The Relationship between Commodity Prices and Currency Exchange Rates: Evidence from the Futures Markets

Kalok Chan
Hong Kong University of Science and Technology
Hong Kong, China

Yiuman Tse
University of Texas at San Antonio
San Antonio, TX, U.S.A.

Michael Williams
University of Texas at San Antonio
San Antonio, TX, U.S.A.

May 2009

We examine the relationship between four commodity-exporting countries' currency returns and a range of index-based commodity returns. We use daily futures data in order to investigate the fast dynamics between commodity prices and currency exchange rates while avoiding market imperfections in the commodity spot market. We find that commodity/currency relationships exist contemporaneously but fail to exhibit lead-lag behavior in either direction. Our results indicate that futures markets are efficient in processing information and that commodity and currency futures prices respond to information shocks simultaneously on a daily basis. The results are robust across different periods ranging from July 1992 through January 2009.

I. Introduction

We examine relationships among currency and commodity futures markets based on four commodity-exporting countries' currency futures returns and a range of index-based commodity futures returns. These four commodity-linked currencies are the Australian dollar, Canadian dollar, New Zealand dollar, and South African rand. We find that commodity/currency relationships exist contemporaneously but fail to exhibit Granger-causality in either direction. We attribute our results to the informational efficiency of futures markets. That is, information is incorporated into commodity and currency futures prices rapidly and simultaneously on a daily basis.

There are a few studies on the relationship between currency and commodity prices. A recent study by Chen et al. (2008) using quarterly data finds that currency exchange rates of commodity-exporting countries have strong forecasting ability for the spot prices of the commodities they export. The authors argue that the currency market is price efficient and can incorporate useful information about future commodity price movements. In contrast, the commodities spot market is far less developed than is the exchange rate market. As a result, exchange rates contain forward-looking information beyond what has been reflected in commodity prices.

However, Chen et al. (2008) use commodity prices from either the spot market or the forward market, both of which are less price efficient than the currency spot market. As a result, their evidence cannot be interpreted as absolute superior information processing ability in the currency exchange market over the commodity market. In this paper, we extend Chen et al. by employing futures market data. Relative to the commodity spot market, the futures market offers more convenient, lower cost trading due to its high liquidity, transparent pricing system, high

leverage, and short positions being allowed. We therefore expect a higher level of informational efficiency within the futures market.

Another advantage of studying the futures market is that we can use higher frequency data, like daily futures prices. Most previous literature examines commodity/currency relationships using lower-frequency data. This allows the previous literature to examine commodity/currency relationships based on business-necessary transactions. Daily data allow us to examine the fast dynamics between commodity prices and currency rates in terms of the information transmission brought about by informed and speculative transactions.

Literature studying commodity/currency relationships began with the Meese-Rogoff Exchange Rate Puzzle which states that fundamentals-based currency forecasting models cannot outperform random walk benchmarks (Meese and Rogoff, 1983). The puzzle thus suggests that no fundamental-to-exchange rate relationship exists. An extensive literature following Meese and Rogoff, however, finds contradictions to the Exchange Rate Puzzle (e.g. MacDonald and Taylor, 1994; Chinn and Meese, 1995; MacDonald and Marsh, 1997; Mark and Sul, 2001; Groen, 2005, and others).

Previous studies often cite three explanations for fundamentals-to-currency relationships in general and commodity-to-currency relationships in particular. The Sticky Price Model states that commodity price increases lead to inflationary pressures on a commodity exporting country's real wages, non-traded goods prices, and exchange rate. However, wages and non-traded goods prices are upwards sticky leading only commodity price increases to impact the country's exchange rate. The efficient relative price between traded and non-traded goods is then restored by the currency's appreciation.

The Portfolio Balance Model states that a commodity exporting country's exchange rate is heavily dependent on foreign-determined asset supply and demand fluctuations. Thus, commodity price increases lead to a balance of payments surplus and an increase in foreign holdings of the country's currency. Both of these factors, in turn, lead to an increase in the relative demand for the country's currency leading to positive currency returns (see Chen and Rogoff, 2003, Chen, 2004, and Chen et al., 2008 for further detailed discussions).

The third explanation for commodity-to-currency relationships states that commodity price changes proxy exogenous shocks in a commodity exporting country's terms-of-trade (Cashin et al., 2003; Chen and Rogoff, 2003). Terms-of-trade shocks then lead to a shift in the relative demand for an exporter's currency which, in turn, leads to changes in that exporter's exchange rate (Chen, 2004; Chen et al., 2008).

Currency-to-commodity relationships are explained by changes in macroeconomic expectations embedded within currency returns being incorporated into commodity price changes (Mark 1995; Sephton, 1995; Gardeazabal et al., 1997; Engel and West, 2005; Klaassen, 2005). This is made possible given that exchange rates are forward looking while commodity prices are based on short-term supply and demand imbalances (Chen et al., 2008). Under this framework, economic expectations embedded within currency returns contain information regarding a commodity exporter's capacity to meet supply expectations. Thus, expectations regarding future commodity conditions can lead to hedging or hoarding behavior which, in turn, leads to commodity price changes.

Each of the above models assumes that economic agents adjust their commodity (or currency) holdings based on business-necessitated activity. Additionally, these models assume that economic agents are capable of capturing incoming commodity/currency information,

accurately interpreting that information in light of their business-specific conditions, and then acting according to their business-specific needs. While these assumptions likely hold over longer periods of time, it is questionable whether they hold for frequencies as low as one day.

Our study examines short-horizon commodity/currency relationships using two types of restriction-based causality tests as well as a rolling, out-of-sample forecasting methodology. We find no evidence of cross-asset causality and predictive ability in either direction. These results suggest that commodity returns information is rapidly incorporated into currency returns (and vice versa) on a daily level. In light of previous literature, our results also suggest that economic expectations information embedded in currency returns is rapidly incorporated into a country's terms-of-trade which are embedded in commodity returns (and vice versa).

We suggest that daily commodity/currency relationships within futures markets are facilitated by relatively informed speculators and these markets' ability to rapidly incorporate information shocks into prices. As a result, commodity/currency lead-lag relationships are not found over daily-horizons given that asymmetric information profits have already been captured by informed speculators.

Many studies provide evidence that the above explanation is aided by futures markets having an important role in the price discovery process. Specifically, futures prices represent unbiased estimates of future spot prices when markets are efficient. While we do not suggest that markets are perfectly efficient, we do recognize that futures markets provide a large proportion of forward-looking price discovery. As such, market participants look to futures prices for information regarding future spot prices.

Chan (1992) and many others show that futures lead stock index movements. In commodity futures markets, Schwartz and Szakmary (1994) report that futures prices lead spot

prices in petroleum markets such as crude oil, heating oil, and unleaded gasoline. Bessler and Covey (1991) find that cattle futures prices provide more price discovery than cattle cash prices. Thus, futures markets provide higher levels of price discovery than spot or cash markets.

Futures markets offer individual and institutional investors the opportunity to trade (for hedging and speculation) in assets that they may not easily access in commodity spot and forward markets. These investors can also readily trade simultaneously in the commodity and currency futures markets on a real time basis. Accordingly, commodities and currencies are more closely linked and more responsive to one another in the futures market than in the spot market.

We continue in Section II with a description of the study's dataset and empirical methodology. Section III reports the study's results while section IV summarizes the study's findings and provides concluding remarks.

II. Data and Methodology

We collect daily commodity and currency futures data from Commodity Systems Inc.'s (CSI) database spanning a maximum range of 7/28/1992 to 1/28/2009. We use the active nearby futures contracts and the prices are denominated in US dollars. We employ two broad commodity index futures, the S&P GSCI (formerly Goldman Sachs Commodity Index) and the Reuters/Jefferies CRB commodity indices which began trading on 7/28/1992 and 3/6/1996, respectively. The GSCI contract is more popular than the CRB contract.

Investors may not have easy access to many commodity spot markets and, as discussed in Chen et al. (2008), many commodities lack liquid forward markets. However, most of the commodity and currency futures contracts used in this study are actively traded by individual and institutional investors.

Rosenberg and Traub (2008) and many others point out that futures markets' wide range of participants (from hedge funds to corporate hedgers and retail traders), centralized location, anonymous trading, and highly transparent trading systems suggest that futures prices can aggregate rich sources of private information. As a result, price discovery is much faster in futures markets. More important, daily futures settlement prices are readily available from various futures exchanges and news media. Daily settlement prices are determined by the futures exchange near the close of trading in order to calculate daily profits and losses on investors' positions. These profits and losses are both realized (resulting from actual purchases and sales) and unrealized (resulting from the daily marking-to-market revaluation).

All but three futures contracts are traded on the CME Group (Chicago Mercantile Exchange/Chicago Board of Trade/New York Mercantile Exchange Company) based in the US. CRB commodity index futures are traded on ICE Futures US (formerly named the New York Board of Trade). Lead and zinc futures used to construct country-specific commodity return indices are traded on the London Metals Exchange (LME). Each of these two metal futures contributes a small percentage to the indices' composition. For robustness purposes we test our results after omitting lead and zinc futures. We find that our results (available on request) are virtually the same.

As discussed previously, unlike other studies that employ data of lower frequencies, we use daily data as in Sephton (1992) to account for commodity/currency relationships being sensitive to time aggregation (Klaassen, 2005). As shown in Table I Panel A, overlapping data periods differ for different commodity/currency combinations due to data reporting limitations. In addition to the full sample, we also base our analyses on a sub-sample that ends on 6/29/2007.

This ensures that our results are not biased by the recent financial crisis that began with the Bear Stearns hedge fund collapse in July 2007.

[Insert Table I here]

The currencies of Australia, Canada, New Zealand, and South Africa are often referred to as "commodity currencies" reflecting that the underlying countries are large commodity exporters. Raw commodities comprise a significant percentage of these countries' exports such that an increase in commodity prices can directly increase their currency price. Panel B of Table I shows that these four countries are economically dependent on commodity exports and that each contributes a non-trivial percentage to total world commodity exports.

Both the S&P GSCI and Reuters/Jefferies CRB commodity index futures track various commodity sectors including energy, agricultural, livestock, precious metal, and industrial metal products. The GSCI is relatively concentrated in energy commodity futures (approximately 68% in May 2009) whereas the CRB is more commodity diverse (39% invested in energy futures). Consistent results between the two indices indicate that our results are not sensitive to index basket diversity.

In addition to the two broad commodity indices, we construct daily "country commodity" return indices which proxy a commodity-exporting country's terms-of-trade (Cashin et al., 2003; Chen and Rogoff, 2003; Chen, 2004). This process begins by identifying commodity series from the CSI database whose export shares are known (IMF Global Financial Database from Appendix 1, Table-A1 of Chen et al., 2008). From there, country-specific returns are calculated as the export share-weighted average of individual commodity returns.

In some cases, early sample data are not fully available for a given country return index. We use export share re-weighting in these cases to compensate for the missing series and to

prevent return attenuation. Using the post-weights found in Table II, the country commodity futures return series for country i at time t consisting of j commodities during unavailable data dates is calculated as follows:

$$\textit{Country Commodity Return}_{it} = \Sigma_j \textit{ Individual Commodity Return}_{jt} * \left(\frac{w_{ij}}{\sum_j w_{ij}} \right)$$

where the commodity-specific weights (w_{ij}) are reweighted according to data availability. Also, individual commodity returns are calculated as the difference in log daily futures prices.

All commodity futures contracts in Table II have consistent trade data after 7/12/2001 for the Australian, Canadian, and South African commodity return indices and after 5/14/1999 for the New Zealand commodity returns index. After these corresponding trading dates, country commodity indices contain an average 70.7%, 72.9%, and 100% of the available commodities for Australia, Canada, and South Africa, respectively. For robustness purposes, we conduct our analyses on a dataset that begins on 7/29/1992 as well as a second dataset which begins on 7/12/2001 for the Australian, Canadian, and South African return indices and 5/14/1999 for the New Zealand returns index. We find that the results (no significant causality and forecasting improvement in all countries) are similar across samples. We summarize these results in Appendix Tables AI and AII.

It is important to note that several futures contracts do not have long data histories. In particular, coal contracts are important components in the Australian and South African country indices but whose futures data are unavailable until 7/12/2001. Thus, these country indices can only replicate 46.3% and 78.0% of the true Australian and South African indices, respectively, before then. Moreover, aluminum futures contracts are important components in the Australian, Canadian, and New Zealand indices yet only begin to have consistent data coverage on

5/14/1999. Therefore, our country commodity indices under-represent the true indices under full information.

Due to data availability, the New Zealand commodity returns index comprises only 25.8% of New Zealand commodity exports. While some New Zealand futures data are available from the Australian Securities Exchange, the 12-hour lag between US and Australian futures trading may introduce non-synchronous trading problems. Further, these omitted futures comprise a large percentage of New Zealand's total exports implying that non-synchronous bias could be large if these components are included. As such, we trade off likely exchange bias in favor of possible index construction bias.

Unlike previous literature, we use currency futures data to mitigate the impacts of overnight currency transaction interest payments. Specifically, spot rate changes are only one component of currency trading profit. Interest earned (paid) on long (short) currency transactions must be included to accurately estimate profits in currency spot markets. Levich and Thomas (1993), Kho (1996), and many others use currency futures to eliminate the need for overnight interest rate accounting.

Pukthuanthong-Le et al. (2007) point out the computational advantages of using futures over spot data in forecasting currency returns. Specifically, price trends and returns can be measured simply by the log difference of futures prices given that futures prices reflect contemporaneous interest differentials between a foreign currency and the US dollar. Thus, using futures data allows us to conveniently measure currency returns.

We use two separate analyses to assess causality between commodity and currency returns. The first analysis uses coefficient restriction tests on the following two models to examine currency-to-commodity and commodity-to-currency causal relationships, respectively:

$$Comm_{j,t} = \alpha_{j,0} + \sum_{k=1}^{5} \beta_{j,k} Comm_{j,t-k} + \sum_{l=1}^{5} \gamma_{j,l} Curr_{i,t-l} + \varepsilon_{j,t} \qquad (1)$$

$$Curr_{i,t} = \alpha_{i,0} + \sum_{k=1}^{5} \beta_{i,k} Curr_{i,t-k} + \sum_{l=1}^{5} \gamma_{i,l} Comm_{j,t-l} + \varepsilon_{i,t} \qquad (2)$$

where $Curr_{i,t}$ are daily log returns for the ith currency at time t and $Comm_{j,t}$ are daily log returns for the jth commodity at time t. While our study's aim is cross-asset predictability, we include own-autoregressive lags in both models. This is done for consistency sake as well as the fact that exchange rates can exhibit non-trivial, own serial dependence (Klaassen, 2005).

The models above are estimated using OLS with the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix. For coefficient testing, two restriction tests are employed as follows on the cross-market coefficients, γ:

$$H_{O,1} : \gamma_1 = ... = \gamma_5 = 0$$
$$H_{O,2} : \gamma_1 + ... + \gamma_5 = 0$$

The first test assumes that all cross-market coefficients are jointly equal to zero. The second test assumes that the sum of all cross-market coefficients is equal to zero. This latter test is included given that it implies a stronger form of causality when rejected. In particular, the magnitude (sign) of summed coefficients indicates economic significance (relationship directionality).

Note that our commodity/currency samples span an average of 2,000-4,000 trading days. Given such large sample sizes, we use the 1% statistical significance level, while we also discuss results significant at the 5% level. Doing so frees our inferences from concluding that significant commodity/currency relationships exist when, in fact they do not.

The second analysis involves comparing forecasts between Model 1 and 2 against their respective own-autoregressive benchmark forecasts. Specifically, Models 1 and 2 and the following benchmark models are estimated using the first half of each available sample:

$$Comm_{j,t} = \alpha_{j,0} + \sum_{k=1}^{5} \beta_{j,k} Comm_{j,t-k} + \varepsilon_{j,t} \qquad (3)$$

$$Curr_{i,t} = \alpha_{i,0} + \sum_{k=1}^{5} \beta_{i,k} Curr_{i,t-k} + \varepsilon_{i,t} \qquad (4)$$

The initial estimate for each model is then used as the basis for a rolling, out-of-sample forecast. Our rolling forecast scheme uses data from time 1 to time t to estimate the above models and then calculates a 1-step ahead forecast for time $t+1$. As the process continues, the in-sample window increases while the out-of-sample window decreases. This process proceeds until the out-of-sample window is exhausted at the end of each (jointly) available sample.

After computing a given returns forecast, Root Mean Square Error (RMSE) percentage differences are calculated as follows:

$$(RMSE - RMSE_{Benchmark}) \Big/ RMSE_{Benchmark}$$

A negative value indicates that augmented Model 1 (Model 2) provides superior forecasting power relative to benchmark Model 3 (Model 4); a positive value indicates inferior forecasting power. Significant negative values also suggest that a given currency (commodity) return series has predictive power for a given commodity (currency) return series.

III. Results

III-A. Contemporaneous Correlations

Figure 1 graphs monthly futures price movements of the two board commodity indices and five currencies from July 1992 through January 2009. There is evidence of comovement between commodity indices and currencies, although these relationships are less obvious for the South African rand and Japanese yen. We also notice that commodity and currency futures prices have become more volatile since the second half of 2007.

Panel A of Table III reports cross-asset contemporaneous correlations for the full sample. We find that all commodity-exporting countries' currency returns are contemporaneously correlated with both broad commodity index as well as each respective country-commodity index returns. All correlation coefficients are significantly positive indicating that commodity price increases are associated with positive currency returns. Australian dollar futures returns are generally more correlated with the broad commodity indices (0.250 with S&P GSCI and 0.412 with CRB) than are other currency futures returns. All other full-sample futures returns also have coefficients larger than 0.20 with both indices, except for the relationship between the rand and GSCI (0.162).

[Insert Table III and Figure 1 here]

We also find that yen returns are not correlated with the two broad commodity index returns (0.001 and 0.055). This result is not surprising given that Japan is not a raw commodity exporting country. Thus, currency-to-commodity relationships likely exist only for commodity-exporting countries.

Of particular note is the fact that while statistically significant, the correlation magnitude for the New Zealand dollar and its country-commodity returns index (0.163) is lower than for the other pairs (0.319 for Australia, 0.225 for Canada, and 0.225 for South Africa). This cannot be attributed to index diversity given that the South African returns index has a relatively high correlation with the rand. Rather, low New Zealand/dollar correlation may be a result of index construction. As seen in Table II, our New Zealand commodity returns index comprises only 25.8% of the IMF export shares.

The GSCI and CRB commodity indices are highly cross correlated (0.710). The significance of this relationship can be explained by both indices tracking the same major

commodity categories. The lack of perfect correlation suggests that different index allocations lead each index to reflect different commodity return aspects. This latter fact affirms that our use of the two indices is not an exercise in redundancy.

Panel B shows that the correlation coefficients between commodity and currency returns decrease substantially during the sub-sample, although the results are still significant at the 1% level. For instance, the correlation coefficient between the Australian dollar and the GSCI index is 0.133, 0.290 for the CRB, and 0.213 for the Australian commodity returns index.

It is also worth noting that correlations between the currency futures and the country-specific commodity return indices are generally higher if the sample starts from the day when all of the component commodities have started trading (i.e., 7/12/2001 for Australia, Canada, and South Africa and 5/14/1999 for New Zealand). See Table AI in the appendix.

III-B. Currency-to-Commodity Lead-Lag Relationships

Table IV reports the results of cross-market coefficient restriction tests on currency-to-commodity return relationships.

[Insert Table IV here]

Panels A and B report zero-coefficient restriction test p-values for the full and sub-samples, respectively. We find that no significant currency-to-commodity relationships exist. The lowest p-value is 0.065 for the sub-sample Australian dollar-CRB index relationship.

Panels C and D report the sum of cross-market coefficients for the full and sub-samples, respectively. Again, we find little evidence of currency-to-commodity relationships for commodity exporting countries. The only exception to this finding is the Australian dollar-to-CRB index relationship. This sum is 0.121 and is significant at the 5% but not 1% level.

- 14 -

Note that the above relationships are re-examined using 10 lags for both commodities and currencies. We find that results throughout the paper remain qualitatively unchanged between the two model specifications (results available on request). This finding indicates that the results in Table IV are robust to lag specification.

Table V compares out-of-sample forecasting accuracy between currency-augmented commodity forecasting models and their own-autoregressive commodity forecasting benchmarks.

[Insert Table V here]

Panels A and B report RMSE percentage differences for the full and sub-samples, respectively. We find that RMSE percentage differences are mixed with respect to sign but all are economically insignificant. The greatest forecasting improvement is still less than 5%. Insignificant differences suggest that currency returns are not capable of forecasting future commodity returns. In other words, currency returns do not possess casual relationships with commodity returns.

Chen et al. (2008) find that currency returns are able to predict future broad commodity index returns at quarterly frequencies. Based on the present value models of exchange rate determination (Campbell and Shiller, 1987; Engel and West, 2005), they argue that the currency exchange rate can predict economic fundamentals because the currency rate reflects expectations of future changes in these fundamentals. Specifically, currency rates are forward looking while commodity prices are focused on short run supply and demand conditions. As a result, forward looking currency exchange rates can predict commodity prices.

A refinement of their explanation for currency-to-commodity relationships may be in macroeconomic expectations leading to changes in a country's terms-of-trade. Currency returns'

forward-looking nature suggest that they contain economic expectations information (Mark, 1995; Sephton, 1995; Gardeazabal et al., 1997; Engel and West, 2005; Klaassen, 2005). Commodity returns, on the other hand, contain information regarding a commodity exporter's terms-of-trade given that commodity price shocks originate from exogenous, international markets and that these exporters are world-price takers (Cashin et al., 2003; Chen and Rogoff, 2003, Chen, 2004).

Under the above framework, economic expectations embedded within currency returns contain information regarding a commodity exporter's capacity to meet exporting expectations. While this exporter is likely a price taker, commodity market elasticity conditions imply that small supply imbalances induce high price responses (Chen et al., 2008). Thus, expectations regarding future commodity conditions could lead to commodity transactions and therefore commodity price changes.

We suggest that the incorporation of economic expectations into trade terms takes place over intervals shorter than what business-motivated economic agents need to alter their commodity positions after an exchange rate shock. These short run intervals are, however, of sufficient length for commodity speculators to profit from economic expectations information embedded in currency prices. These speculators have greater information processing abilities relative to the average economic agent and therefore are able to capture asymmetric information profits. Given commodity futures markets' ability to rapidly incorporate information, speculative activity brings about rapid currency (economic expectations) to commodity (terms-of-trade) comovement.

Note that our explanation does not contradict previous findings of long-horizon commodity/currency relationships. Rather, we make a distinction between speculative versus

business-necessitated commodity transactions. The former transaction takes place over daily frequencies in liquid futures markets and involves informed traders profiting from superior information collection and processing skills. The latter transaction takes place over much longer time frames and involves relatively uninformed agents adjusting commodity positions according to their business-specific economic outlooks.

III-C. Commodity-to-Currency Lead-Lag Relationships

Table VI reports cross-market coefficient restriction causality tests for commodity-to-currency return relationships.

[Insert Table VI here]

Panels A and B report zero-coefficient restriction test p-values for the full and sub-samples, respectively. We find little evidence that commodities cause currency returns. Two possible exceptions to this finding are the Australian returns index-to-Australian dollar and the Canadian returns index-to-Canadian dollar relationships. While these relationships are significant at the 5% level in the full sample (p-values of 0.011 and 0.043 for the Australian-index and Canadian-index, respectively), they are not significant in the sub-sample (p-values of 0.070 and 0.590, respectively).

Panels C and D report the sum of cross-market coefficients. There is no evidence of significant daily lead-lag, commodity-to-currency relationships. Specifically, neither broad nor country-specific commodity returns can consistently explain future currency returns. The sums of coefficients are generally economically insignificant. Two exceptions are, again, the Australian returns index-to-Australian dollar and the Canadian returns index-to-Canadian dollar causal relationships. Both of these relationships are significant at the 1% level in the full sample

but only the former relationship is significant at the 5% level in the sub-sample. Moreover, only the Australian returns index-to-Australian dollar results are moderately and economically significant given that the sum of cross-asset coefficients is 0.130 and 0.095 for the full and sub-samples, respectively.

Table VII reports forecasting accuracy results between commodity-augmented currency return models and their own-autoregressive currency benchmarks. We find that commodity returns are rarely capable of increasing out-of-sample forecasting accuracy for currency returns, relative to own autoregressive models. Like the currency-to-commodity forecasting results in Table V, no improvement for the commodity-to-currency forecasting is larger than 5%. In other words, we find evidence that commodity returns do not lead currency returns at relatively short time intervals. Our results are consistent across sample selection indicating that these results are robust to both index construction and the effects of the financial crisis.

[Insert Table VII here]

For comparison purposes, we repeat the causality and forecasting analyses on Japanese yen-to-broad commodity index returns to assess if currency-to-commodity relationships exist for a non-commodity exporting country. As in the correlation analysis, we find no significant links between the yen and broad commodity index returns.

The commodity-to-currency causality and forecasting results in Tables VI and VII indicate the efficient information transmission between the commodity and currency markets. This market efficiency also suggests that the terms-of-trade information embedded within commodity returns is rapidly incorporated into the economic expectations embedded in a commodity-exporting country's currency returns.

Theoretical models discussed in the introduction suggest a causal relationship between commodity prices and currency exchange rates. While these models (particularly the Sticky Price Model and Portfolio Balance Model) provide adequate commodity-to-currency explanations over longer time frames, they likely do not hold over shorter intervals in liquid futures markets. The reason for this is that each model requires economic agents to make currency transactions in response to exogenous stimuli. However, the average economic agent will not likely recognize and incorporate economic expectations into their business decisions over very short time intervals.

The lack of commodity-to-currency causal relationships at daily intervals does not, however, preclude rapid information transfers between asset classes as we suggest. In this case, speculators in futures markets rapidly incorporate terms-of-trade information into economic expectations over daily (or shorter) time frames while other economic agents cause long-horizon commodity-to-currency relationships through their business-necessitated activity.

Overall, we find no significant causality and forecasting power between the currency and commodity futures markets in both directions and in both the full and sub periods. If anything, the Australian commodity returns index Granger-causes the Australian dollar in the full period analysis, while we find no forecasting improvement. Moreover, all pairs of commodity and currency futures are significantly and contemporaneously correlated.

IV. Conclusions

We examine short-run commodity/currency relationships in four commodity-exporting countries (Australia, Canada, New Zealand, and South Africa) using both restriction-based causality tests and an out-of-sample forecasting analysis. We use daily futures prices from July

1992 through January 2009. While investors do not have easy access to many commodity spot and forward markets, they can readily trade in futures markets. They can even speculate on the commodity and currency futures prices simultaneously on a real time basis.

We find that commodity exporting countries' currency returns are contemporaneously correlated with both broad and country-specific commodity index returns. In contrast, currency and commodity returns do not have causal relationships with each other. Currency (commodity) returns are not capable of predicting future commodity (currency) returns. These results, which are robust to the recent financial crisis, show that currency exchange rates and commodity prices are closely related, but that the lead-lag relationship disappears within a day. We conclude that commodity-exporting countries' terms-of-trade information embedded in commodity returns is rapidly incorporated into these countries' economic expectations which are embedded in their exchange rates (and vice versa).

Our results are different from Chen et al. (2008) who use quarterly spot data. They find that currency exchange rates can remarkably forecast commodity prices, suggesting that currency rates contain information beyond what has been reflected in commodity prices. However, their findings may be resulted from the less informational efficient commodity spot markets.

In our paper, the rapid information transmission between the commodity and currency markets is a consequence of informed traders using futures markets to profit from expectations/trade-term information. Previous literature notes that futures markets in general take price leadership roles with respect to spot markets. This is because futures markets are active, transparent, of low transaction costs, and have no short selling constraints. The very nature of futures markets allows informed traders to instantaneously incorporate economic expectations into the currency and commodity futures prices.

For future research, we suggest examining individual commodity futures to individual currency futures relationships. Of particular interest among practitioners is the relationship between the Australian dollar and gold and the relationship between the Canadian dollar and crude oil (see, e.g., Lien, 2008). Another avenue is how monetary policy and real interest rates would affect commodity/currency relationships. Frankel (2005; 2006) and Blanch (2008) note that US monetary policy has significant impacts on commodity prices. It is also interesting to examine whether investor psychology motivates commodity/currency relationships. An example would be whether increased investor risk appetite entices investors into both the commodity and high-yielding currency futures markets. All this warrants future research.

References

Bessler, D.A., and Covey, T. (1991). Cointegration: Some results on U.S. cattle prices. *Journal of Futures Markets* 11, 461-474.

Blanch, F. (2008). Insight: Commodities rally driven by fundamentals, not speculators. *Financial Times* June 24, 2008.

Campbell, J.Y., and Shiller, R. (1987). Cointegration and tests of present value models. *Journal of Political Economcy* 95, 1062-1088.

Cashin, P., Cespedes, L., and Sahay, R. (2003). Commodity currencies: Developing countries reliant on commodity exports see the fate of their exchange rates tied to fickle commodity markets. *Finance and Development* 40, 45-48.

Chan, K. (1992). A further analysis of the lead-lag relationship between the cash market and stock index futures market. *Review of Financial Studies* 5, 123-152.

Chen, Y., (2004). Exchange rates and fundamentals: Evidence from commodity economies. *Unpublished Working Paper*, Nov. 2004.

Chen, Y.C., and Rogoff, K. (2003). Commodity currencies. *Journal of International Economics* 60, 133-160.

Chen, Y., Rogoff, K., and Rossi, B. (2008). Can exchange rates forecast commodity prices? *NBER Working Paper* No. 13901.

Chinn, M., and Meese, R. (1995). Banking on currency forecasts: How predictable is change in money? *Journal of International Economics* 38, 161-178.

Engel, C., and West, K. (2005). Exchange rates and fundamentals. *Journal of Political Economy* 113, 485-517.

Frankel, J. (2005). How interest rates cash a shadow over oil. *Financial Times* April, 14 2005.

Frankel, J. (2006). The effect of monetary policy on real commodity prices. In Campbell, J. (ed.) *Asset Prices and Monetary Policy*, University of Chicago Press.

Gardeazabal, J., Regulez, M., and Vazquez, J. (1997). Testing the Canonical Model of exchange rates with unobservable fundamentals. *International Economic Review* 38, 389-404.

Groen, J.J. (2005). Exchange rate predictability and monetary fundamentals in a small multi-country panel. *Journal of Money, Credit, and Banking* 37, 495-516.

Kho, B.C. (1996). Time-varying risk premia, volatility, and technical trading rule profits: Evidence from foreign currency futures markets. *Journal of Financial Economics* 41, 249-290.

Klaassen, F. (2005). Long swings in exchange rates: Are they really in the data? *Journal of Business and Economic Statistics* 23, 87-95.

Levich, R.M., and Thomas, L.R. (1993). The significance of technical trading rules in the FX market: A bootstrap approach. *Journal of International Money and Finance* 12, 451-474.

Lien, K. (2006). *Day Trading and Swing Trading the Currency Market: Technical and Fundamental Strategies to Profit from Market Moves*. 2nd Edition, Wiley Trading.

MacDonald, R., and Marsh, I. (1997). On fundamentals and exchange rates: A Casselian perspective. *Review of Economics and Statistics* 79, 655-664.

MacDonald, R., and Taylor, M.P. (1994). The Monetary Model of exchange rate: Long-run relationships, short-run dynamics and how to beat a random walk. *Journal of International Money and Finance* 13, 276-290.

Mark, N. (1995). Exchange rates and fundamentals: Evidence on long-horizon predictability. *American Economic Review* 85, 201-218.

Mark, N.C., and Sul, D. (2001). Nominal exchange rates and monetary-fundamentals: Evidence from a small post-Bretton Woods sample. *Journal of International Economics* 53, 29-52.

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

Pukthuanthong-Le, K., Levich, R.M., and Thomas III, L.R. (2007). Do foreign exchange markets still trend? *Journal of Portfolio Management* Fall, 114-118.

Rosenberg, J.V., and Traub, L.G. (2008). Price discovery in the foreign currency futures and spot market. *Federal Reserve Bank of New York Staff Reports, Number 262*.

Sephton, P.S. (1992). Modeling the link between commodity prices and exchange rates: The tale of daily data. *Canadian Journal of Economics* 25, 156-171.

Schwartz, T.V., and Szakmary, A.C. (1994). Price discovery in petroleum markets: Arbitrage, cointegration, and time interval of analysis. *Journal of Futures Markets* 14, 147-167.

Table I: Sample Information

Panel A: Overlapping Sample Beginning Dates

The following table reports overlapping date ranges for each currency/commodity pair. AD, CD, NZ, RA, and JY refer to the Australian dollar, Canadian dollar, New Zealand dollar, South African rand, and Japanese yen, respectively.

	AD	CD	RA	NZ	JY
S&P GSCI Commodity Index	7/29/1992	7/29/1992	5/08/1997	5/08/1997	7/29/1992
CRB Commodity Index	3/07/1996	3/07/1996	5/08/1997	5/08/1997	3/07/1996
Country Specific Indices	7/29/1992	7/29/1992	5/08/1997	5/08/1997	

Panel B: Commodity Export Ratios

The following table reports each country's total exports by commodity type relative to that country's Gross Domestic Product (% GDP) and relative to the total level of World exports by commodity type. Each measure is the average of yearly observations ranging from 1977 to 2007 (where data permits) as reported by the World Bank's World Development Indicators database. Note that all values reported by the World Bank are relative to constant US Dollars (2000).

	% GDP				% World Export Share			
	Agriculture	Food	Fuel	Ore	Agriculture	Food	Fuel	Ore
Australia	1.30%	3.31%	2.81%	2.80%	3.43%	2.61%	2.29%	6.02%
Canada	2.23%	2.46%	3.57%	2.07%	10.92%	3.53%	4.95%	8.13%
New Zealand	4.15%	10.68%	0.39%	1.06%	1.63%	1.29%	0.05%	0.35%
South Africa	0.86%	2.29%	1.81%	3.17%	1.07%	0.81%	0.82%	3.49%
World	0.52%	1.72%	1.76%	0.64%				

Table II: Export Shares

The following table reports pre and post weighting export shares for four commodity exporting countries. The pre weighting column refers to International Monetary Fund (IMF) export shares reported in Chen et al. (2008). The post weighting column refers to IMF export shares that are reweighted based on data availability in the CSI dataset. Note that the CSI dataset does not include a futures contract on beef. As such, beef returns are proxied by an average of live cattle and feeder cattle returns.

Australia	Pre	Post		Canada	Pre	Post
Coal	24.4	34.5		Crude Oil	21.4	29.4
Gold	9.4	13.3		Lumber	13.6	18.7
Wheat	8.3	11.7		Natural Gas	10.7	14.7
Aluminum	8.1	11.5		Beef	7.8	10.7
Beef	7.9	11.2		Aluminum	5.0	6.9
Natural Gas	4.8	6.8		Wheat	3.4	4.7
Cotton	2.8	4.0		Gold	2.3	3.2
Copper	2.8	4.0		Zinc	2.3	3.2
Zinc	1.5	2.1		Copper	2.0	2.7
Lead	0.7	1.0		Coal	1.8	2.5
Total	70.7			Hogs	1.8	2.5
				Corn	0.5	0.7
				Silver	0.3	0.4
				Total	72.9	

New Zealand	Pre	Post		South Africa	Pre	Post
Beef	9.4	36.4		Gold	48.0	48.0
Aluminum	8.3	32.2		Platinum	30.0	30.0
Lumber	8.1	31.4		Coal	22.0	22.0
Total	25.8			Total	100	

Table III: Contemporaneous Correlations

The tables below report contemporaneous correlations between various commodity and currency returns. AD, CD, RA, NZ, and JY refer to the Australian dollar, Canadian dollar, South African rand, New Zealand dollar, and Japanese yen currency return series, respectively. All correlations are statistically different from zero at the 1% significance level except for the full sample GSCI/JY pair.

Panel A: Full Sample (7/29/1992 or later to 1/28/2009)

	AD	CD	RA	NZ	JY
S&P GSCI Commodity Index	0.250	0.261	0.162	0.214	0.001
CRB Commodity Index	0.412	0.375	0.266	0.349	0.055
Country Specific Indices	0.319	0.225	0.225	0.163	

Panel B: Sub-Sample (7/29/1992 or later to 6/29/2007)

	AD	CD	RA	NZ	JY
S&P GSCI Commodity Index	0.133	0.136	0.073	0.102	0.056
CRB Commodity Index	0.290	0.239	0.178	0.237	0.157
Country Specific Indices	0.213	0.122	0.185	0.074	

Table IV: Currency-to-Commodity Causality Tests

The tables below report coefficient restriction tests on the following OLS estimated model:

$$Comm_{j,t} = \alpha_{j,0} + \sum_{k=1}^{5} \beta_{j,k} Comm_{j,t-k} + \sum_{l=1}^{5} \gamma_{j,l} Curr_{i,t-l} + \varepsilon_{j,t}$$

In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. The sample period starts on 7/29/1992 (or later depending on data availability; See Table I, Panel A) and ends on 1/28/2009 for the full sample (6/29/2007 for the sub-sample). P-values are reported for the cross-market zero-coefficient results while the sum of cross-market coefficients are reported for the coefficient-sum results. ** and * in Panels C and D denote statistical significance at the 1% and 5% significance levels, respectively.

Panel A: P-values of Cross-market Zero-Coefficient Tests, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.721	0.654	0.477	0.780
CRB Commodity Index	0.419	0.551	0.378	0.957
Country Specific Indices	0.847	0.407	0.979	0.258

Panel B: P-values of Cross-market Zero-Coefficient Tests, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.381	0.784	0.661	0.900
CRB Commodity Index	0.065	0.309	0.434	0.731
Country Specific Indices	0.362	0.645	0.393	0.874

Panel C: Sum of Cross-market Coefficients, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.152	0.009	0.138	0.009
CRB Commodity Index	0.104	0.069	0.087	0.019
Country Specific Indices	0.056	0.044	0.030	0.073

Panel D: Sum of Cross-market Coefficients, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.153	0.004	0.066	0.102
CRB Commodity Index	0.121*	0.096	0.056	0.030
Country Specific Indices	0.079	0.094	-0.034	0.040

Table V: Currency-to-Commodity Forecasting Results

The tables below report RMSE percentage differences between a currency-augmented commodity forecasting model

$$Comm_{j,t} = \alpha_{j,0} + \sum_{k=1}^{5} \beta_{j,k} Comm_{j,t-k} + \sum_{l=1}^{5} \gamma_{j,l} Curr_{i,t-l} + \varepsilon_{j,t}$$

and an own-autoregressive forecasting model

$$Comm_{j,t} = \alpha_{j,0} + \sum_{k=1}^{5} \beta_{j,k} Comm_{j,t-k} + \varepsilon_{j,t}$$

Each model is estimated using OLS with the first half of available data while rolling, out-of-sample forecasts are computed for the remaining half. Negative (positive) values indicate that the currency-augmented commodity (benchmark) forecasting model is superior to the benchmark (currency-augmented commodity) forecasting model. In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. The sample period starts on 7/29/1992 (or later depending data availability) and ends on 1/28/2009 for the full sample and 6/29/2007 for the sub-sample.

Panel A: RMSE Percentage Differences, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	-0.06%	-0.20%	0.85%	1.06%
CRB Commodity Index	0.88%	1.35%	0.80%	1.05%
Country Specific Indices	0.27%	0.04%	0.29%	-0.09%

Panel B: RMSE Percentage Differences, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	-1.33%	-1.25%	0.06%	0.97%
CRB Commodity Index	-0.66%	0.16%	-1.10%	-0.24%
Country Specific Indices	0.14%	-0.02%	0.26%	0.29%

Table VI: Commodity-to-Currency Causality Tests

The tables below report coefficient restriction tests on the following OLS estimated model:

$$Curr_{i,t} = \alpha_{i,0} + \sum_{k=1}^{5} \beta_{i,k} Curr_{i,t-k} + \sum_{l=1}^{5} \gamma_{i,l} Comm_{j,t-l} + \varepsilon_{i,t}$$

In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. The sample period starts on 7/29/1992 (or later depending on data availability) and ends on 1/28/2009 for the full sample and 6/29/2007 for the sub-sample. P-values are reported for the cross-market zero-coefficient results while the sum of cross-market coefficients are reported for the coefficient-sum results. ** and * in Panels C and D denote statistical significance at the 1% and 5% significance levels, respectively.

Panel A: P-values of Cross-market Zero-Coefficient Tests, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.196	0.029	0.817	0.258
CRB Commodity Index	0.264	0.098	0.671	0.260
Country Specific Indices	0.011	0.043	0.828	0.995

Panel B: P-values of Cross-market Zero-Coefficient Tests, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.167	0.738	0.396	0.088
CRB Commodity Index	0.433	0.288	0.188	0.052
Country Specific Indices	0.070	0.590	0.704	0.823

Panel C: Sum of Cross-markets Coefficients, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.033	0.045 **	-0.016	0.019
CRB Commodity Index	0.077	0.057	-0.070	0.066
Country Specific Indices	0.130 **	0.052 **	-0.031	0.019

Panel D: Sum of Cross-markets Coefficients, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.011	0.019	-0.008	-0.021
CRB Commodity Index	0.011	-0.007	-0.083	0.000
Country Specific Indices	0.095 *	0.020	-0.050	-0.018

Table VII: Commodity-to-Currency Forecasting Results

The tables below report RMSE percentage differences between a commodity-augmented currency forecasting model

$$Curr_{i,t} = \alpha_{i,0} + \sum_{k=1}^{5} \beta_{i,k} Curr_{i,t-k} + \sum_{l=1}^{5} \gamma_{i,l} Comm_{j,t-l} + \varepsilon_{i,t}$$

and an own-autoregressive forecasting model

$$Curr_{i,t} = \alpha_{i,0} + \sum_{k=1}^{5} \beta_{i,k} Curr_{i,t-k} + \varepsilon_{i,t}$$

Each model is estimated using OLS with the first half of available data while rolling, out-of-sample forecasts are computed for the latter half. Negative (positive) values indicate that the commodity-augmented currency (benchmark) forecasting model is superior to the benchmark (commodity-augmented currency) forecasting model. In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. The sample period starts on 7/29/1992 (or later depending data availability) and ends on 1/28/2009 for the full sample and 6/29/2007 for sub-sample.

Panel A: RMSE Percentage Differences, Full Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.32%	-0.02%	0.22%	0.21%
CRB Commodity Index	0.54%	0.05%	0.34%	0.50%
Country Specific Indices	-0.29%	-0.07%	0.14%	0.14%

Panel B: RMSE Percentage Differences, Sub-Sample

	AD	CD	RA	NZ
S&P GSCI Commodity Index	0.59%	0.00%	-0.23%	-0.55%
CRB Commodity Index	-0.17%	-0.49%	-1.10%	-0.72%
Country Specific Indices	-0.04%	0.00%	0.15%	0.17%

Figure 1: Monthly Futures Prices
July 1992 – January 2009

The figure below reports end-of-the-month futures prices (log scale) each with a scaled starting value of 100 in July 1992. The price series are the S&P GSCI commodity index, CRB commodity index, AD (Australian dollar), CD (Canadian dollar), AR (South African rand), NZ (New Zealand dollar), and JY (Japanese yen).
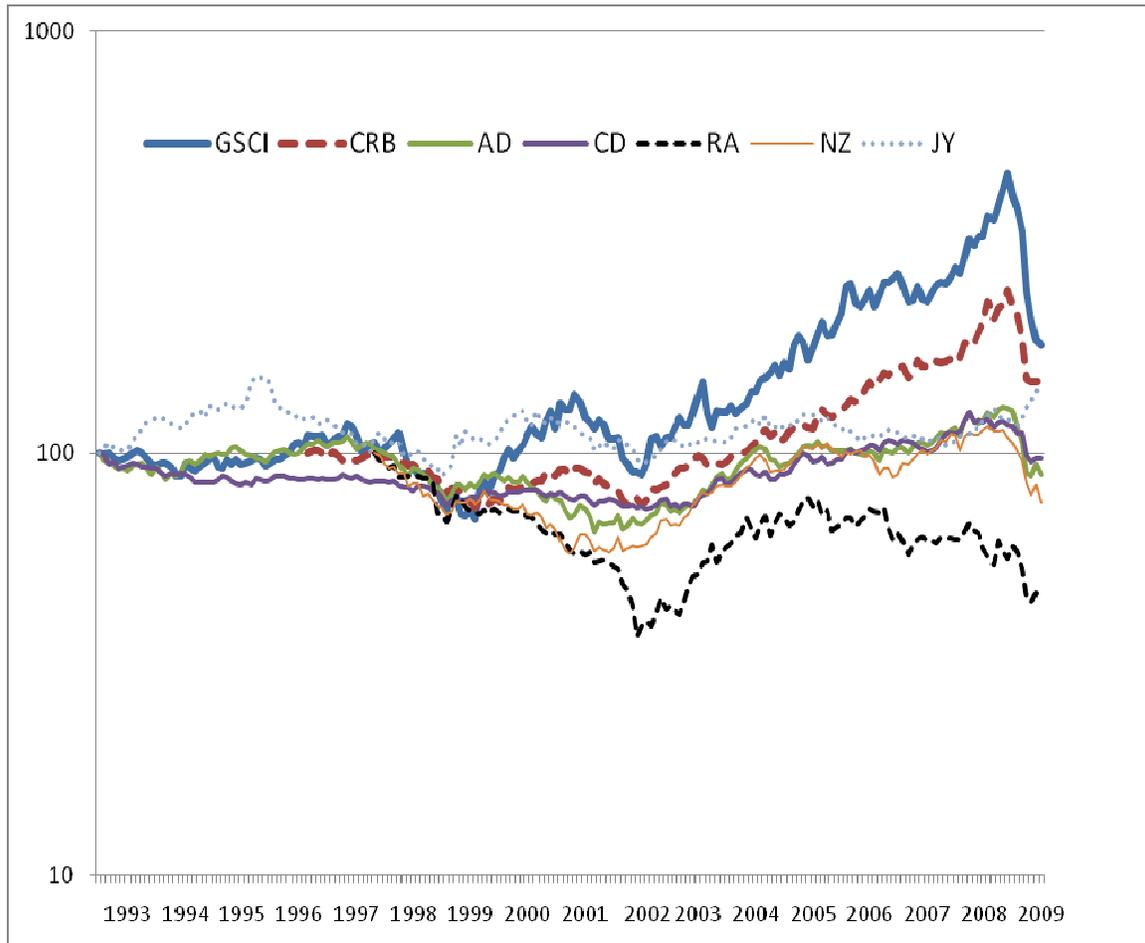
Appendix

Table AI: Contemporaneous Correlations and Currency-to-Commodity Sample Robustness

The tables below report robustness results for currency-to-commodity relationships across two samples not included in the discussions above. Panel A reports sample date ranges. Panel B reports cross-market zero-coefficient Granger causality test p-values while Panel C reports the summed coefficients of cross-market variables as well as indicators of statistical significance. Panel D reports RMSE percentage differences of currency-augmented commodity forecasting models relative to own-autoregressive commodity benchmarks. In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. ** and * in Panel C denote statistical significance at the 1% and 5% significance levels, respectively. The beginning date of each sample corresponds to when a given country-commodity return index's individual commodity components were all trading. The end of Sample B corresponds to the (approximate) beginning of the world financial crisis.

Panel A: Sample Ranges and Contemporaneous Correlations between Currency and Country Index

		AD	CD	NZ	RA
Sample A	Beginning	7/12/2001	7/12/2001	5/14/1999	7/12/2001
	Ending	1/28/2009	1/28/2009	1/28/2009	1/28/2009
	Corr. Coeff.	0.393	0.332	0.265	0.161
Sample B	Beginning	7/12/2001	7/12/2001	5/14/1999	7/12/2001
	Ending	6/29/2007	6/29/2007	6/29/2007	6/29/2007
	Corr. Coeff.	0.239	0.193	0.230	0.063

Panel B: P-values of Cross-market Zero-Coefficient Tests

	AD	CD	RA	NZ
Country Indices (Sample A)	0.746	0.433	0.976	0.287
Country Indices (Sample B)	0.331	0.408	0.641	0.405

Panel C: Sum of Cross-markets Coefficients

	AD	CD	RA	NZ
Country Indices (Sample A)	0.015	0.025	0.046	0.019
Country Indices (Sample B)	0.031	0.132	-0.008	0.027

Panel D: RMSE Percentage Differences

	AD	CD	RA	NZ
Country Indices (Sample A)	-1.31%	-0.32%	0.25%	-1.71%
Country Indices (Sample B)	-5.60%	-2.36%	0.20%	-1.48%

Table AII: Contemporaneous Correlations and Commodity-to-Currency Sample Robustness

The tables below report robustness results for commodity-to-currency relationships across two samples not included in the discussions above. Panel A reports sample date ranges. Panel B reports cross-market zero-coefficient Granger causality test p-values while Panel C reports the summed coefficients of cross-market variables as well as indicators of statistical significance. Panel D reports RMSE percentage differences of commodity-augmented currency forecasting models relative to own-autoregressive currency benchmarks. In each panel, AD, CD, RA, and NZ refer to the Australian dollar, Canadian dollar, South African rand, and New Zealand dollar return series, respectively. ** and * in Panel C denote statistical significance at the 1% and 5% significance levels, respectively. The beginning date of each sample corresponds to when a given country-commodity return index's individual commodity components were all trading. The end of Sample B corresponds to the (approximate) beginning of the world financial crisis.

Panel A: Sample Date Ranges

		AD	CD	NZ	RA
Sample A	Beginning	7/12/2001	7/12/2001	5/14/1999	7/12/2001
	Ending	1/28/2009	1/28/2009	1/28/2009	1/28/2009
Sample B	Beginning	7/12/2001	7/12/2001	5/14/1999	7/12/2001
	Ending	6/29/2007	6/29/2007	6/29/2007	6/29/2007

Panel B: P-values of Cross-market Zero-Coefficient Tests

	AD	CD	RA	NZ
Country Index (Sample A)	0.038	0.019	0.891	0.956
Country Index (Sample B)	0.118	0.603	0.841	0.932

Panel C: Sum of Cross-markets Coefficients

	AD	CD	RA	NZ
Country Index (Sample A)	0.148*	0.083	-0.051	0.029
Country Index (Sample B)	0.083	0.020	-0.092	-0.011

Panel D: RMSE Percentage Differences

	AD	CD	RA	NZ
Country Index (Sample A)	-0.33%	0.17%	0.68%	0.44%
Country Index (Sample B)	1.66%	0.86%	0.80%	0.40%