The Fluctuation Factors of Commodity Currencies: Exporting Resource Countries vs. Importing Resource Countries*

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Abstracts

This paper focuses on Australian and Canadian commodity currencies and discusses an empirical analysis of their operation as a carry trade. The objective of the empirical analysis was to identify the correlation between the yield spread between the Australian 10-year government bond (or Canadian 10-year government bond) and the Japanese 10-year government bond and the related commodity markets from 2012 to 2022 using autoregressive distributed lags. The estimation results show that both of the two types of yield spreads are statistically significantly negative correlated with gold futures. In Canada-Japan, the correlation was also statistically significant positive with energy resource (crude oil and natural gas) and major mineral (iron ore and copper) futures, providing evidence that could suggest the possibility of risk management using the relevant commodity markets. On the other hand, there were some variables for which the Australia-Japan results differed from the Canada-Japan estimates or were not statistically significant. This suggests that the related commodities, especially natural gas, coal, and iron ore, with the exception of gold futures, are not suitable for risk management of the Australia-Japan yield spread.

Keywords: Commodity currency, Carry trade, Autoregressive distributed lag model

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1. Introduction

Today, as the world economy is slowly recovering from the impact of Covid-19, most countries, including the United States and Europe, are working hard to return to pre-Covid-19 conditions. Obviously, the revitalization of economic activity requires the revitalization of all sectors, including the manufacturing industry. In parallel, the recent shift to high-tech has led to increased demand for semiconductors and the start of infrastructure projects such as high-speed telecommunications networks, which are expected to increase demand for commodity markets such as copper, iron ore, and palladium, which are considered to be the backbone of such infrastructure projects. The same applies not only to the metal commodity market, but also to the crude oil and natural gas markets needed for transportation and energy generation for manufacturing. Regarding the relationship and influence between industries and commodity markets, an empirical analysis by Dupoyet and Shank (2018) suggests that the crude oil market has a positive and significant impact on three U.S. industries: manufacturing, energy, and utilities. This suggests that there is some relationship between economic growth and commodity markets.

When one considers the perspectives of institutional and individual investors, it is easy to imagine that the expectation of a strong commodity market accompanying such an increase in economic activity will lead to an increase in market participants, not only in terms of trade, but also in terms of asset management. In the past, commodities were often used as candidates for combination with stocks and other financial assets in portfolio selection as described in previous studies such as Bodie and Rosansky (1980). In addition, a wide variety of asset management activities are being conducted, as exemplified by the use of exchange-traded funds (ETFs) linked to specific commodity markets as well as alternative investments in the commodity markets. On the other hand, there are other ways to invest in commodity markets, such as investing in countries that export commodities. This approach is to invest in the field of foreign exchange, which is referred to as resource or commodity currencies. Commodity currencies are currencies of countries that are able to extract commodities such as mineral and energy resources in their own countries, and whose main exports are commodities such as the Australian dollar, the Canadian dollar, and the Brazilian real.

Commodity currencies are directly affected by price fluctuations and trends in the related commodity markets, as they handle commodities as the mainstay of trade in their respective countries. Therefore, the multiple risks of the commodity market are reflected in commodity currencies, and as a result, the magnitude of risk may be reflected in higher interest rates. In other words, commodity currencies may have higher interest rates than countries that import resources. Therefore, commodity currencies are expected to be used as carry trades in foreign exchange, in which funds are raised in the currency of a low-interest-rate (or low-yielding) country and used to purchase the currency of a high-interest-rate (or high-yielding) country.

However, carry trades are sensitive to volatility risk because they deal with currencies with high interest rates, or in other words, currencies with high risk. In addition, the difficulty of dealing with commodity currencies would be even greater than that of normal operations if one also has to keep a close watch on the trends and volatility risks of the related commodity markets. Therefore, risk diversification is essential for carry trades in commodity currencies. Fortunately, based on the fact that there is a relationship with related commodity markets, there is room to suggest the possibility of risk diversification or risk hedging by exploring correlations with those markets, and we can expect to find significance in the research.

Therefore, this paper will attempt to identify, through empirical analysis, whether or not there is a correlation between two commodity currencies, the Australian dollar and the Canadian dollar, which are treated as major exports, such as energy resources and major minerals (critical minerals), and related commodity markets. First, focusing on the recent energy situation and economic activities, energy resources and major minerals among major exports will be the commodity markets to be analyzed. In addition, gold, a real asset that is considered a safe asset, is also an export product of the two countries, and the correlation between commodity currencies and gold will be analyzed from the perspective of asset management. Finally, given that this is a carry trade, this paper would like to mention the interest rate (or yield) spread. In this case, the high interest rates will be those of the two commodity currencies and the low interest rate will be that of the Japanese yen, which is a resource-importing country and currently has a zero-interest rate. In summary, the purpose of this paper is to examine how the yield spreads between the two commodity currencies and resource-importing countries correlate with the three relevant types of commodities, energy resources, major minerals and real assets, in each country. And, based on these empirical analyses, to make recommendations on risk management for the commodity currencies of the two countries.

One point to note when engaging in the empirical analysis is that while most of the commodity markets are based on daily data, data on interest rates of currencies in various countries are subject to variations. Therefore, yields on long-term government bonds, which are considered to be linked to interest rates, are used as a surrogate. Then, "yield spread" which is defined as spread (or difference) between the 10-year Australian government bond with the 10-year Japanese government bond and between the 10-year Canadian government bond with the 10-year Japanese government bond will be used. Furthermore, with regard to the three commodity markets used in this empirical analysis, it is noted which commodities will be used for the two commodities other than gold. The first is crude oil, natural gas, and coal, which are exported as energy resources. Australia is particularly well known for its coal exports. In the global trend toward decarbonization, the correlation with trends in these fossil fuels is a very sensitive factor, and therefore, it is essential from a risk management perspective. Next, from the perspective of economic activity and industry, iron ore and copper were selected as critical minerals. Iron ore contributes to all industries, and copper is a material that is used in a wide range of applications, from daily commodities to power lines that transmit energy. Since demand for iron ore and copper is expected to increase in a booming economy, they are expected to be similarly useful for risk management. To summarize again, (1) energy resources: crude oil, natural gas, and coal, (2) critical minerals: iron ore and copper, and (3) real assets: gold will be used as appropriate explanatory variables for the yield spread between the two, and the correlation between the two will be clarified.

As a supplement, in order to conduct this empirical analysis, several hypotheses regarding the relationship between the yield spread and the three commodity markets should be formulated. This is to assist in the interpretation of the results in the empirical analysis.

Hypotheses

① There is a positive correlation between government bond yields and energy resources (because demand for energy increases as the economy improves and government bond prices fall as interest rates rise in a booming economy, it leads to higher government bond yields).

② Positive correlation between government bond yields and critical minerals (same mechanism as hypothesis (1))

③ The correlation between government bond yields and gold prices is inversely proportional (because of the Keynesian liquidity preference hypothesis or the negative correlation between U.S. Treasury bond yields and gold prices, and the possibility that the same is true for the Canadian dollar and Australian dollar)

In addition, Gorton and Rouwenhorst (2006) provide evidence that commodity futures return tends to be negatively correlated with bond returns. Given this empirical result, it can be inferred that daily changes in yields are positively related to commodity returns (hypothesis ① and ②), assuming that yields are inversely related to bond prices. Based on these three hypotheses, an empirical analysis will be conducted to determine the correlation between each yield spread.

From the empirical analysis, the results can be briefly stated as follows. Only real assets are correlated with the yield spread between Australia and Japan, as hypothesized. On the other hand, the three commodities, energy resources, major minerals, and real assets are generally correlated with the yield spread between Canada and Japan. These estimates confirm that gold and yield spreads are consistently negative correlation in both cases, but the correlations with energy resources and critical minerals are different for Australia and Canada. The Canadian dollar, which is considered to be highly linked to the U.S. dollar, was generally as hypothesized, especially the contemporaneous correlation was statistically significant. Therefore, diversification and hedging using related commodities against the yield spread between Canada and Japan can be expected. In contrast, the correlation between Australia and energy resources, in particular, varies according to the lag order, and it is unclear whether there is a rule of thumb. Hence, when using commodities related to commodity currencies as a risk management factor, it is more feasible to use the Canadian dollar than the Australian dollar to read correlations. Thus, this paper can contribute as evidence to promote investment in the Canadian dollar, which is relatively less difficult to manage risk with volatility factors in mind, especially for institutional investors and investors who want to use commodity currencies in their carry trades.

The remainder of this paper is organized as follows. In the next section 2, various explanations of the commodity markets and commodity currencies used in this paper and previous studies on commodity currencies are presented. Section 3 describes the derivation of the empirical model used in this paper, Section 4 describes the distributional properties and stationarity of the sample data, Section 5 explains the estimation results of the empirical model, and Section 6 concludes the paper.

2. Literature Review

In the past, commodities were of widespread interest as optimal portfolio targets relative to equities, and even today the effectiveness of commodity market-based risk diversification is being tested (See Cheung and Miu (2010); Jensen et al. (2000)). More recently, studies have emerged that offer warnings against portfolios using commodity markets. One example is the work of Lombardi and Ravazzolo (2016), who used a dynamic conditional correlation model with a Bayesian process to test whether it works as a portfolio. Empirical results found that joint modeling with commodity and stock returns produced accurate predictions and benefited portfolio allocation. However, they also noted that such a portfolio comes at the trade-off of increased volatility, suggesting a greater emphasis on managing risk. Strictly speaking, yields on government bonds and treasuries are not the same as those on stocks, but in the financial markets that have grown abundantly, combined with their complexity, they could be viewed as part of the same framework. Based on this idea, players who are attracted to the high interest rates (or highly risks) of commodity currencies may consider carry trades as an option as a challenging experiment. In such cases, it is worthwhile to study the correlation of commodity currencies with other commodities to ensure accurate risk management.

In the introduction, we stated that commodity currencies are the currencies of countries whose principal exports are commodities. There is a wide variety of them, and in addition to the Australian and Canadian dollars, there are also the New Zealand dollar and the South African rand. The Australian and Canadian dollars are used in this paper's analysis of countries that produce and export iron ore, coal, crude oil, and natural gas, all of which are essential to their manufacturing industries. According to the Australian Department of Foreign Affairs and Trade, Australia is the world's largest exporter of iron ore and natural gas (LNG), and one of the world's largest exporters of coal. Statistics Canada, meanwhile, reports that Canada exports crude oil and natural gas, as well as metals and non-metallic minerals.[1] Japan, a resource-importing country, imports not only coal, iron ore, crude oil, and natural gas from Middle Eastern countries, but also minerals, oil gases, and other energy resources from

[1] In general, iron, copper, and aluminum are referred to as metals, while other metals such as gold, silver, and lead are classified as nonmetals.

Australia and Canada. In other words, both Australia and Canada are relevant to Japan.

Therefore, it is easy to imagine that the currencies of countries that export multiple commodities as the keystone of their trade are affected by commodity prices. The study by Clements and Fry (2008) using a Kalman filter provides evidence that commodity prices do have an impact on currencies (or exchange rates) of countries rich in natural resources, such as Australia and Canada. Incidentally, the paper analyzed the exchange rate and the commodity market in both directions, and stated that according to the spillover values, the impact from the exchange rate on commodity prices was larger. Also, according to Chen and Rogoff (2003), the world price of commodities as exports measured in real U.S. dollars appears to have a strong and stable influence on the real exchange rate in Australia. For Canada, on the other hand, they found this relationship to be somewhat less robust and particularly vulnerable to changes in trend. While the Canadian dollar and the U.S. dollar are considered to be highly interlinked, the difference between the two countries is a quite interesting point. Therefore, it is necessary to carefully examine how the results relate to the results of this paper, in which yields on government bonds are the subject of analysis. Thus, this paper will begin with a detailed analysis of the correlation between commodity prices and currencies.

3. Empirical Modeling

This section provides an explanation of the derivation and definition of the empirical analysis model used in this paper. First, an explanation will be given of the derivation of the yield spread between the two types of yields as the explained variables, followed by a description of each explained variable, and finally an explanation of the model selection.

The yield spread between the yield of 10-year Australian government bond and 10-year Japanese government bond is defined as $gap_{AUD-JPY}$ the yield spread between the yield of 10-year Canadian government bond and 10-year Japanese government bond is defined as $gap_{CAD-JPY}$. The yield spread of each yield is then derived as in equation (1) and (2) below. Also, equations (3) and (4) below are expressions for daily changes in equations (1) and (2), respectively.

$$gap_{AUD-JPY} = yield_{AUD} - yield_{JPY} \tag{1}$$

$$gap_{CAD-JPY} = yield_{CAD} - yield_{JPY} \tag{2}$$

$$y_{Gap(AUD-JPY),t} = \frac{\left(gap_{AUD-JPY,t} - gap_{AUD-JPY,t-1}\right)}{gap_{AUD-JPY,t-1}} \tag{3}$$

$$y_{Gap(CAD-JPY),t} = \frac{\left(gap_{CAD-JPY,t} - gap_{CAD-JPY,t-1}\right)}{gap_{CAD-JPY,t-1}} \tag{4}$$

Equation (5) below expresses the daily returns for each of the explanatory variables: crude oil futures price, natural gas futures price, coal futures price, iron ore futures price, copper futures price, and gold futures price.

$$y_{i,t} = \frac{\left(price_{i,t} - price_{i,t-1}\right)}{price_{i,t-1}}, i = oil, gas, coal, iron, copper, gold \tag{5}$$

Finally, a step-by-step explanation is given regarding model selection. First, the model follows the return generation process using equation (3), which is shown in equation (6) below.

$$y_{gap(AUD-JPY),t} = \alpha + \beta y_{gap(AUD-JPY),t-1} + \varepsilon_t \tag{6}$$

where, α is the drift term of equation (6) and β is the coefficient of the autoregressive term at time t-1. The error term ε is assumed to follow a standard normal distribution.

Equation 6 above then incorporates the daily returns of the relevant commodity markets as explanatory variables. Since Equation 6 is an expression for the daily change in the Australia-Japan yield spread, the relevant commodity markets are crude oil, natural gas, coal, iron ore, copper, and gold futures, seven in total, which are incorporated as explanatory variables. The model developed is shown in Equation 7 below.

$$\begin{gathered} y_{gap(AUD-JPY),t} = \alpha + \beta_1 y_{gap(AUD-JPY),t-1} + \beta_2 y_{oil,t-1} + \beta_3 y_{gas,t-1} \\ + \beta_4 y_{coal,t-1} + \beta_5 y_{iron,t-1} + \beta_6 y_{copper,t-1} + \beta_7 y_{gold,t-1} + \varepsilon_t \end{gathered} \tag{7}$$

where, α and ε are defined as in equation (6). β_1 is the coefficient of the autoregressive term at time t-1, and $\beta_2 \sim \beta_7$ are the coefficients of the daily returns of the respective associated commodities.

On the other hand, the model follows the return generation process using equation (4) as well as equation (6), which is shown in equation (8) below.

$$y_{gap(CAD-JPY),t} = \alpha + \gamma y_{gap(CAD-JPY),t-1} + \varepsilon_t \tag{8}$$

where, in this case, α is the drift term and γ is the coefficient of the autoregressive term at time t-1. The error term ε is assumed to follow a standard normal distribution.

Next, as in the modeling of equation (7), daily returns in the commodity market associated with equation (8) are incorporated as explanatory variables. Since equation (8) is an expression for the daily change in the Canada-Japan yield spread, the five relevant commodity markets are crude oil, natural gas, iron ore, copper, and gold futures, which are incorporated as explanatory variables. The model constructed is shown in equation (9) below

$$y_{gap(CAD-JPY),t} = \alpha + \gamma_1 y_{gap(CAD-JPY),t-1} + \gamma_2 y_{oil,t-1} + \gamma_3 y_{gas,t-1} + \gamma_4 y_{iron,t-1} + \gamma_5 y_{copper,t-1} + \gamma_6 y_{gold,t-1} + \varepsilon_t \tag{9}$$

where, α and ε are defined as in equation (8). γ_1 is the coefficient of the autoregressive term at time t-1, and $\gamma_2 \sim \gamma_5$ are the coefficients of the daily returns of the respective associated commodities.

Finally, the autoregressive distributed lag model (ARDL model) of Pesaran et al. (2001) is introduced in equations (7) and (9), respectively, to construct explanatory variables that are time series analysis and that include contemporaneous periods in order to make recommendations regarding risk management. Each model introduced is shown in equations (10) and (11) below.

$$y_{gap(AUD-JPY),t} = \omega + \sum_{k=1}^{m} \beta_{1,k}\, y_{gap(AUD-JPY),t-k} + \sum_{k=0}^{m} \beta_{2,k}\, y_{oil,t-k} + \sum_{k=0}^{m} \beta_{3,k}\, y_{gas,t-k} + \sum_{k=0}^{m} \beta_{4,k}\, y_{coal,t-k} + \sum_{k=0}^{m} \beta_{5,k}\, y_{iron,t-k} + \sum_{k=0}^{m} \beta_{6,k}\, y_{copper,t-k} + \sum_{k=0}^{m} \beta_{7,k}\, y_{gold,t-k} + \varepsilon_t \tag{10}$$

$$y_{gap(CAD-JPY),t} = \omega + \sum_{k=1}^{m} \gamma_{1,k}\, y_{gap(CAD-JPY),t-k} + \sum_{k=0}^{m} \gamma_{2,k}\, y_{oil,t-k} + \sum_{k=0}^{m} \gamma_{3,k}\, y_{gas,t-k} + \sum_{k=0}^{m} \gamma_{4,k}\, y_{iron,t-k} + \sum_{k=0}^{m} \gamma_{5,k}\, y_{copper,t-k} + \sum_{k=0}^{m} \gamma_{6,k}\, y_{gold,t-k} + \varepsilon_t \tag{11}$$

where, ω in equations (10) and (11), respectively, is the drift term and the disturbance terms are white noise distributed with $\varepsilon t \sim i.\ i.\ d.\ N$ (0, σ2). m is lag up to 1, 2, ..., 4, where m is selected as the optimal lag length by the Akaike Information Criteria (AIC).

It is notion that this model has a partially problem to estimate correlations between independent variable with explanatory variables, which is pointed out by Sims (1990) that describes that autoregressive models using polynomial lags have limitation of estimation and it is not truly estimated results without denying endogeneity issues for equation modeling. It means that this paper will provide partially significant evidence even if appropriate modelling is derived at ARDL model. However, ARDL model is considered the preferred model for detecting optimal lags including contemporaneous periods and for estimating dynamic relationships. Thus, this paper will adopt ARDL model as an empirical modelling.

4. Data Properties

The purpose of this section is to understand the explanatory and distributional properties regarding the sample data under analysis using multiple moments (mean, standard deviation, skewness and kurtosis). In addition, the null hypothesis regarding the unit root process by means of the Augmented Dickey-Fuller test (ADF test) will also be performed for the stationarity of each sample data. From these efforts, it will be examined whether the sample in question is suitable for empirical analysis.

The sample period used in this paper is approximately 10 years, from January 1, 2012 to December 31, 2022. First, yields on 10-year Australian, Canadian, and Japanese government bonds are daily data obtained from Investing.com. Next, all commodity futures prices are daily data from Investing.com, as are the yields on government bonds. For all commodities, a major commodity with a large market size was selected because the aim of this paper is to provide recommendations on management and investment strategies. Thus, daily data for West Texas Intermediate (WTI) crude oil futures, crude oil; Henry Hub for natural gas; CME Group FOB Richard Bay coal futures for coal; CMO Group TIO futures for iron ore; COMEX copper futures for copper; and COMEX Gold futures for gold will be used.

Figures 1 and 2 below depict graphs of government bond yields and commodity market futures prices for each country, arranged in chronological order. From Figure 1, it is easy to see that yields in Australia and Canada have moved up and down at relatively diverse times. In addition, Japan also has a zero-interest-rate policy, so the ups and downs seem to be less pronounced than in the other two countries, but the ups and downs seem to occur at similar times to the other two countries, albeit within a smaller range. In particular, the Covid－19 global bond market is expected to be the most important source of growth in the world economy. In 2020－2021, when the global economic stagnation caused by Covid－19 hit, yields on Australian and Canadian government bonds declined sharply. In contrast, Figure 1 also shows that the economy is gradually recovering, as yields have been rising sharply since around 2022.

Judging from Figure 3, which shows the same daily changes in yields for each country as in Figure 1, there are frequent fluctuations and volatility clustering in the two periods of 2013 and 2015－2017, in addition to 2020－2021. Japan, with its zero-interest-rate policy and extreme volatility, seems to have a similar trend to the other two countries, although it is difficult to judge. On the other hand, the commodity markets are also unique. Note that the crude oil market is an exception to the rule, as the time-series data includes a negative price on April 20, 2020 (note: WTI recorded a negative price of －$36 for the first time in its history), which makes the transition extreme. It can be seen from Figure 2 that the timing of the ups and downs in all markets is similar. In particular, all markets have experienced large corrections in the two periods of 2016 and 2020. At Figure 4, which plots daily returns in time-series order, also seems to differ slightly from Figure 2. Copper and gold, in particular, seem to fluctuate frequently, but the fluctuations are within a boundary of －0.1 to +0.1, which means that the fluctuation range is smaller than the other three markets. In contrast, natural gas, coal, and iron ore have been experiencing continuous fluctuations above the －0.1 to +0.1 boundary, and the volatility clustering appears to have been less pronounced during the periods when it was broken. However, the daily returns for crude oil are more extreme due to the presence of an outlier of －$36, while daily returns prior to 2020 showed similar volatility to natural gas and other commodities.

Figure 1. Time-series of governmental 10Y-bond yield (Australia, Canada and Japan)

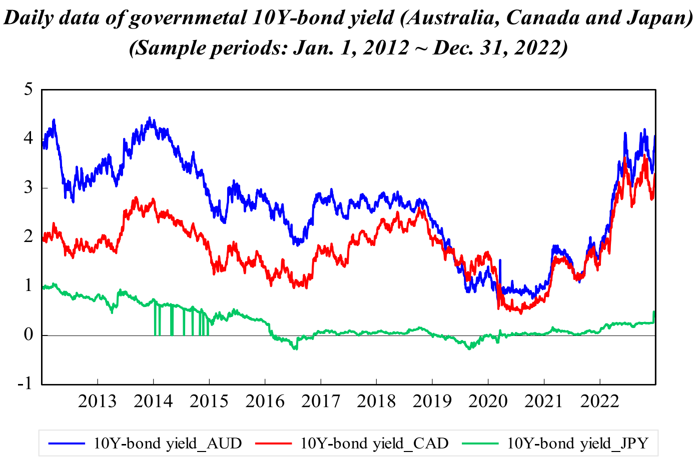


Figure 2. Time-series of commodity markets: daily data

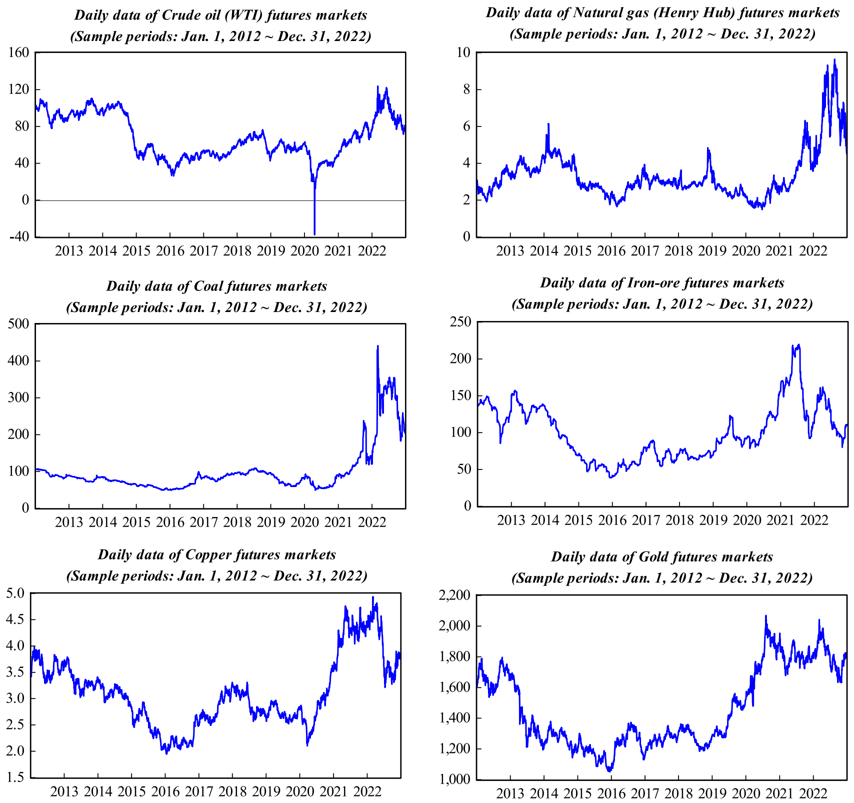


Figure 3. Daily changes of 10Y-bond yield (Australia, Canada, and Japan)

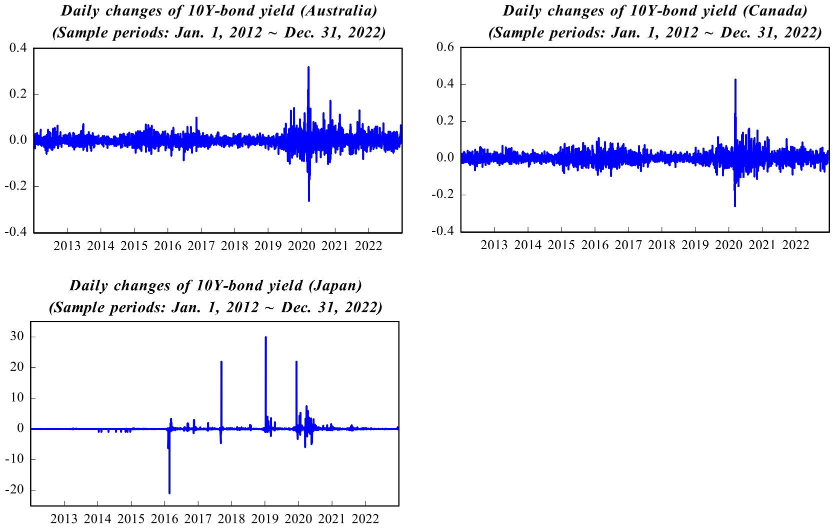
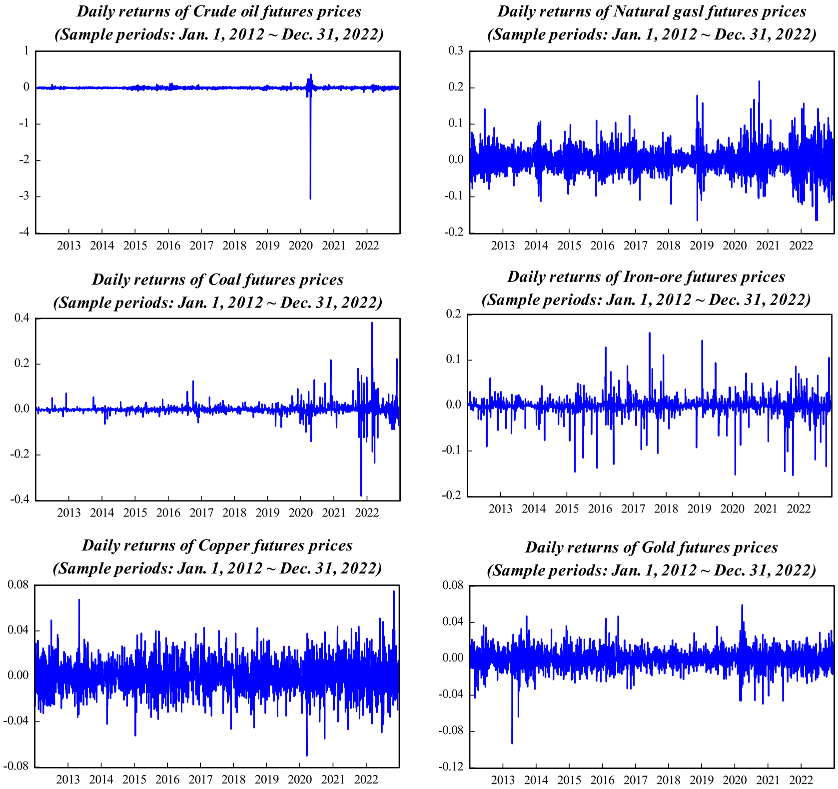
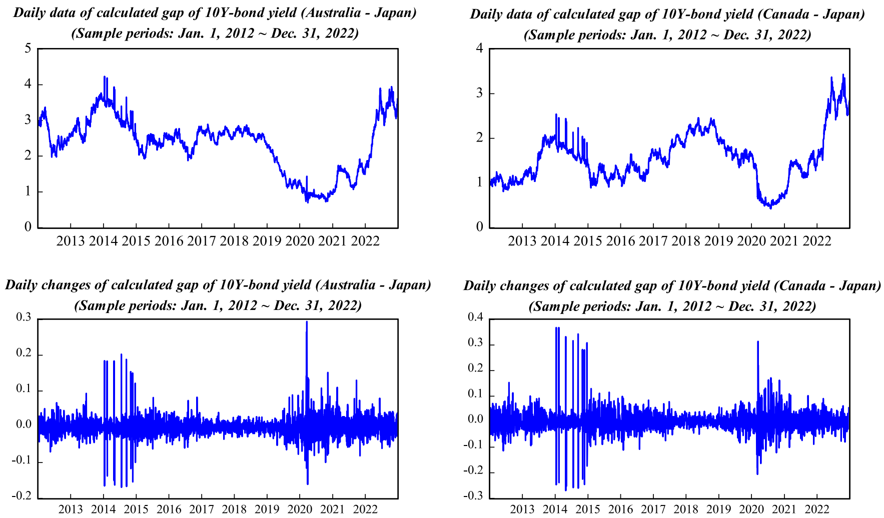


Figure 4. Daily returns of commodity markets



The daily data and daily changes in the two types of yield spreads, which will be used in this paper, are also plotted as Figure 5. Figure 5 shows that there are no extreme changes from Figure 1, as it is simply the yield spread between Australia and Japan, and between Canada and Japan. The daily changes are also not very significant, as is the difference in yields spread. Since both trends are subject to large instantaneous fluctuations depending on the yield on Japanese government bonds, it is difficult to say how this point will affect future empirical analysis.

Figure 5. Daily changes of yield spreads (AUD－JPY and CAD－JPY)



Based on the above, the distribution properties for the yields of the three countries, the difference between the two types of yields, and the six commodity markets are described from each of them. Note that, since this paper uses the yield spread between the two types of yields, the distribution properties for the yields of the three countries are given in terms of level only. First, Table 1 shows the distribution properties for the yields spread between the three countries and the two types of yields. The names of the sample data are written in the notation defined in the modeling in section 3. In addition to the arithmetic mean, standard deviation, skewness, and kurtosis, the distribution properties in Table 1 also include the results of hypothesis testing using the Jarque-Bera and ADF tests. The skewness and kurtosis indicate that the five samples' data are time series data following a normal distribution, which can also be judged from the p-value of the Jarque-Bera test. See Figure 6 for the histogram.

Nevertheless, the results of the ADF test indicate that the five-sample data are non-stationary processes because the unit root process cannot be rejected, and Table 1 suggests that the empirical analysis may result in a spurious regression equation, i.e., correct estimation results cannot be obtained.

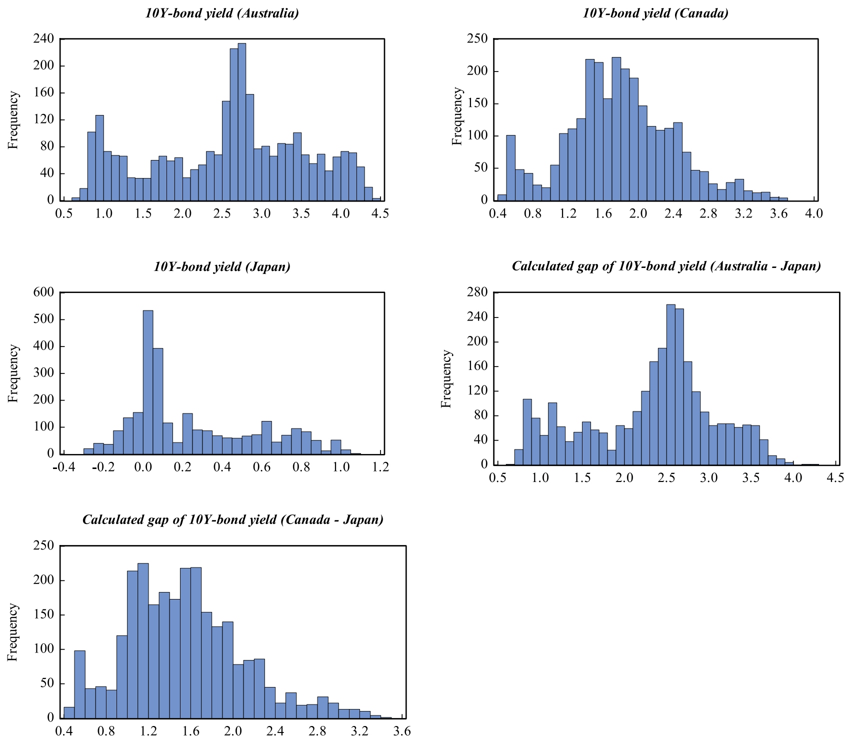
The distribution properties for each commodity market are then presented in Table 2 below. It should be noted that, unlike Table 1, two methods are estimated for the ADF test, one with an intercept and one without any intercept. Comparing the skewness and kurtosis for each market, it can be seen that natural gas and coal are above the general guideline values. Referring to Figure 7, which is represented as a histogram, the four markets except natural gas and coal had two peaks represented in the histogram.

Table 1. Distributional properties of yields and yield spreads

	$yield_{AUD}$	$yield_{CAD}$	$yield_{JPY}$	$gap_{AUD-JPY}$	$gap_{CAD-JPY}$
Mean	2.5788	1.7913	0.2480	2.3270	1.5425
Std. Dev.	0.9616	0.6098	0.3175	0.7555	0.5583
Skewness	−0.2236	0.1855	0.7610	−0.3924	0.5805
Kurtosis	2.1762	3.1005	2.4141	2.4299	3.3549
Jarque-Bera	104.6329	17.0595	305.9813	107.8218	164.1322
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ADF test	−0.2118	−0.2247	−1.1049	−0.4932	0.0488
	(0.6101)	(0.6055)	(0.2448)	(0.5027)	(0.6983)

Notes: The stationarity of time series is estimated with the Augmented Dickey–Fuller methodology using with neither intercept nor trend terms. Jarque–Bera statistics for normal tests are distributed as $\chi 2$ on the null.

Figure 6. Histograms of 10Y-bond yields and yield spreads



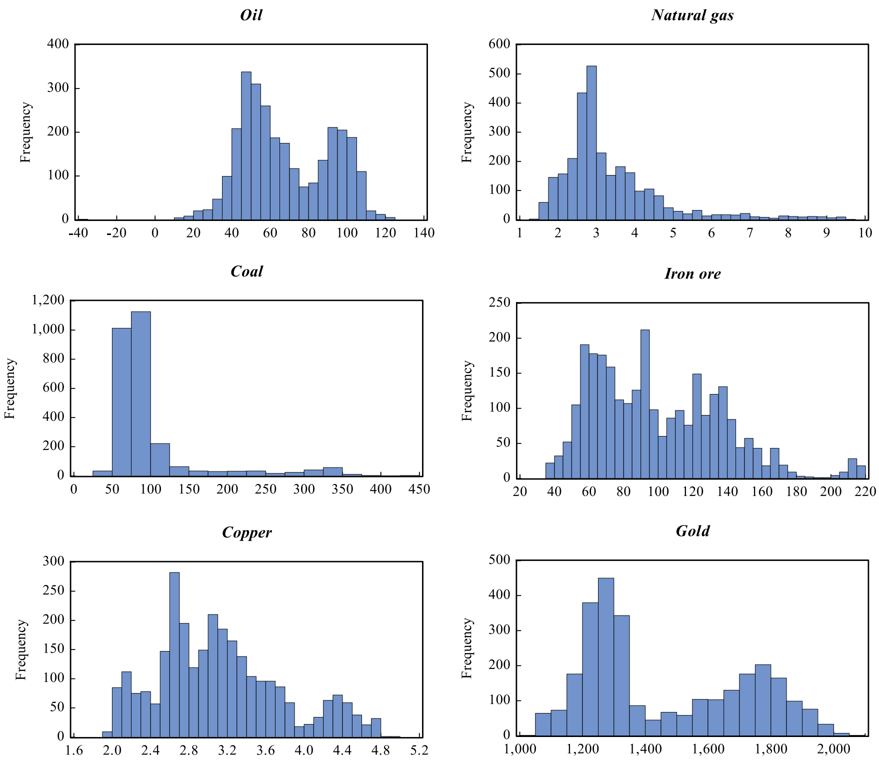
The estimation results of the ADF test suggest that crude oil and natural gas are stationary processes, rejecting the unit root process, while coal, iron ore, copper, and gold cannot be rejected, suggesting that they are non-stationary processes. Therefore, the results may be statistically insignificant if these variables are used in the empirical analysis.

Table 2. Distributional properties of commodity markets

	$price_{oil}$	$price_{gas}$	$price_{coal}$	$price_{iron}$	$price_{copper}$	$price_{gold}$
Mean	68.2607	3.3643	99.0819	99.5501	3.1194	1460.9900
Std. Dev.	23.1162	1.3489	63.7954	37.4496	0.6541	254.9942
Skewness	0.2261	1.9659	2.7138	0.6980	0.5699	0.4376
Kurtosis	2.0413	7.6325	9.9993	3.1567	2.7436	1.7469
Jarque-	133.0857	4373.3710	8985.7880	227.1201	159.6888	276.4570
Berra	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ADF test	-2.8782^{a}	-2.7335^{a}	-1.2262^{c}	-0.6918^{c}	-0.3021^{c}	0.0423^{c}
	(0.0480)	(0.0685)	(0.2025)	(0.4174)	(0.5771)	(0.6963)

Notes: The stationarity of time series is estimated with the Augmented Dickey–Fuller methodology using the intercept only and with neither intercept nor trend terms as denoted by superscripts a and c respectively. Jarque–Bera statistics for normal tests are distributed as $\chi 2$ on the null.

Figure 7. Histogram of commodity markets: Daily data



Lastly, the distribution properties of the daily changes in the two yield spreads and the daily returns of the six commodity markets are shown in Table 3 and Table 4, respectively. Although the skewness and kurtosis are extreme for all of them, the histograms in Figure 8 show that the distributions follow a relatively normal distribution. In addition, all of the sample data reject the unit-root process, and the estimation results suggest a stationary process. Therefore, in this paper, these daily changes and daily returns are used as variables in the empirical analysis.

Table 3. Distributional properties of daily changes on yield spreads

	$y_{gap(AUD-JPY)}$	$y_{gap(CAD-JPY)}$
Mean	0.000574	0.001162
Std. Dev.	0.028198	0.042202
Skewness	1.115250	1.018775
Kurtosis	18.65886	19.82803
Jarque-Bera	27790.28	30158.11
	(0.0000)	(0.0000)
ADF test	−35.86794 [c]	−40.51907 [a]
	(0.0000)	(0.0000)

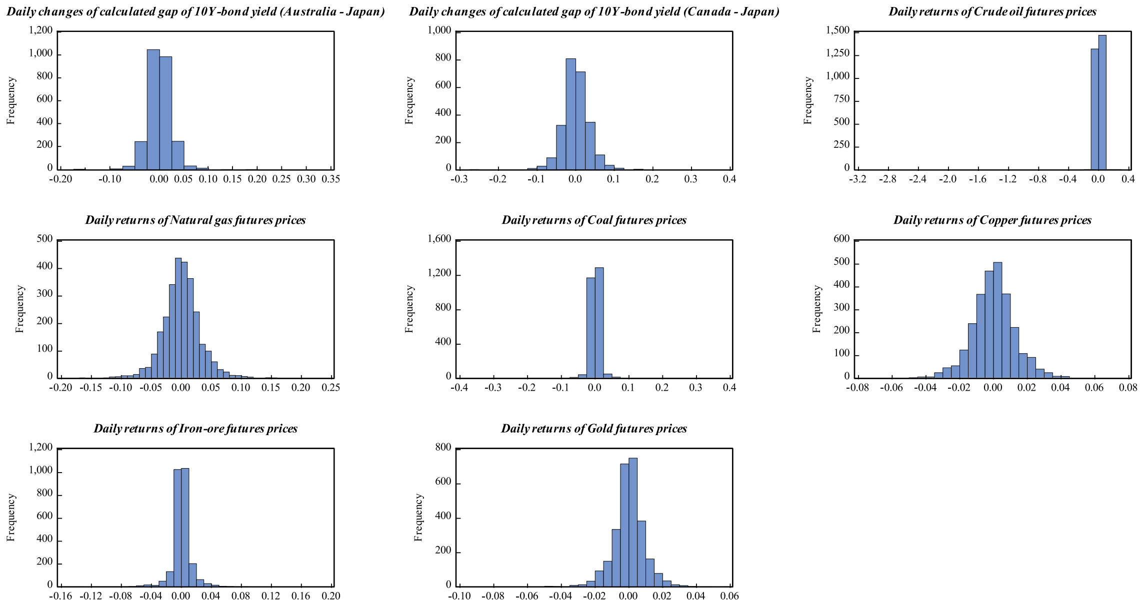
Notes: The stationarity of time series is estimated with the Augmented Dickey–Fuller methodology using the intercept only and with neither intercept nor trend terms as denoted by superscripts a and c respectively. Jarque–Bera statistics for normal tests are distributed as $\chi2$ on the null.

Table 4. Distributional properties of daily returns on commodity markets

	y_{oil}	y_{gas}	y_{coal}	y_{iron}	y_{copper}	y_{gold}
Mean	−0.0010	0.0007	0.0005	0.0002	0.0001	3.83E-05
Std. Dev.	0.0682	0.0331	0.0230	0.0170	0.0131	0.0098
Skewness	−34.2292	0.2653	1.4293	−1.2615	0.0518	−0.3803
Kurtosis	1481.0720	6.5549	90.7305	29.8067	4.8234	9.6318
Jarque−	2.57E+08	1515.7840	845281.7000	80229.2900	381.6596	5217.1860
Bera	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ADF test	−41.1771	−57.9061	−33.4923	−47.585	−56.0323	−56.9883
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)

Notes: The stationarity of time series is estimated with the Augmented Dickey–Fuller methodology using with neither intercept nor trend terms. Jarque–Bera statistics for normal tests are distributed as $\chi2$ on the null.

Figure 8. Histograms of daily returns of commodities and yield spreads



5. Results

In this section, estimation results based on the empirical model derived in Chapter 3 will be discussed. First, results from equation (10) will be presented, followed by results from equation (11).

5.1. Estimation result with equation (10): Australia －Japan

Table 5 summarizes the results estimated by equation (10) based on the optimal lag order selected by the AIC, including the value of the coefficient, standard error, and t-value for each explanatory variable. The two types of asterisks next to each coefficient value are based on the p-value. The *** indicates statistically significant at the 1% level, and the * indicates statistically significant at the 10% level. Log likelihood and AIC are also listed at the bottom of the table as criteria for adequacy of the model.

The results of the estimation using equation (10) for the January 2012 to December 2022 sample period show that, first, according to the AIC, the optimal lag of the explanatory variables including the autoregressive term is (3, 0, 0, 2, 0, 0, 1, 1). According to the estimation results in Table 5, the autoregressive terms are seen to have mean reversion properties. Energy resources, with the exception of natural gas, were statistically significantly correlated with the daily change in yield spread. However, in terms of the sign of the correlation, crude oil was positively correlated, while coal was negatively correlated. As for the major minerals, only copper in the t-1 period had a statistically significant correlation with a positive sign. Gold, a real asset, had a statistically significant correlation in both the contemporaneous and t-1 periods, with a negative sign. The variables with absolute values greater than

2, according to the t-values, were the autoregressive terms in time t-1 and t-2, crude oil in time t-1, coal in time t-2, copper in time t-1, and gold in time t-1 and t-2. gold in period t-1. Together, the estimates and t-values suggest that gold returns in period t-1 is the most influential variable, with a relatively large coefficient value of −0.4.

Table 5. Estimated result with equation (10)

	Sample periods: Jan. 1, 2012 ~ Dec. 31, 2022		
ARDL (3,0,0,2,0,1,1)	**Coefficient**	**Std. Error**	**t−Statistic**
$y_{gap(AUD-JPY),t-1}$	-0.1517^{***}	0.0222	−6.8332
$y_{gap(AUD-JPY),t-2}$	0.0663^{***}	0.0228	2.9067
$y_{gap(AUD-JPY),t-3}$	−0.0356	0.0233	−1.5255
$y_{oil,t}$	0.0241^{***}	0.0082	2.9472
$y_{gas,t}$	−0.0225	0.0190	−1.1811
$y_{coal,t}$	-0.0467^{*}	0.0275	−1.6949
$y_{coal,t-1}$	−0.0376	0.0269	−1.3999
$y_{coal,t-2}$	0.0751^{***}	0.0260	2.8904
$y_{iron,t}$	0.0532	0.0384	1.3848
$y_{copper,t}$	2.50E-05	0.0515	0.0005
$y_{copper,t-1}$	0.2149^{***}	0.0501	4.2866
$y_{gold,t}$	-0.2004^{***}	0.0669	−2.9973
$y_{gold,t-1}$	-0.4799^{***}	0.0668	−7.1802
Log Likelihood	4420.5410	AIC	−4.2596

Note: *** indicates statistically significant at the 1% level, and * indicates statistically significant at the 10% level.

In the Australia-Japan case, the relationship between daily changes in yield spreads and real asset returns was as hypothesized, but there were several cases where energy resources and major minerals had different results than hypothesized. This can be suggested that, from the perspective of real assets, credit for the Australian dollar remains low, as noted in previous studies, and this is reflected in yields. Gold may therefore function as a risk diversifier against the yield spread of government bonds. In addition, copper, critical mineral, has a statistically significant correlation in the t-1 period, suggesting that it is not suitable for profit-oriented risk management, but rather there may be room to make this recommendation to businesses that actually handle copper as a real commodity. On the other hand, since energy resources cannot be said to be an estimation result with a rule of thumb in the correlation trend, it cannot be said that the hypothesis established is correct, and a redesign of the hypothesis and a retrial of variable selection are required. To speak on the basis of the estimation results, it is possible to construct a portfolio by taking advantage of the fact that contemporaneous periods for crude oil and coal are statistically significant, but there is a large possibility that it will not be an effective portfolio design.

5.2. Estimation result with equation (11): Canada －Japan

Table 6 summarizes the results estimated by equation 11. As in Table 5, the estimation results are based on the optimal lag order selected by the AIC, and the values of the coefficients, standard errors, and t-values for each explanatory variable are listed. The three types of asterisk marks next to each coefficient value are based on the p-value. These are *** indicates statistically significant at the 1% level, ** indicates statistically significant at the 5% level, and * indicates statistically significant at the 10% level. Log likelihood and AIC are also listed at the bottom of the table as criteria for adequacy of the model.

The results of the estimation using equation (11) for the January 2012 to December 2022 sample period first show that according to the AIC, the optimal lags for the explanatory variables including the autoregressive terms are (4, 1, 0, 0, 0, 3, 3). According to the estimation results in Table 6, all the autoregressive terms in equation (11) are statistically significant except for the t-3 period, suggesting from the estimates that there is a tendency toward negative long memory, or negative momentum. The returns for crude oil and natural gas, defined as energy resources, were all statistically significant and positively correlated to the yield spread. For the major minerals, iron ore in the same period and copper in the same and t-3 periods were statistically significantly and positively correlated. For real assets, gold values from time t to time t-3 are statistically significantly and negatively correlated except in time t-2. Judging from the t-values of the estimated coefficients, the autoregressive term in period t-1 has by far the strongest effect on the daily change in yield spread, followed by copper and gold in the same period. In the Canada-Japan case, the estimation results are in line with the hypothesis established. In addition, since the contemporaneousness of each explanatory variable is statistically significant, appropriate risk diversification and hedging can be expected.

Table 6. Estimated result with equation (11)

Model parameters	**Sample periods: ~**		
ARDL (4, 1, 0, 0, 3, 3)	**Coefficient**	**Std. Error**	**t−Statistic**
$y_{gap(CAD-JPY),t-1}$	−0.2901***	0.0236	−12.3070
$y_{gap(CAD-JPY),t-2}$	−0.0803***	0.0249	−3.2288
$y_{gap(CAD-JPY),t-3}$	−0.0406	0.0257	−1.5817
$y_{gap(CAD-JPY),t-4}$	−0.0596**	0.0254	−2.3467
$y_{oil,t}$	0.0292**	0.0128	2.2862
$y_{oil,t-1}$	0.0212*	0.0128	1.6568
$y_{gas,t}$	0.0593**	0.0301	1.9688
$y_{iron,t}$	0.1251**	0.0610	2.0500
$y_{copper,t}$	0.4276***	0.0810	5.2790
$y_{copper,t-1}$	0.1178	0.0816	1.4439
$y_{copper,t-2}$	0.0706	0.0799	0.8840
$y_{copper,t-3}$	0.2162***	0.0797	2.7110
$y_{gold,t}$	−0.6638***	0.1052	−6.3097
$y_{gold,t-1}$	−0.2104**	0.1062	−1.9820
$y_{gold,t-2}$	−0.1593	0.1093	−1.4576
$y_{gold,t-3}$	−0.3231***	0.1087	−2.9726
Log Likelihood	3166.2300	AIC	−3.4779

Note: *** indicates statistically significant at the 1% level, ** indicates statistically significant at the 5% level, and * indicates statistically significant at the 10% level.

6. Conclusion

A start of this paper was to focus on commodity currencies, which are currencies of countries that produce commodities in their own countries and use them as major exports, and on carry trade, a method of investing using credit risk (or yield) spread. Therefore, the yields on 10-year Australian and Canadian government bonds, which are representative commodity currencies, were selected for analysis, and an empirical analysis of the yield spread between them and the 10-year Japanese government bond, which has strong creditworthiness from the perspective of carry trade, was attempted. The purpose was then to estimate the correlation between three commodity markets related to commodity currencies, energy resources (crude oil, natural gas, and coal), critical minerals (iron ore and copper), and real assets (gold), and their respective yield spreads, and to verify whether there is any possibility of risk management for commodity currencies.

Using daily data from January 2012 to December 2022 as sample data, the ARDL model estimation verified that the Canada-Japan yield spread is statistically significantly correlated with the relevant commodities (crude oil, natural gas, iron ore, copper, and gold). The estimated results provide evidence to suggest that it is possible to construct an investment strategy for Canada-related commodities based on variable factors relative to the Canada-Japan yield spread. On the other hand, the correlations between the yield spread between Australia and Japan and the related commodities (crude oil, natural gas, coal, iron ore, copper, and gold) were not statistically significant compared to the estimated results for Canada-Japan, which is a lot, except for the correlation with gold. This estimation result suggests that Australia-related commodities may not provide effective risk management for the Australia-Japan yield spread. Note that for gold, both estimation results show relatively strong negative correlations, suggesting that the conventional relationship between the gold market and government bonds (yields) is preserved. Therefore, for investors planning to engage in carry trades using commodity currencies, this paper's empirical results are expected to be of assistance.

In the end of this paper, a future research question is to pursue the factors that cause the estimated results to differ from the expected results which the fact that Australia is a larger resource-exporting country than Canada. First, the hypothesis established in this paper is inadequate. In this regard, it would be desirable to design a more realistic hypothesis that is more aware of the flows of energy resources and major minerals and commodity currencies in particular. Next is the limitation of the ARDL model pointed out in previous studies, namely, addressing feedback effects among variables. The VAR model proposed by Sims (1980) will be used to test in future research and it will be looking forward to see how different the results will be from those in this paper. As the number of empirical analyses on commodities is increasing year by year, this paper will hopefully be of help to those who conduct research from a practical perspective in the future.

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