R US$	−0.230	0.315	−0.708**	−0.261	−0.103	−0.397*
	(0.237)	(0.258)	(0.296)	(0.166)	(0.196)	(0.214)
Adjusted R^2	0.210	0.063	0.360	0.325	0.101	0.484
	Norway			New Zealand		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.366*	1.083***	0.130	0.174	0.156	0.039
	(0.199)	(0.403)	(0.231)	(0.169)	(0.280)	(0.232)
Energy	0.112***	*0.056*	*0.110**	0.796	−1.568	1.915
	(0.035)	*(0.038)*	*(0.060)*	(0.715)	(1.822)	(1.652)
Metals	0.233	−0.229	0.454	*2.085*	1.441	*3.516*
	(0.378)	(0.421)	(1.043)	*(1.289)*	(1.419)	*(2.445)*
R US$	−0.168	0.095	−0.268	−0.049	0.052	−0.261
	(0.108)	(0.142)	(0.199)	(0.177)	(0.203)	(0.255)
Adjusted R^2	0.242	0.113	0.226	0.112	−0.037	0.296

Notes: The table summarizes the results of estimating (3b) using nominal exchange rate and commodity price data. See notes to Tables 3 and 6.

4.2. Nominal data

Some existing studies have used nominal effective exchange rates and nominal commodity price indexes to examine the commodity price effect; nominal rates are not uncommonly discussed in policymaking, forecasting, and financial markets.[19] We present our results based on nominal data in Table 7.[20]

---

[19] See, for example, Chaban (2009), Chen (2004), Chen, et al. (2010), Ferraro, et al. (2015), and Zhang, et al. (2016).

[20] The data on nominal commodity price indexes are constructed based on (1) but without the MUV normalization.

Compared with results based on real data, the Australian dollar and New Zealand dollar do not respond to the metals sector RCPI variable in all three time periods, and the Norwegian krone does not respond to the energy sector RCPI in the pre-GFC period but does respond to it in the post-GFC period. The Canadian dollar specification shows no change in the pattern of significant variables. The New Zealand dollar specification under the nominal data setting has neither significant sectoral RCPI nor US dollar variable in all three sample periods.

Overall, the use of nominal data instead of real data alters the inference on sectoral commodity price effects and yields weaker evidence of commodity price effects on exchange rates. Nevertheless, these nominal data display heterogeneous effects of commodity prices on exchange rates and of the US dollar.

4.3. Macroeconomic fundamentals

Third, we evaluate the effect of augmenting (3b) with macroeconomic fundamentals:

$$\Delta reer_{c,t} = \alpha + \Sigma_{i=commoditysector}\beta_i \Delta rcp_{i,t} + \delta \Delta reer_{us,t} + \Sigma_{i=macro}\gamma_i \Delta z_{i,t} + \varepsilon_t \tag{4}$$

where $z_{i,t}$ is i-th macro variable and γ_i is its coefficient. We consider variables from the monetary model, which is a common basis of studies comparing exchange rate models. Specifically, $\Delta z_{i,t}'$s include the rates of money supply growth, GDP growth, interest rate, and inflation.

The results of estimating (4) are summarized in Table 8. The row labeled "F test" presents the F test statistics for the null hypothesis of the coefficients on the macro variables are jointly zero. The four commodity currencies respond differently to these macro variables. For the three New Zealand dollar cases and for the Australian dollar and Norwegian krone specifications in the post-GFC period, the F test indicates that the macro variables are jointly significant. The Canadian dollar shows no significant response. The diverse response pattern confirms the finding that exchange rate models have differential performance across time periods and currencies (Cheung, et al., 2019; Rossi, 2013).

The presence of these macro variables has implications for the reported sectoral RCPI and the US dollar effects. Notably, depending on the currency and the sample period, the significance of the RCPIs and the US dollar REER variables can reverse in the presence of macro variables. The inclusion of these macro variables slightly favors the significant commodity price effect result in the post-GFC period.

Our results align with the observation that "incorporating commodity prices into standard monetary-type regressions only underscores the 'fickleness' of standard models in the literature, and provides little support for a commodity-price-augmented Dornbusch model" (Chen and Rogoff, 2003).[21] Furthermore, evidence remains regarding the "fickleness" of the effects of commodity prices and the US dollar.

4.4. The GFC period

The GFC was characterized by extreme conditions that imposed strains on normal economic interactions.[22] Table 9 presents results of incorporating the GFC period 2007Q3–2008Q4 into either the pre-GFC or the post-GFC period to illustrate the GFC effect. The inclusion of these six crisis period observations yields a noticeable increase in the model's explanatory power as measured by adjusted R^2 estimates; this is especially true for the pre-GFC case—the adjusted R^2 estimates of the Australian dollar, the Canadian dollar, and the Norwegian krone specifications increased to above 20 %, and the New Zealand dollar specification turned from negative to positive. This finding corroborates the common belief that asset prices, including exchange rates and commodity prices, exhibit strong comovement during market turmoil (Appendix A.5.v).

As indicated by the *italic* font in Table 9 that signifies a change in the classification of significance (compared with Tables 4 and 5), the inclusion of the six crisis period observations, at least from an empirical perspective, has modified the evidence on the commodity price effect.

The sensitivity to the duration of the sample period buttresses the difficulty of inferring the commodity price effect. Depending on the manner in which the crisis effect is accounted, the empirical commodity price effect may be altered.

4.5. Leading commodity export destination

The third-country exchange rate effect beyond the US dollar effect is not commonly addressed in the literature. The US dollar is included to control for its central roles in the global commodity and global foreign exchange markets. Some countries may, in practice, implicitly (soft-)peg to their major trading partners to alleviate exchange rate volatility, whereas some allow the market forces to take their course. Heller (1978) and Melvin (1985) have discussed the implications of major trading partners for exchange rate arrangement choices. To illustrate the possible trading partner effect, we consider the following:

$$\Delta reer_{c,t} = \alpha + \Sigma_{i=commoditysector}\beta_i \Delta rcp_{i,t} + \delta \Delta reer_{us,t} + \Sigma_{i=1,2}\lambda_i \Delta w_{i,t} + \varepsilon_t \tag{5}$$

---

[22] For instance, Cheung, et al. (2019) considered differential macro news effects in pre-GFC, GFC, and post-GFC periods.

Table 8
Sectoral Commodity Price Effects in the Presence of Macroeconomic Fundamentals.

	Australia			Canada		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	1.061**	0.337	−0.022	−0.800	−1.572	−0.165
	(0.493)	(0.549)	(1.025)	(0.788)	(1.017)	(0.947)
Energy	0.261	−0.296	0.009	0.657***	0.905**	0.467**
	(0.207)	(0.255)	(0.243)	(0.150)	(0.390)	(0.187)
Metals	0.210*	*0.610*	*0.277***	1.061**	1.415***	1.477**
	(0.115)	*(0.462)*	*(0.134)*	(0.515)	(0.419)	(0.625)
R US$	−0.177	0.304	−0.518*	−0.236	−0.179	*−0.257*
	(0.216)	(0.244)	(0.275)	(0.158)	(0.208)	*(0.181)*
F test	0.867	1.813	2.256*	1.022	1.243	1.688
Adjusted R^2	0.239	0.046	0.425	0.307	0.101	0.542
	Norway			New Zealand		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.527**	1.106***	0.346	0.158	0.082	−0.156
	(0.230)	(0.423)	(0.319)	(0.179)	(0.288)	(0.226)
Energy	0.195***	0.111**	*0.212****	0.570	−2.505	*2.185**
	(0.051)	(0.053)	*(0.079)*	(0.705)	(2.069)	*(1.264)*
Metals	0.396	−0.208	*2.026***	*2.123*	0.943	4.170**
	(0.384)	(0.459)	*(0.896)*	*(1.354)*	(1.551)	(2.061)
R US$	−0.029	0.177	−0.014	−0.054	0.053	−0.254
	(0.107)	(0.134)	(0.175)	(0.197)	(0.222)	(0.282)
F test	1.818	1.521	3.198**	2.031*	2.279*	2.141*
Adjusted R^2	0.253	0.142	0.322	0.126	−0.009	0.455

Notes: The table summarizes the results of estimating (4) that includes macro variables. The row labeled "F test" presents the F test statistics for the null hypothesis of the estimated coefficients on the macro variables are jointly zero. See the text for the list of macro variables and notes to Tables 3 and 6.

Table 9
Sensitivity to the Inclusion of the Crisis Period (1990Q2–2008Q4).

	Australia		Canada		Norway		New Zealand	
	1990Q2-2008Q4	2007Q3-2019Q4	1990Q2-2008Q4	2007Q3-2019Q4	1990Q2-2008Q4	2007Q3-2019Q4	1990Q2-2008Q4	2007Q3-2019Q4
Agriculture	0.782	*1.800**	−1.343	−0.077	0.900**	0.306	0.032	0.175
	(0.476)	*(1.045)*	(0.951)	(0.856)	(0.416)	(0.255)	(0.245)	(0.218)
Energy	*0.493**	0.196	0.758***	0.280*	0.141***	*0.131****	0.797	−0.402
	(0.263)	(0.184)	(0.251)	(0.167)	(0.051)	*(0.049)*	(0.742)	(0.705)
Metals	*0.341*	0.070	*0.694*	*0.713*	0.029	0.587	1.757	5.458***
	(0.380)	(0.116)	*(0.684)*	*(0.664)*	(0.496)	(0.631)	(1.407)	(1.665)
R US$	0.005	−0.671**	−0.192	−0.534**	0.025	−0.265	0.062	−0.270
	(0.315)	(0.277)	(0.222)	(0.240)	(0.151)	(0.163)	(0.212)	(0.243)
Adjusted R^2	0.214	0.554	0.220	0.505	0.249	0.429	0.028	0.403

Notes: The table summarizes the results of estimating (3b) for the augmented pre-GFC period (1990Q2–2008Q4) and the augmented post-GFC period (2007Q3–2019Q4). See notes to Tables 3 and 6.

where $\Delta w_{i,t}$ s are the changes in log REERs of the leading two commodity export markets. If the US is one of the leading two commodity export destinations, then $\Delta w_{i,t}$ contains only the REER of the other leading export destination. For Australia, Canada, Norway, and New Zealand, their leading two commodity export markets are Japan and China, the US and Japan, the Euro area[23] and the UK, and Australia and the US, respectively. With the exception of Canada, these are also the leading two trading partners of commodity-exporting countries. Canada's leading two trading partners are the US and China.[24]

Table 10 summarizes the results of estimating the augmented Equation (5). In general, (5) offers better explanatory power than (3b) in Tables 3–5—the adjusted R^2 estimates are all higher except for the pre-GFC Canadian dollar case.

There are two cases in which the effect of trading partners' exchange rates is positive—the euro REER on the Norwegian krone in the full and pre-GFC periods, and the Australian REER on the New Zealand dollar in all the three sample periods. The results can be attributed to the fact that the euro and the Australian dollar have each served as anchor currencies for the

---

[23] Regarding countries, the UK leads with the first position, and Germany, the Netherlands, and France occupy the second, third, and fourth positions, respectively.

[24] The correlation between the REER variables of the US and these trading partners is typically not large—only 4 of 18 estimates are larger than 0.5 (in absolute value), with the largest one being −0.601 between Australian and US REERs in the post-GFC period (Appendix A.5.iv).

Table 10
Currency Effects of the Leading Two Commodity Export Destinations.

	Australia			Canada		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.811**	0.385	0.306	−0.967	−1.312	−0.190
	(0.384)	(0.390)	(0.742)	(0.698)	(0.974)	(0.876)
Energy	0.141	−0.209	0.060	0.463***	0.912***	0.362**
	(0.136)	(0.230)	(0.217)	(0.165)	(0.348)	(0.170)
Metals	*0.162*	*0.510*	0.081	0.893*	*0.629*	1.411**
	(0.108)	*(0.440)*	(0.116)	(0.493)	*(0.543)*	(0.592)
Top market 1	−0.305***	−0.233*	−0.138			
	(0.107)	(0.133)	(0.110)			
Top market 2	−0.198***	−0.119**	−0.773***	−0.114**	−0.136**	−0.003
	(0.049)	(0.051)	(0.230)	(0.051)	(0.067)	(0.075)
R US$	−0.279	0.081	−0.432**	*−0.331***	−0.254	*−0.346*
	(0.201)	(0.294)	(0.210)	*(0.154)*	(0.202)	*(0.211)*
F test	9.138***	2.892*	6.564***	3.536**	2.229	1.346
Adjusted R^2	0.364	0.112	0.499	0.327	0.158	0.481
	Norway			New Zealand		
	Full	Pre-GFC	Post-GFC	Full	Pre-GFC	Post-GFC
Agriculture	0.457**	0.860**	0.194	0.188	0.068	0.170
	(0.215)	(0.420)	(0.201)	(0.152)	(0.178)	(0.250)
Energy	0.147***	0.127***	*0.121****	*−1.138***	−1.292	0.428
	(0.035)	(0.040)	*(0.046)*	*(0.570)*	(1.618)	(1.656)
Metals	0.499	−0.264	0.630	*0.503*	−0.071	*1.345*
	(0.410)	(0.430)	(0.807)	*(1.150)*	(1.321)	*(2.491)*
Top market 1	0.215**	0.358***	0.029	0.591***	0.568***	0.469***
	(0.092)	(0.095)	(0.101)	(0.085)	(0.099)	(0.181)
Top market 2	−0.069	0.067	−0.390***			
	(0.069)	(0.070)	(0.104)			
R US$	0.070	*0.428****	−0.227	−0.090	−0.057	−0.122
	(0.117)	*(0.133)*	(0.171)	(0.143)	(0.178)	(0.229)
F test	4.916***	7.268***	9.332***	24.435***	16.633***	3.358**
Adjusted R^2	0.284	0.259	0.434	0.373	0.248	0.433

Notes: The table summarizes the results of estimating (5) in the text. The row labeled “F test” presents the F test statistics for the null hypothesis of the coefficients on the REER changes of the leading two commodity export markets are jointly zero. For Australia, Canada, Norway, and New Zealand, the leading two commodity export markets are Japan and China, the US and Japan, the Euro area and the UK, and Australia and the US, respectively. See notes to Tables 3 and 6.

Norwegian krone and the New Zealand dollar, respectively (Ilzetzki, et al., 2019; Munro, 2004). The other trading partner currency effects, if statistically significant, are negative. Notably, the effects of trading partners’ exchange rates and the US dollar are not uniform across these commodity currencies and sample periods.

The presence of the exchange rates of trading partners alters the empirical sectoral RCPI effect. For example, the metals sector RCPI variable becomes insignificant for the Australian dollar (full and pre-GFC samples), Canadian dollar (pre-GFC sample), and the New Zealand dollar (full and post-GFC samples) regressions, whereas the energy sector RCPI variable is significant for the Norwegian krone (post-GFC sample) and the New Zealand dollar (pre-GFC sample, but with a negative sign) regressions.

Overall, these additional regressions indicate that the heterogeneous commodity price effects are unlikely due to our choices of time-varying weights and real series. Moreover, commodity price effects do not consistently enhance the performance of a monetary exchange rate model and display discernible dependence on crisis events and exchange rates of leading trading partners. These results question the applicability of a single commodity-price-based exchange rate model and policies that assume a stable commodity price effect.[25]

5. Concluding remarks

Using quarterly data on four commodity-exporting countries, we conducted an in-sample analysis of RCPI REERs. While REERs respond to RCPIs, the pattern of responses is country-specific, displays nonuniform sectoral commodity effects, and changes over time. The US dollar effect is not as strong as anticipated—it primarily emerges in certain cases in the post-GFC period. The heterogeneous RCPI effects are unlikely to be an artifact of the choices of time-varying weights and real data. The inclusion of commodity prices does not consistently improve the performance of a monetary exchange rate model. Further, the GFC and exchange rates of leading trading partners alter the empirical commodity price effect.

---

[25] We performed a few additional investigations that include a) the asymmetric commodity price effect, b) effect of the interacting US dollar and commodity price effects, and c) bounds test. Ultimately, these results are weak and insignificant, and they are made available upon request.

Compared with a mix of developed and developing countries, the four commodity-exporting countries considered in this paper are relatively homogenous, small, open, and developed economies. The differences between developed and developing countries do not play a significant role in generating these heterogeneous RCPI effects.

Our empirical results do not contradict the presence of commodity price effects. Instead, the results highlight the heterogeneity of these effects. Given the heterogeneous commodity price effect, one must be cautious about using a single commodity price model of exchange rate determination to explain diverse currencies across different time periods. The empirical heterogeneity is likely to attenuate the usefulness of a general commodity-price-based exchange rate model. The Balassa–Samuelson setup outlined in Appendix A.1 and discussed in Section 2, which indicates the possible roles of labor intensity, commodity productivity, and sectoral wage weights in determining the heterogeneous RCPI effect, thereby warrants further investigation.

For commodity-exporting countries, commodity price movements can have significant implications for their economies; the real exchange rate is a main conduit of commodity price effects on economic performance. Our empirical results provide a cautionary note regarding the indiscriminate use of empirical commodity price effect estimates in evaluating commodity price variability on the macro economy. Policymaking pertaining to commodity and exchange rate management would benefit from further detailed analysis on how commodity currencies respond to sectoral and even individual commodity prices under varying market conditions.

CRediT authorship contribution statement

Wenhao Wang: Software, Validation, Data curation, Visualization, Writing – original draft. **Yin-Wong Cheung:** Conceptualization, Methodology, Formal analysis, Supervision, Funding acquisition, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank Weshah Razzak and Dagfinn Rime, two anonymous referees and Menzie Chinn (The Editor) for their comments and suggestions. Cheung and Wang gratefully thank the Hung Hing Ying and Leung Hau Ling Charitable Foundation for its continuing support via the Hung Hing Ying Chair Professorship of International Economics. Wang would like to acknowledge the financial support from National Natural Science Foundation of China (No. 72273073).

Appendix

A.1. A modified exchange rate model of Patel, et al. (2019)

The discussion below is based on the Global Value Chains REER model proposed by Patel, et al. (2019). The model has two countries: the home country and the foreign country.

On production, the home country produces nontradable final goods and a group of commodities. The foreign country produces nontradable and tradable final goods. The final goods are produced with two inputs: labor and commodities. First order conditions of production that incorporate the Balassa–Samuelson effect yield the relationship between the price of final goods (nontradable or tradable goods) and that of commodities.

On consumption, the home country consumes the nontradable and tradable final goods imported from the foreign country. The foreign country consumes the nontradable and tradable final goods. First order conditions identify the proportions of nontradable and tradable goods in each country that are used to construct the home country and foreign country price indexes.

Some specifics of the setup are outlined below.

A.1.1. Production

The home country production function of the i-th commodity (i = 1, 2, 3…, m) is as follows:

$$Q_{ci} = A_{ci}\beta_i L_{ci}$$

where Q_{ci} is the i-th commodity output, A_{ci} is the productivity, L_{ci} is the labor input, and $0 < \beta_i < 1$ is the labor intensity in commodity production.

The production function of nontradable final goods is as follows:

$$Q_N = A_N[(L_N)^{\frac{\sigma_N - 1}{\sigma_N}} + (COM_N)^{\frac{\sigma_N - 1}{\sigma_N}}]^{\frac{\sigma_N}{\sigma_N - 1}}$$

where Q_N is the output of non-tradable final goods, A_N is its productivity, L_N is the labor input, COM_N is the aggregate commodity input, and σ_N is the elasticity of substitution between labor and commodity.

The aggregate commodity input is as follows:

$$COM_N = [\Sigma_i (C_{Ni})^{\frac{\sigma_{Nc}-1}{\sigma_{Nc}}}]^{\frac{\sigma_{Nc}}{\sigma_{Nc}-1}}$$

where C_{Ni} is the i-th commodity input and σ_{Nc} is the elasticity of substitution among commodities.

The foreign country production function of the nontradable final goods is as follows:

$$Q_N^* = A_N^*[(L_N^*)^{\frac{\sigma_N^*-1}{\sigma_N^*}} + (COM_N^*)^{\frac{\sigma_N^*-1}{\sigma_N^*}}]^{\frac{\sigma_N^*}{\sigma_N^*-1}}$$

$$COM_N^* = [\Sigma_i (C_{Ni}^*)^{\frac{\sigma_{Nc}^*-1}{\sigma_{Nc}^*}}]^{\frac{\sigma_{Nc}^*}{\sigma_{Nc}^*-1}}$$

where "*" indicates parameters and variables of the foreign country.

The production function of tradable final goods is as follows:

$$Q_T^* = A_T^*[(L_T^*)^{\frac{\sigma_T^*-1}{\sigma_T^*}} + (COM_T^*)^{\frac{\sigma_T^*-1}{\sigma_T^*}}]^{\frac{\sigma_T^*}{\sigma_T^*-1}}$$

$$COM_T^* = [\Sigma_i (C_{Ti}^*)^{\frac{\sigma_{Tc}^*-1}{\sigma_{Tc}^*}}]^{\frac{\sigma_{Tc}^*}{\sigma_{Tc}^*-1}}$$

where the subscript "T" indicates "tradable" goods.

A.1.3. Consumption

The home country consumption function is as follows:

$$F = [(Q_N)^{\frac{\theta-1}{\theta}} + (\kappa Q_T^*)^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}$$

where Q_N is the home nontradable final goods, Q_T^* is the foreign tradable final goods, κ is the share of tradable final goods imported by the home country, and θ is the elasticity of substitution between nontradable final goods and imported final goods.

The foreign country consumption function is as follows:

$$F^* = \{(Q_N^*)^{\frac{\theta^*-1}{\theta^*}} + [(1-\kappa)Q_T^*]^{\frac{\theta^*-1}{\theta^*}}\}^{\frac{\theta^*}{\theta^*-1}}$$

where the "*" indicates the foreign country parameters and inputs.

A.1.3. First order conditions of productions

In the home country, the first order conditions of commodity production are as follows:

$$\frac{\mathrm{d}(P_{ci}Q_{ci} - w_{ci}L_{ci})}{\mathrm{d}(L_{ci})} = P_{ci}A_{ci}\beta_i - w_{ci} = 0 \Rightarrow P_{ci}A_{ci}\beta_i = w_{ci}$$

where P_{ci} is the price of the i-th commodity and w_{ci} is the labor wage rate prevailing in the i-th commodity sector.

The first order conditions of nontradable final goods are as follows:

$$\frac{\mathrm{d}(P_NQ_N - w_NL_N - \Sigma_iP_{ci}C_{Ni})}{\mathrm{d}(L_N)} = P_NA_N(Q_N/A_N)^{1/\sigma_N}(L_N)^{-1/\sigma_N} - w_N = 0$$

$$\Rightarrow P_N = w_N(L_N)^{1/\sigma_N}[A_N(Q_N/A_N)^{1/\sigma_N}]^{-1}$$

$$\frac{\mathrm{d}(P_NQ_N - w_NL_N - \Sigma_iP_{ci}C_{Ni})}{\mathrm{d}(C_{Ni})} = \frac{\mathrm{d}(P_NQ_N)}{\mathrm{d}(COM_N)}\frac{\mathrm{d}(COM_N)}{\mathrm{d}(C_{Ni})} - \frac{\mathrm{d}(\Sigma_iP_{ci}C_{Ni})}{\mathrm{d}(C_{Ni})}$$

$$= P_NA_N(Q_N/A_N)^{1/\sigma_N}(COM_N)^{\frac{\sigma_N-\sigma_{Nc}}{\sigma_{Nc}\sigma_N}}(C_{Ni})^{-1/\sigma_{Nc}} - P_{ci} = 0$$

$$\Rightarrow P_N = P_{ci}(COM_N)^{\frac{\sigma_{Nc}-\sigma_N}{\sigma_{Nc}\sigma_N}}(C_{Ni})^{1/\sigma_{Nc}}[A_N(Q_N/A_N)^{1/\sigma_N}]^{-1}$$

Assuming the labor moves freely across sectors and wage rates of workers in commodity and nontradable sectors are the same. That is,

$$w_N = w_{ci} = \Sigma\tau_iw_{ci}$$

where τ_i is the sectoral wage weight of the i-th commodity and$\Sigma\tau_i = 1$. A possible way to specify τ_i is$\tau_i = C_{Ni}/\Sigma_iC_{Ni}$, which is the ratio of the i-th commodity input to the total commodity input in producing nontradable products.

Similarly, in the foreign country, the first order conditions of nontradable and tradable goods production are as follows:

$$\frac{\mathrm{d}(P_N^*Q_N^*-w_N^*L_N^*-\Sigma_iP_{ci}^*C_{Ni}^*)}{\mathrm{d}(L_N^*)}=P_N^*A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}(L_N^*)^{-1/\sigma_N^*}-w_N^*=0$$

$$\Rightarrow P_N^*=w_N^*(L_N^*)^{1/\sigma_N^*}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]^{-1}$$

$$\frac{\mathrm{d}(P_N^*Q_N^*-w_N^*L_N^*-\Sigma_iP_{ci}^*C_{Ni}^*)}{\mathrm{d}(C_{Ni}^*)}=\frac{\mathrm{d}(P_N^*Q_N^*)}{\mathrm{d}(COM_N^*)}\frac{\mathrm{d}(COM_N^*)}{\mathrm{d}(C_{Ni}^*)}-\frac{\mathrm{d}(\Sigma_iP_{ci}^*C_{Ni}^*)}{\mathrm{d}(C_{Ni}^*)}$$

$$=P_N^*A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}(COM_N^*)^{\frac{\sigma_N^*-\sigma_{Nc}^*}{\sigma_{Nc}^*\sigma_N^*}}(C_{Ni}^*)^{-1/\sigma_{Nc}^*}-P_{ci}^*=0$$

$$\Rightarrow P_N^*=P_{ci}^*(COM_N^*)^{\frac{\sigma_{Nc}^*-\sigma_N^*}{\sigma_{Nc}^*\sigma_N^*}}(C_{Ni}^*)^{1/\sigma_{Nc}^*}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]^{-1}$$

where P_{ci}^* is the foreign country price of the *i*-th commodity. Assuming the Law of One Price,$P_{ci}=eP_{ci}^*$, where e is the nominal exchange rate.

$$\frac{\mathrm{d}(P_T^*Q_T^*-w_T^*L_T^*-\Sigma_iP_{ci}^*C_{Ti}^*)}{\mathrm{d}(L_T^*)}=P_T^*A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}v_L^{1/\sigma_T^*}(L_T^*)^{-1/\sigma_T^*}-w_T^*=0$$

$$\Rightarrow P_T^*=w_T^*(L_T^*)^{1/\sigma_T^*}[A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}]^{-1}$$

$$\frac{\mathrm{d}(P_T^*Q_T^*-w_T^*L_T^*-\Sigma_iP_{ci}^*C_{Ti}^*)}{\mathrm{d}(C_{Ti}^*)}=\frac{\mathrm{d}(P_T^*Q_T^*)}{\mathrm{d}(COM_T^*)}\frac{\mathrm{d}(COM_T^*)}{\mathrm{d}(C_{Ti}^*)}-\frac{\mathrm{d}(\Sigma_iP_{ci}^*C_{Ti}^*)}{\mathrm{d}(C_{Ti}^*)}$$

$$=P_T^*A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}(COM_T^*)^{\frac{\sigma_T^*-\sigma_{Tc}^*}{\sigma_{Tc}^*\sigma_T^*}}(C_{Ti}^*)^{-1/\sigma_{Tc}^*}-P_{ci}^*=0$$

$$\Rightarrow P_T^*=P_{ci}^*(COM_T^*)^{\frac{\sigma_{Tc}^*-\sigma_T^*}{\sigma_{Tc}^*\sigma_T^*}}(C_{Ti}^*)^{1/\sigma_{Tc}^*}[A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}]^{-1}$$

A.1.4. First order conditions of consumptions

In the home country, the first order conditions of consumption are as follows:

$$\frac{\mathrm{d}(F-P_NQ_N-P_T\kappa Q_T^*)}{\mathrm{d}(Q_N)}=F^{\frac{1}{\theta}}(Q_N)^{-\frac{1}{\theta}}-P_N=0\Rightarrow Q_N=P_N^{-\theta}F$$

$$\frac{\mathrm{d}(F-P_NQ_N-P_T\kappa Q_T^*)}{\mathrm{d}(\kappa Q_T^*)}=F^{\frac{1}{\theta}}(\kappa Q_T^*)^{-\frac{1}{\theta}}-P_T=0\Rightarrow \kappa Q_T^*=P_T^{-\theta}F$$

In the foreign country, the first order conditions of consumption are as follows:

$$\frac{\mathrm{d}[F^*-P_N^*Q_N^*-P_T^*(1-\kappa)Q_T^*]}{\mathrm{d}(Q_N^*)}=(F^*)^{\frac{1}{\theta^*}}(Q_N^*)^{-\frac{1}{\theta^*}}-P_N^*=0\Rightarrow Q_N^*=(P_N^*)^{-\theta^*}F^*$$

$$\frac{\mathrm{d}[F^*-P_N^*Q_N^*-P_T^*(1-\kappa)Q_T^*]}{\mathrm{d}\left[(1-\kappa)Q_T^*\right]}=(F^*)^{\frac{1}{\theta^*}}\left[(1-\kappa)Q_T^*\right]^{\frac{1}{\theta^*}}-P_T^*=0$$

$$\Rightarrow (1-\kappa)Q_T^*=(P_T^*)^{-\theta^*}F^*$$

A.1.5. The price index in home and foreign country

The home and foreign country price indexes are as follows:

$$P=P_N\frac{Q_N}{F}+P_T\frac{\kappa Q_T^*}{F}=P_N^{1-\theta}+P_T^{1-\theta}$$

and.

$$P^*=P_N^*\frac{Q_N^*}{F^*}+P_T^*\frac{(1-\kappa)Q_T^*}{F^*}=(P_N^*)^{1-\theta^*}+(P_T^*)^{1-\theta^*}$$

According to Equations (A.1.10), (A.1.11), and (A.1.13), it can be shown that.

$$P_N=\Sigma\tau_iP_{ci}A_{ci}\beta_i(L_N)^{1/\sigma_N}[A_N(Q_N/A_N)^{1/\sigma_N}]^{-1}$$

and the nontradable price can be determined assuming labor mobility and the commodity prices are exogenous. From (A.1.14) and (A.1.16),

$$P_T^* = P_N^*(L_T^*)^{1/\sigma_T^*}(L_N^*)^{-1/\sigma_N^*}[A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}]^{-1}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]$$

Assume$\gamma_{TN}^* = \{(L_T^*)^{1/\sigma_T^*}(L_N^*)^{-1/\sigma_N^*}[A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}]^{-1}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]\}^{1-\theta^*}$.
Then, the real exchange rate given by the home-to-foreign price ratio is as follows:

$$\frac{P}{eP^*} = \frac{1}{e}\frac{P_N^{1-\theta}+P_T^{1-\theta}}{(P_N^*)^{1-\theta^*}+(P_T^*)^{1-\theta^*}} = \frac{1}{e(1+\gamma_{TN}^*)}\frac{P_N^{1-\theta}+(eP_T^*)_T^{1-\theta}}{(P_N^*)^{1-\theta^*}}$$
$$= \frac{1}{e(1+\gamma_{TN}^*)}[\frac{P_N^{1-\theta}}{(P_N^*)^{1-\theta^*}} + \lambda(P_N^*)^{\theta^*-\theta}]$$

$$\lambda = \{e(L_T^*)^{1/\sigma_T^*}(L_N^*)^{-1/\sigma_N^*}[A_T^*(Q_T^*/A_T^*)^{1/\sigma_T^*}]^{-1}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]\}^{1-\theta}$$

For simplicity, if we assume the preferences in two countries are the same; that is, the home and foreign country elasticities of substitution between nontradable and tradable final goods are same ($\theta = \theta^*$), then the second term in the square brackets in Equation (A.1.26) drops out.

OnP_N^*, from (A.1.15) and assume $\Sigma\tau_i^* = 1$ (and $\tau_i^* = C_{Ni}^*/\Sigma_i C_{Ni}^*$), we have:

$$P_N^* = \Sigma\tau_i^* P_{ci}^*(COM_N^*)^{\frac{\sigma_{Nc}^*-\sigma_N^*}{\sigma_{Nc}^*\sigma_N^*}}(C_{Ni}^*)^{1/\sigma_{Nc}^*}[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}]^{-1}$$

Then,

$$\frac{P_N^{1-\theta}}{(P_N^*)^{1-\theta^*}} = \eta\frac{(\Sigma\tau_i P_{ci} A_{ci}\beta_i)^{1-\theta}}{(\Sigma\tau_i^* P_{ci})^{1-\theta^*}}$$

where$\eta = \frac{\left\{(L_N)^{1/\sigma_N}\left[A_N(Q_N/A_N)^{1/\sigma_N}\right]^{-1}\right\}^{1-\theta}}{\left\{e^{-1}\left(COM_N^*\right)^{\frac{\sigma_{Nc}^*-\sigma_N^*}{\sigma_{Nc}^*\sigma_N^*}}\left(C_{Ni}^*\right)^{1/\sigma_{Nc}^*}\left[A_N^*(Q_N^*/A_N^*)^{1/\sigma_N^*}\right]^{-1}\right\}^{1-\theta^*}}$,

and is not related to commodity prices. Thus, (A.1.26), (A.1.27), and (A.1.28) imply that the real exchange rate depends onτ_i,τ_i^*, β_i θ and. It could be shown that commodity prices positively affect the nontradable price ratio if greater than 0$A_{ci}\beta_i - \frac{\Sigma\tau_i P_{ci} A_{ci}\beta_i}{\Sigma\tau_i^* P_{ci}}\frac{\tau_i^*}{\tau_i}$. That is, the commodity price effect depends on the labor intensity (β_i), commodity productivity (A_{ci}), and the relative ratio between cross-country sectoral wage weights (τ_i and τ_i^*). Note that these terms can change over time, which makes the effect time-varying.

Note that we do not work with a full-blown model, which would require additional assumptions on the market clearing conditions, trade balance, and budget constraints, among others. However, for the purpose of illustrating the factors affecting the commodity price effect, we do not have to solve the model completely.

A.2. Measures of Openness, and global FX average daily turnover ratios

	Openness I: Total Trade/GDP (%)	Openness II: Export/GDP (%)	Ranking of Global FX Turnover	Daily Turnover/ GDP (%)	Daily Turnover/ Total Trade (%)
Australia	*34.75*	*18.10*	*5th*	*31.31*	*90.11*
Canada	*54.71*	*26.18*	*6th*	*19.51*	*35.66*
New Zealand	*40.94*	*19.77*	*10th*	*66.84*	*163.27*
Norway	*49.11*	*28.24*	*14th*	*27.65*	*56.30*

Notes: The table lists two openness measures (total trade/GDP and exports/GDP), rankings of global FX average daily turnover, daily turnover to GDP ratios, and daily turnover to international trade ratios. Data on FX turnover are from BIS (2019) and data on GDP and international trade volume are from IFS and IMF DOTS, respectively.

A.3. List of individual commodities/ce:section-title>

Agriculture			Energy	Metals
Apple	Legumes	Soya Bean Oil	Coal	Aluminum
Banana	Milk	Soybeans	Crude Oil	Cobalt
Barley	Natural Rubber	Sugar	Natural Gas	Copper
Beef	Oats	Sunflower Seed Oil		Gold
Cocoa	Olive Oil	Swine Meat		Iron Ore
Coffee	Oranges	Tea		Lead
Corn	Palm Kernel Oil	Timber		Molybdenum
Cotton	Palm Oil	Tobacco		Nickel
Fish	Plywood	Tomatoes		Palladium
Groundnuts	Poultry	Wheat		Platinum
Groundnuts Oil	Rapeseed Oil	Wood Pulp		Silver
Hides	Rice	Wool		Tin
Lamb	Shrimp			Zinc

Notes: The classification is based on IMF Primary Commodity Price database and the World Bank Commodities Price data. Copra is not included due to the lack of data.*A.4. Data*

Here is a summary of the data sources:

a. Consumer price index-based real and nominal effective exchange rates are from IFS database.

b. Commodity prices are from the IMF Primary Commodity Price database and the World Bank Commodities Price data.

c. Manufactured exports unit value index is from the Bloomberg.

d. Commodity export values are from the UN Comtrade database.

e. Nominal GDP data are from IFS, money supply (M3, M1 for New Zealand) and CPI inflation data are from the OECD Main Economic Indicators database, and interest rates (euro-currency deposit rates) are from DataStream.

A.5. Correlations and graphs

A.5.1. Full sample

		REER	Aggregate	Agriculture	Energy	Metals
Australia	Aggregate	0.467				
	Agriculture	0.394	0.522			
	Energy	0.378	0.807	0.351		
	Metals	0.338	0.844	0.296	0.407	
	R US$	−0.332	−0.448	−0.315	−0.347	−0.335
Canada	Aggregate	0.524				
	Agriculture	0.249	0.680			
	Energy	0.500	0.939	0.485		
	Metals	0.440	0.748	0.532	0.521	
	R US$	−0.401	−0.594	−0.579	−0.480	−0.490
Norway	Aggregate	0.485				
	Agriculture	0.308	0.333			
	Energy	0.455	0.987	0.200		
	Metals	0.296	0.515	0.258	0.429	
	R US$	−0.323	−0.477	−0.378	−0.428	−0.388
New Zealand	Aggregate	0.317				
	Agriculture	0.246	0.960			
	Energy	0.312	0.652	0.438		
	Metals	0.338	0.572	0.380	0.583	
	R US$	−0.248	−0.534	−0.430	−0.536	−0.447

A.5.2. Pre-Crisis period (1990Q2-2007Q2)

		REER	Aggregate	Agriculture	Energy	Metals
Australia	Aggregate	0.169				
	Agriculture	0.170	0.602			
	Energy	−0.013	0.720	0.197		
	Metals	0.236	0.798	0.304	0.308	
	R US$	0.090	−0.261	−0.015	−0.117	−0.309
Canada	Aggregate	0.249				
	Agriculture	−0.104	0.609			
	Energy	0.324	0.839	0.200		
	Metals	0.205	0.669	0.367	0.305	
	R US$	−0.101	−0.348	−0.409	−0.160	−0.267
Norway	Aggregate	0.317				
	Agriculture	0.362	0.439			
	Energy	0.290	0.988	0.319		
	Metals	0.065	0.403	0.260	0.309	
	R US$	−0.056	−0.311	−0.494	−0.254	−0.197
New Zealand	Aggregate	0.011				
	Agriculture	0.002	0.974			
	Energy	−0.056	0.468	0.320		
	Metals	0.088	0.393	0.204	0.363	
	R US$	0.030	−0.296	−0.246	−0.279	−0.214

A.5.3. Post-Crisis period (2009Q1-2019Q4)

		REER	Aggregate	Agriculture	Energy	Metals
Australia	Aggregate	0.467				
	Agriculture	0.537	0.497			
	Energy	0.256	0.730	0.350		
	Metals	0.401	0.908	0.340	0.398	
	R US$	−0.601	−0.430	−0.715	−0.206	−0.356
Canada	Aggregate	0.676				
	Agriculture	0.465	0.651			
	Energy	0.570	0.935	0.473		
	Metals	0.640	0.725	0.510	0.467	
	R US$	−0.635	−0.690	−0.668	−0.520	−0.661
Norway	Aggregate	0.449				
	Agriculture	0.200	0.185			
	Energy	0.402	0.979	−0.007		
	Metals	0.449	0.570	0.223	0.481	
	R US$	−0.396	−0.456	−0.222	−0.388	−0.641
New Zealand	Aggregate	0.484				
	Agriculture	0.406	0.984			
	Energy	0.548	0.647	0.524		
	Metals	0.582	0.643	0.522	0.639	
	R US$	−0.540	−0.644	−0.560	−0.642	−0.688

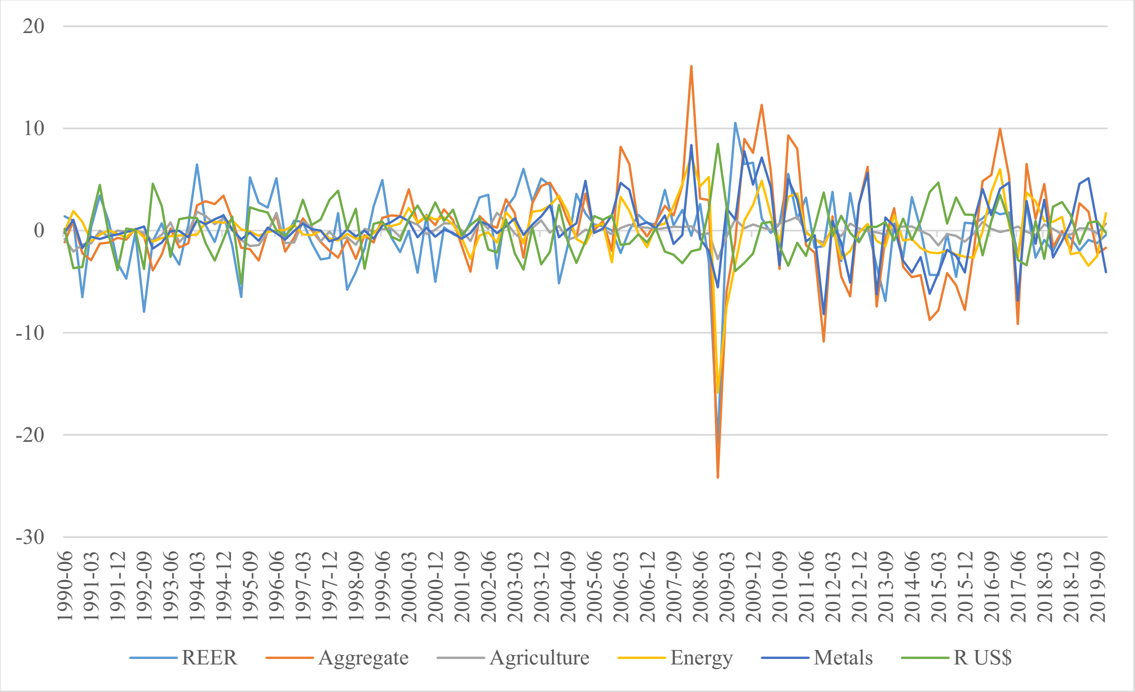
A.5.4. Correlations between changes of log US REER and of log REER of the top two commodity export destinations

		Australia	Canada	Norway	New Zealand
Full Period	Top market 1	−0.104	–	−0.510	−0.332
	Top market 2	0.318	−0.104	−0.131	–
Pre-Crisis	Top market 1	−0.425	–	−0.595	0.090
	Top market 2	0.271	−0.425	−0.050	–
Post-Crisis	Top market 1	0.014	–	−0.317	−0.601
	Top market 2	0.467	0.014	−0.138	–

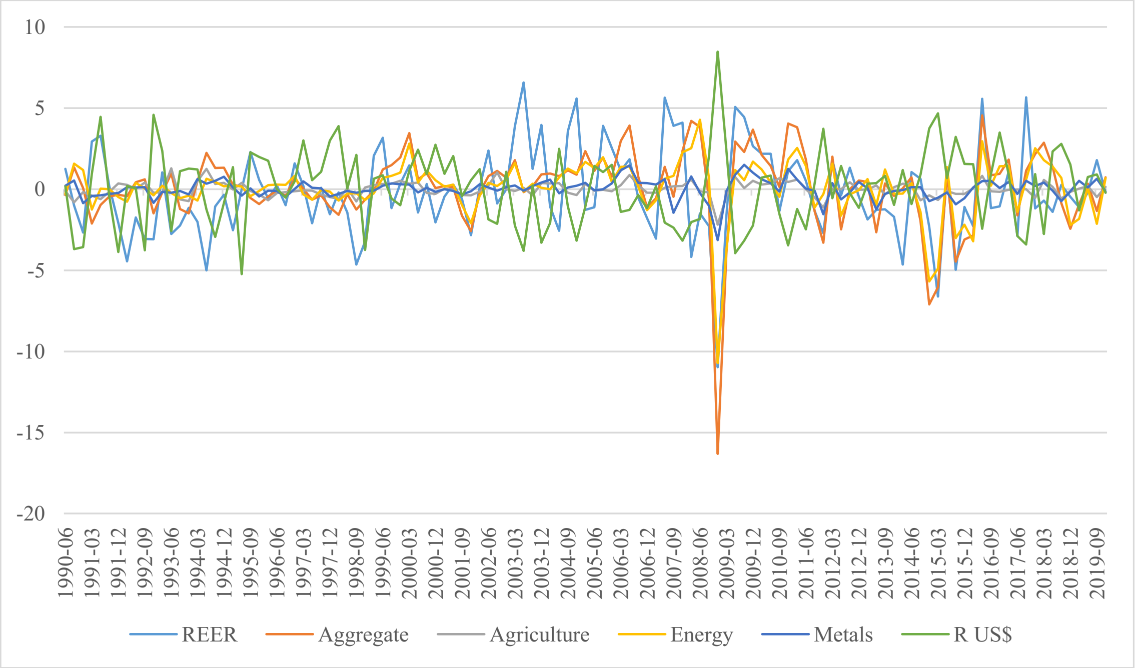
Notes: For Australia, Canada, Norway, and New Zealand, their top two commodity export markets are, respectively, Japan and China, the US and Japan, the Euro area and the UK, and Australia and the US.

A.5.5. Graphs of changes in REERs and RCPIs

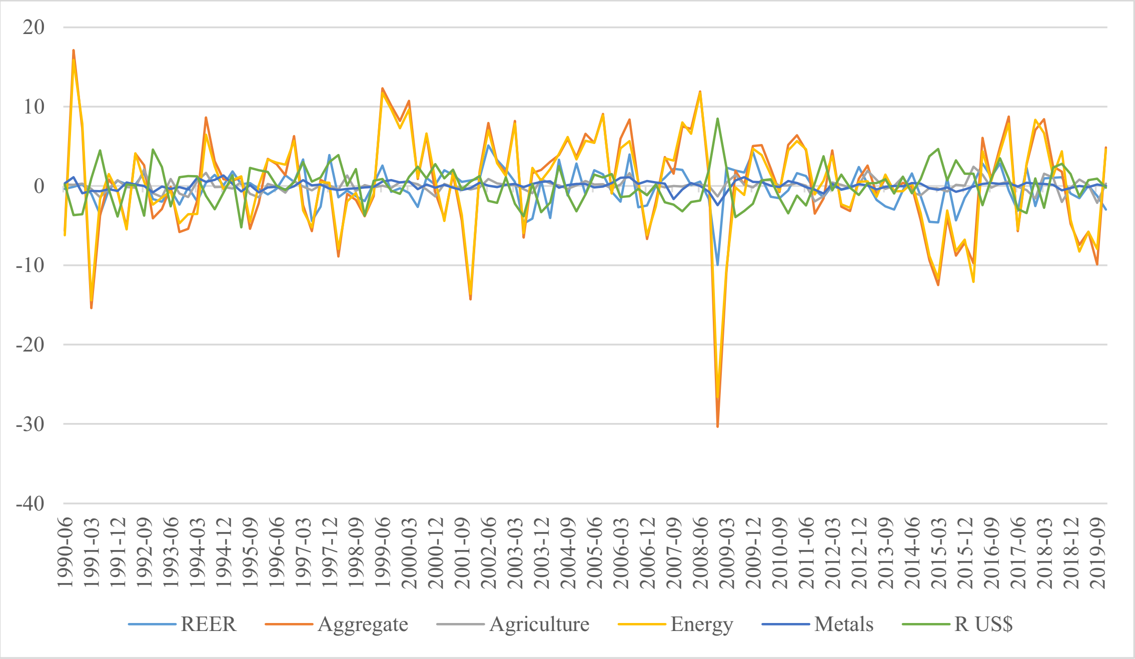
Australia.



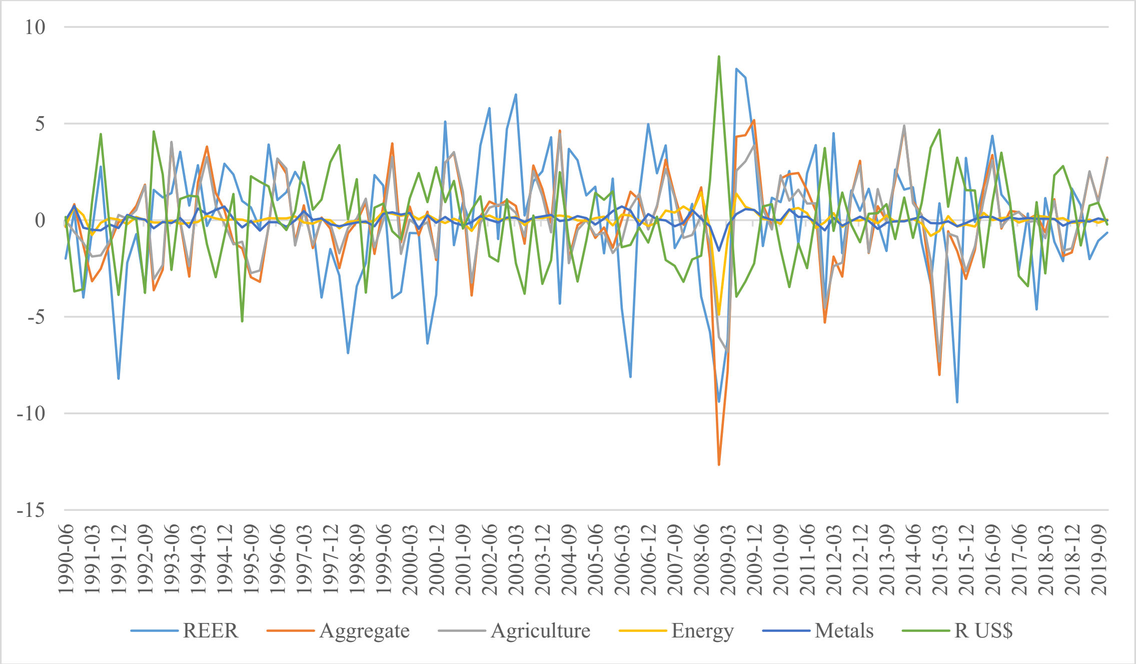
Canada.



Norway.



New Zealand.



.

References

Adams, Z., Glück, T., 2015. Financialization in commodity markets: A passing trend or the new normal? J. Bank. Finance 60, 93–111.
Ayres, J., Hevia, C., Nicolini, J.P., 2020. Real exchange rates and primary commodity prices. J. Int. Econ. 122, 103261.
Baker, S.D., 2021. The financialization of storable commodities. Manage. Sci. 67 (1), 471–499.
Balassa, B., 1964. The purchasing-power parity doctrine: a reappraisal. J. Polit. Econ. 72 (6), 584–596.
Bank for International Settlements. Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2019, Bank for International Settlements: Basel (2019).
Basak, S., Pavlova, A., 2016. A model of financialization of commodities. The Journal of Finance 71 (4), 1511–1556.
Bodart, V., Candelon, B., Carpantier, J.-F., 2012. Real exchanges rates in commodity producing countries: A reappraisal. Journal of International Money and Finance 31 (6), 1482–1502.
Bodart, V., Candelon, B., Carpantier, J.-F., 2015. Real exchanges rates, commodity prices and structural factors in developing countries. Journal of International Money and Finance 51, 264–284.
Byrne, J.P., Ibrahim, B.M., Sakemoto, R., 2019. Carry trades and commodity risk factors. Journal of International Money and Finance 96, 121–129.
Cardi, O., Restout, R., 2015. Imperfect mobility of labor across sectors: a reappraisal of the Balassa-Samuelson effect. Journal of International Economics 97 (2), 249–265.
Cashin, P., Céspedes, L.F., Sahay, R., 2004. Commodity currencies and the real exchange rate. J. Dev. Econ. 75 (1), 239–268.
Chaban, M., 2009. Commodity currencies and equity flows. Journal of International Money and Finance 28 (5), 836–852.
Chen, Y.-C., 2004. Exchange rates and fundamentals: evidence from commodity economies. Harvard University, Mimeograph.
Chen, Y.-C., Lee, D., 2018. Market power, inflation targeting, and commodity currencies. Journal of International Money and Finance 88, 122–139.
Chen, Y.-C., Rogoff, K., 2003. Commodity currencies. Journal of International Economics 60 (1), 133–160.
Chen, Y.-C., Rogoff, K.S., Rossi, B., 2010. Can exchange rates forecast commodity prices? Q. J. Econ. 125 (3), 1145–1194.
Cheung, Y.-W., Chinn, M.D., Pascual, A.G., 2005. Empirical exchange rate models of the nineties: Are any fit to survive? Journal of international money and finance 24 (7), 1150–1175.
Cheung, Y.-W., Chinn, M.D., Pascual, A.G., Zhang, Y.i., 2019. Exchange rate prediction redux: new models, new data, new currencies. Journal of International Money and Finance 95, 332–362.
Cheung, Y.-W., Fujii, E., 2014. The Penn Effect within a Country – Evidence from Japan, with Eiji Fujii. Oxford Economic Papers 66 (4), 1070–1089.
Chinn, M.D., 2006. A primer on real effective exchange rates: determinants, overvaluation, trade flows and competitive devaluation. Open Economies Review 17 (1), 115–143.
Clements, K.W., Fry, R., 2008. Commodity currencies and currency commodities. Resour. Policy 33 (2), 55–73.
Collier, P., Goderis, B., 2012. Commodity prices and growth: An empirical investigation. European Economic Review 56 (6), 1241–1260.
Coudert, V., Couharde, C., Mignon, V., 2015. On the impact of volatility on the real exchange rate–terms of trade nexus: Revisiting commodity currencies. Journal of International Money and Finance 58, 110–127.
Égert, B., Drine, I., Lommatzsch, K., Rault, C., 2003. The Balassa-Samuelson effect in Central and Eastern Europe: myth or reality? Journal of comparative Economics 31 (3), 552–572.
Engel, C., Lee, D., Liu, C., Liu, C., Wu, S.P.Y., 2019. The uncovered interest parity puzzle, exchange rate forecasting, and Taylor rules. Journal of International Money and Finance 95, 317–331.

Ferraro, D., Rogoff, K., Rossi, B., 2015. Can oil prices forecast exchange rates? An empirical analysis of the relationship between commodity prices and exchange rates. Journal of International Money and Finance 54, 116–141.

Frankel, Jeffrey A. The natural resource curse: a survey. No. w15836. National Bureau of Economic Research, 2010.

Gopinath, G., Boz, E., Casas, C., Díez, F.J., Gourinchas, P.-O., Plagborg-Møller, M., 2020. Dominant currency paradigm. American Economic Review 110 (3), 677–719.

Gruss, B., Kebhaj, S., 2019. Commodity terms of trade: a new database. International Monetary Fund.

Hassan, F., 2016. The price of development: The Penn–Balassa–Samuelson effect revisited. Journal of International Economics 102, 291–309.

Heller, H.R., 1978. Determinants of exchange rate practices. Journal of Money, Credit and Banking 10 (3), 308–321.

Henderson, B.J., Pearson, N.D., Wang, L.i., 2015. New evidence on the financialization of commodity markets. The Review of Financial Studies 28 (5), 1285–1311.

Ilzetzki, E., Reinhart, C.M., Rogoff, K.S., 2019. Exchange arrangements entering the twenty-first century: Which anchor will hold? Q. J. Econ. 134 (2), 599–646.

Lothian, J.R., Taylor, M.P., 2008. Real exchange rates over the past two centuries: how important is the Harrod-Balassa-Samuelson effect? Econ. J. 118 (532), 1742–1763.

Meese, Richard, and Kenneth Rogoff. ‘‘The out-of-sample failure of empirical exchange rate models: Sampling error or misspecification?, in ‘‘Exchange Rates and International Macroeconomics”.” J. Frenkel. Chicago: University of Chicago Press (1983b).

Meese, R.A., Rogoff, K., 1983a. Empirical exchange rate models of the seventies: Do they fit out of sample? Journal of International Economics 14 (1-2), 3–24.

Melvin, M., 1985. The choice of an exchange rate system and macroeconomic stability. Journal of Money, Credit and Banking 17 (4), 467–478.

Munro, A., 2004. What drives the New Zealand dollar? The Reserve Bank of New Zealand Bulletin 67 (2), 21.

Ordu, B.M., Oran, A., Soytas, U., 2018. Is food financialized? Yes, but only when liquidity is abundant. J. Bank. Finance 95, 82–96.

Patel, N., Wang, Z., Wei, S.-J., 2019. Global Value Chains and Effective Exchange Rates at the Country-Sector Level. Journal of Money, Credit and Banking 51, 7–42.

Ready, R., Roussanov, N., Ward, C., 2017a. After the tide: Commodity currencies and global trade. Journal of Monetary Economics 85, 69–86.

Ready, R., Roussanov, N., Ward, C., 2017b. Commodity trade and the carry trade: A tale of two countries. The Journal of Finance 72 (6), 2629–2684.

Rossi, B., 2013. Exchange rate predictability. Journal of Economic Literature 51 (4), 1063–1119.

Wang, W., Xue, J., Chonghua, D.u., 2016. The Balassa-Samuelson hypothesis in the developed and developing countries revisited. Economics Letters 146, 33–38.

Zhang, H.J., Dufour, J.-M., Galbraith, J.W., 2016. Exchange rates and commodity prices: Measuring causality at multiple horizons. Journal of Empirical Finance 36, 100–120.