Impact of Commodity Prices on High-yield Currencies: The Role of Financial Conditions*

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ABSTRACT

This paper examines the relation between high-yield currencies and commodity prices. We propose a smooth transition-structural vector error correction model that incorporates commodity price indices, nominal exchange rates, and macroeconomic factors. Our analysis shows that unexpected decreases in commodity prices depreciate currencies in commodity-exporting countries, but only during episodes of high funding illiquidity, financial uncertainty, and currency volatility. Importantly, this asymmetric effect arises from changes in financial conditions rather than in the business cycle. Moreover, we find that commodity price shocks immediately affect these currencies, while the dynamics of the currency response also depend on how a country's macroeconomic fundamentals adjust to such shocks. Overall, this paper helps explain the severe depreciation of high-yield currencies in periods of financial distress, thus contributing to our comprehension of carry trade reversals.

JEL Codes: C32, F31, G15

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1 Introduction

The currency carry trade strategy involves borrowing in low interest rate currencies and investing in high interest rate currencies. This strategy typically implies a long exposure to currencies of developed, commodity-exporting economies, such as Australia, Canada, and New Zealand. These currencies are volatile and tend to fluctuate with commodity prices (see Figure 1). Moreover, the relation appears to be particularly pronounced in times of financial distress, as illustrated by the severe currency depreciations (relative to the US dollar) and sharp commodity price decreases during the latest financial crisis. Given this observation, does the unexpected decline in commodity prices help explain the weak profitability of the carry trade in periods of financial turmoil? The aim of this paper is to answer this question and, thus, to enrich our understanding of the structural relation between commodity prices and high-yield currencies in times of financial distress.

Figure 1 [about here]

Addressing this question requires an econometric model that allows extracting unanticipated commodity price changes to ensure that currency responses are not contaminated by other shocks. Further, this model should offer a decomposition of the currency responses by favorable and unfavorable regimes to be able to study how these effects vary with current financial conditions. To this end, we propose a specification that contains both features and consider a smooth transition-structural vector error correction model (ST-SVECM) involving a country's commodity price index, its nominal exchange rate, and a set of key macroeconomic variables. We exploit market information about the level of funding liquidity, financial uncertainty, and currency volatility to distinguish periods of favorable and unfavorable financial conditions.

With the aim of understanding the severe currency depreciations observed in times of financial distress, we analyze the structural relation between commodity prices and currencies through the lens of different financial conditions. We thus investigate whether – and to what extent – the impact (i.e., contemporaneous) and dynamic responses of currencies to a commodity price shock differ across financial regimes. Although our analysis focuses mostly on the short-run currency reactions, we also compare short-run and long-run elasticities of currencies with respect to commodity prices.[1] The presence of an asymmetry in the structural relation over the short-run – but not necessarily over the long-run – would contribute to our comprehension of why the carry trade strategy tends to be unprofitable during the rare and short-lived episodes of financial turbulences (commonly referred to as 'carry trade reversals').

Our analysis departs from the existing literature in two important dimensions. First, most previous studies have documented the structural effects of commodity prices on exchange rates under the critical assumption that the relation does not vary over different regimes, as measured by financial conditions. These studies essentially show that currencies of commodity-exporting countries appreciate immediately, and over the short run, after a positive, unanticipated commodity price shock (see, e.g., Cologni and Manera, 2008; Brahmasrene, Huang, and Sissoko, 2014; Ferraro, Rogoff, and Rossi, 2015). In addition, evidence of cointegration relations between exchange rates and commodity prices for commodity-exporting countries suggest a wide range of long-run elasticities, as currencies converge to an appreciation of between 0.1% and 2% when commodity prices increase by 1% (see, e.g., Amano and van Norden, 1995, 1998; Chen and Rogoff, 2003; Cashin, Céspedes, and Sahay, 2004; Ricci, Milesi-Ferretti, and Lee, 2013). The results obtained to date, however, potentially mask some important asymmetries in the relation between commodity prices and currencies, which may likely vary across different financial conditions.

Second, we contribute to the recent literature related to the explanation of the forward-premium puzzle. This strand of studies provides strong evidence that high-yield currencies (and thus the carry trade) perform poorly when financial conditions deteriorate, in particular when funding liquidity dries out, financial uncertainty increases, and currencies become more volatile (see, e.g., Brunnermeier, Nagel, and Pedersen, 2009; Burnside, Eichenbaum, Kleshchelski, and

[1] The short-run elasticities are computed from the impact responses and measure the instantaneous sensitivity of exchange rates to commodity prices. The long-term elasticities are computed from the cointegration relations and measure the sensitivity of exchange rates to commodity prices at equilibrium (i.e., when the variables of the system do not deviate from the common stochastic trends).

Rebelo, 2011; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012; Bakshi and Panayotov, 2013). However, these studies mostly investigate how such properties could help explain average excess currency returns. Therefore, this literature remains silent (and agnostic) about whether the weak performance of high-yield currencies during financial distress is a consequence of specific structural shocks, such as adverse commodity price shocks.[2]

Our econometric approach consists in evaluating currency responses and cointegration relations by conditioning the analysis on being in financial distress or in a tranquil regime. To do so, we measure three pairs of regimes associated with unfavorable and favorable financial conditions, whose choice is motivated by the existing literature. First, we consider low and high funding liquidity periods, which are defined from the top and bottom quintiles of the TED spread. A large spread typically reflects reduction in the banks' willingness to provide funding in the interbank market, which leads to lower liquidity for currency traders (see Mancini, Ranaldo, and Wrampelmeyer, 2013). Second, we study high and low financial uncertainty episodes corresponding to high and low CBOE option-implied volatility index (VIX). This index represents a proxy of currency and commodity traders' risk appetite (see Menkhoff et al., 2012; Cheng, Kirilenko, and Xiong, 2015). Third, we distinguish times of high and low currency volatility, which we measure at the country level (see Bakshi and Panayotov, 2013). Our conjecture is that these conditions have not only an effect on currencies and commodity prices, taken individually, but also on the relation between these two asset classes.

We focus on three representative small-open commodity-exporting countries, namely Australia, Canada, and New Zealand (e.g., Chen and Rogoff, 2003). We identify commodity price shocks by setting commodity prices to be predetermined relative to all other variables involved in the ST-SVECM, which include output, the price index of goods and services, and the nominal interest and exchange rates. This specification follows the assumption that small-open economies do not affect current commodity prices, which are determined on the world market.

[2]As an exception, Bakshi and Panayotov (2013) find that changes in global commodity prices help predict future carry trade returns. However, their analysis is not aimed to identify unexpected commodity price shocks, nor to decompose their effects by financial conditions.

To ease comparisons across countries, we estimate our model for each country over a common floating exchange rate episode, which spans the period 1986Q1-2012Q4.[3]

The main finding of this paper is that currency responses to unanticipated changes in commodity prices are much more pronounced in times of financial distress than during the tranquil regime. In periods of financial turmoil, the impact responses indicate a sharp, statistically significant, currency appreciation (depreciation) when there is a positive (negative) commodity price shock. The short-run elasticities highlight an instantaneous currency appreciation of about 0.5%, as commodity prices increase by 1% in times of financial distress. Further, these impact responses imply that commodity price shocks explain about 20% of the currency fluctuations over the short-run. The dynamic responses suggest that these currency reactions constitute a short-lived phenomenon, as the exchange rates become insignificantly different from their pre-shock level within a horizon of four quarters, except for the New Zealand dollar. These results hold whether we define the financial distress regime as low funding liquidity, high financial uncertainty, or high currency volatility.

In contrast, the impact currency responses and the short-run elasticities become statistically insignificant during tranquil periods, for all countries and regime definitions. Moreover, we find that, for most measures of favorable financial conditions, commodity price shocks explain less than 2% of the short-run currency fluctuations. In addition, the dynamic responses are almost always statistically insignificant for all horizons.

Hence, the effect of commodity price fluctuations on currencies appears to be concentrated and stronger during unfavorable financial conditions, which implies pronounced asymmetries in the short-run structural relation between commodity prices and exchange rates. Analyzing the unconditional relation (i.e., obtained without conditioning on financial regimes) would thus lead to a misinterpretation of the impact response of currencies to commodity price changes, as we

[3]This assumption does not imply that exchange rates have no forecasting power for commodity prices, and vice versa. In fact, we almost always find statistically significant, bi-directional, Granger causalities between exchange rates and commodity prices, under both favorable and unfavorable financial conditions. This complements the existing evidence, documented without conditioning on financial regimes, that exchange rates of commodity-exporting countries help predict commodity prices (see, e.g., Chen, Rogoff, and Rossi, 2010, 2014) and vice versa (see, e.g., Amano and van Norden, 1995, 1998; Cashin, Céspedes, and Sahay, 2004).

are only able to observe a short-run relation during the rare but important periods of financial turmoil. In comparison, we find that the long-run relations remain similar across favorable and unfavorable financial conditions.[4] Hence, a decomposition by financial conditions appears crucial to better explain currency fluctuations, and their relation with commodity prices, over the short-run.

We provide further evidence that the asymmetric structural relation between commodity prices and exchange rates is driven by financial conditions and not by business cycle conditions. To show this, we perform a decomposition of the historical dynamics of our financial conditions to recover the component that is exclusively generated from financial shocks. We then use this component to condition the responses of exchange rates to a commodity price shock. The results indicate that the responses remain similar when we replace the original financial condition measure by its component capturing solely the effects orthogonal to business cycle shocks. This exercise confirms the idea that the asymmetry underlying the responses is induced by financial conditions, although some periods of financial distress do actually coincide with economic recessions.

Finally, we perform an additional analysis to identify the channels through which commodity prices affect currencies. To this end, we undertake a counterfactual exercise and decompose the currency response into two components: the effect directly induced by commodity price shocks, on the one hand, and the effect that indirectly occurs through an adjustment of the country's macroeconomic fundamentals, on the other. We find that, for all countries, the instantaneous currency response to a commodity price shock corresponds exclusively to a direct effect, regardless of the financial regime. A decomposition of the dynamic responses suggests that this pattern is persistent in the case for Australia and Canada, thus suggesting that adjustments of economic fundamentals do not create persistence in a currency's reaction to commodity price fluctuations. However, the persistent response of the New Zealand dollar, following a commodity price shock in times of financial distress, mostly occurs through an adjustment of the

[4] The long-run elasticities indicate that a currency's appreciation converges to nearly 2% following a 1% increase in commodity prices irrespective of the financial regime under analysis.

country's macroeconomic fundamentals. Our analysis thus reveals that the mechanism behind the dynamic currency responses to commodity price shocks varies across countries.

Overall, our results highlight the existence of a pronounced asymmetry in the short-run structural relation between currencies and commodity prices. In particular, this study suggests that commodity prices contain insightful information for participants of the foreign exchange market during times of high funding illiquidity, financial uncertainty, and currency volatility. Interestingly, it is precisely during these market conditions that traders tend to reverse their (long) positions on high-yield currencies (see Brunnermeier, Nagel, and Pedersen, 2009; Menkhoff et al. 2012). Further, we provide new evidence that a substantial part of the short-run depreciation in such currencies during financial distress is actually due to a decline in commodity prices. The findings of this paper thus contribute to our understanding of how and when commodity prices play a decisive role in influencing high-yield currencies, thereby helping to explain carry trade reversals.

The remainder of the paper is organized as follows. Section 2 describes our econometric framework. Section 3 discusses our main empirical findings regarding the structural relation between commodity prices and currencies by financial conditions. Section 4 discusses various extensions that help understand the asymmetric relation. In particular, we verify that the asymmetry is due to financial conditions rather than to business cycle conditions and disentangle the currency responses into direct and indirect effects of commodity price shocks. Finally, Section 5 concludes.

2 Econometric Framework

In this section, we present our empirical approach to gauge the effect of commodity prices on exchange rates. We first discuss the econometric specification, then elaborate the estimation method, and finally describe the data.

2.1 Specification

We specify a system that admits a smooth transition across two regimes. The probability of being in each regime satisfies

$$P_{1,t} = \frac{\exp(\gamma z_t)}{1+\exp(\gamma z_t)} \text{ and } P_{2,t} = (1 - P_{1,t}), \tag{1}$$

where $P_{s,t}$ is the probability associated with regime $s = 1, 2$ in period t, z_t corresponds to an observable standardized (i.e. zero mean and unit variance) state variable, while the parameter γ determines the speed of transitions across regimes.

We assume that a set of variables X_t are governed by regime-specific contemporaneous interactions Θ_s, dynamic feedbacks Φ_s, and cointegration relations Π_s. Specifically, we propose smooth transition-structural vector error correction model (ST-SVECM) that corresponds to:

$$\begin{aligned} \triangle X_t = {} & P_{1,t-1}\left[\Phi_{1,0} + \sum_{i=1}^{l} \Phi_{1,i}\triangle X_{t-i} + \Pi_1 X_{t-1}\right] \\ & + P_{2,t-1}\left[\Phi_{2,0} + \sum_{i=1}^{l} \Phi_{2,i}\triangle X_{t-i} + \Pi_2 X_{t-1}\right] + U_t, \end{aligned} \tag{2}$$

with

$$E[U_t U_t'] = P_{1,t-1}(\Theta_1\Theta_1') + P_{2,t-1}(\Theta_2\Theta_2'). \tag{3}$$

Equation (2) specifies the dynamic characterizing the changes in the variables X_t, whereas Equation (3) describes the scedastic structure of the statistical innovations U_t.

The operators $\triangle$ and E denote the first difference and expectation, respectively, and the vector U_t captures the statistical innovations, which are assumed to be normally distributed with zero means. The vector $X_t = (c_t\ p_t\ y_t\ r_t\ q_t)'$ contains the variables of interest, where c_t denotes the logarithm of the price of commodities, p_t is the logarithm of a price index of goods and services, y_t is the logarithm of output, r_t is the interest rate, and q_t is the logarithm of the exchange rate.

Note that commodity prices, c_t, are expected to affect the key macroeconomic aggregates p_t, y_t, and r_t for various reasons. For example, an increase in the price of commodities, c_t, tends to i) increase the price index, p_t, following a higher cost of living, ii) affect output, y_t, due to an increase of production in the commodity sector or a reduction of output in commodity intensive industries, and iii) increase interest rates, r_t, when monetary authorities pursue a tight policy to control future inflation.

In turn, changes in the key macroeconomic aggregates are also expected to affect the exchange rate, q_t. The effect may occur through i) an increase in the price index, p_t, which may depreciate a country's currency via an international substitution effect inducing a decrease in net exports, ii) an increase in output, y_t, which tends to depreciate the domestic currency due to an income effect leading to an increase in imports, and iii) a decrease in interest rate, r_t, which is expected to depreciate the domestic currency following a portfolio rebalancing that reduces expositions to domestic bonds.

In this context, accounting for these macroeconomic aggregates is important for two reasons. First, it leads to a more accurate and comprehensive assessment of the effects of commodity prices, c_t, on exchange rate, q_t, given that p_t, y_t, and r_t likely respond to c_t and affect q_t. Second, it allows disentangling the effects of commodity prices, c_t, on exchange rate, q_t, in terms of an effect that is directly induced by an unexpected change in commodity prices and an effect that indirectly occurs through an adjustment of the key macroeconomic aggregates following a commodity price shock.

The lower triangular matrix Θ_s^{-1} captures the contemporaneous interactions across the variables in regime s. The ordering of the variables in X_t implies that commodity prices, c_t, are predetermined, as they are unrelated to any other contemporaneous variable. In line with Chen and Rogoff (2003), this is a reasonable assumption given that the analysis is performed for small-open, commodity-exporting countries, as it is the case in our analysis. Recall that commodity prices are determined mainly on the world market, rather than on domestic markets such as those associated with small-open economies. In contrast, the exchange rate, q_t, is endogenous, as it depends on other contemporaneous variables of the system.[5] We also assume that the elements on the first column of the lower triangular matrix Θ_s are the impact responses of the variables to the structural innovation corresponding to the commodity price shock.[6] In this context, a commodity price shock instantaneously affects all variables, but other structural shocks do not immediately affect commodity prices.

The unrestricted matrix $\Phi_{s,i}$ captures the short-run dynamic feedbacks for the lag $i = 1, \ldots, l$. This allows the possibility that the exchange rate has forecasting power for commodity prices and vice versa, and as such admits bi-directional Granger causalities between these two variables. Also, the restricted matrix $\Pi_s = \alpha_s \beta_s'$ is related to the long-run relations, where the matrix α_s includes the error-correction coefficients and the matrix β_s stacks the k cointegration relations — where the elements of β_s are identified by imposing k^2 restrictions, as in the triangularization approach (Phillips 1991, 1995). Both sets of matrices shape the dynamic responses of the various variables following a commodity price shock. Note that the unrestricted vector $\Phi_{s,0}$ includes the intercepts. Finally, our system (2)–(3) assumes that the probability of being in regime s is dated in $(t-1)$ to avoid simultaneous interactions between the variables of interest included in X_t and the state variable z_t.

2.2 Estimation

Admittedly, it is a challenging task to jointly estimate all the parameters involved in the ST-SVECM, given that this system is highly non linear in the parameters. To avoid this difficulty, we follow Granger (1993) and adopt a 'specific-to-general' strategy.

In particular, we first estimate by Ordinary Least Squares (OLS) a version of system (2)–(3) involving a single regime and no cointegration relation. From this specification, we apply information criteria to determine the relevant number of lags, $l = l^*$. Given this lag structure, we

[5] As long as c_t is ordered first, the ordering of the other variables does not alter the relation between commodity prices and the exchange rate.

[6] Commodity demand shocks may differ from commodity supply shocks (see Kilian, 2009). However, given the focus of our study, disentangling the source of these shocks is certainly beyond the scope of this paper. We thus leave this analysis for further research.

perform Johansen's (1988, 1991) maximum eigenvalue and trace tests to determine the relevant number of cointegration relations, $k = k^*$. For the remaining of the analysis, we assume that $l = l^*$ and $k = k^*$ in each regime.

Second, we follow the suggestion of Granger and Terasvirta (1993), which consists in fixing the value of the parameter γ involved in Equation (1), rather than estimating it. As will be clear in Section 3.2.2, we calibrate the parameter γ such that it leads to relevant interpretations of the financial regimes.

Third, we jointly estimate by maximum likelihood (ML) the coefficients involved in the two-regime system (2)–(3), namely the parameters related to the contemporaneous interactions Θ_s, short-term dynamic feedbacks $\Phi_{s,i}$, and long-term relations α_s and β_s (with $s = 1, 2$, $i = 1, \ldots, l^*$, and $k = k^*$). To do so, we apply the Monte Carlo Markov Chain (MCMC) procedure developed by Chernozhukov and Hong (2003). We then use the estimated parameters to compute the responses of exchange rates prevailing in each regime following a positive, one standard-deviation, commodity price shock. Finally, we use the MCMC procedure to construct the 90 percent confidence intervals of the responses.[7]

2.3 Data

For a given financial regime, we separately estimate the ST-SVECM for each of the following small open, commodity-exporting economies: Australia, Canada, and New Zealand. To this end, we rely on quarterly data for the 1986Q1 to 2012Q4 period.[8]

The variable c_t is measured by the logarithm of an index of representative domestic commodity prices for each country, in line with Chen, Rogoff (2003) or Chen, Rogoff and Rossi (2010). Specifically, we consider the commodity price indices for Australia, Canada, and New Zealand, which are compiled by the Reserve Bank of Australia, the Bank of Canada, and the

[7] The MCMC procedure is explained in detail in Appendix.

[8] The series of commodity prices used in this paper were initiated shortly after these currencies started floating (1984 for Australia, 1972 for Canada, and 1986 for New Zealand). While Canadian data are available since 1972, we restrict our sample for the sake of comparison across countries.

Australia and New Zealand Banking Group.[9] These indices are denominated in US dollar.

The variable q_t corresponds to the logarithm of the nominal exchange rate released by the IMF's International Financial Statistics (IFS) for all countries.[10] This variable is measured in terms of the local currency per US dollar, so that a decrease in exchange rate represents an appreciation of the local currency. Note that the US dollar is the reference currency in our analysis because it is the numeraire of almost all commodities and remains the most important trade currency.

Turning to the macroeconomic aggregates, output y_t corresponds to the logarithm of real GDP taken from the Federal Reserve Bank of St. Louis, the price index p_t is the logarithm of the consumer price index available from IFS, and the interest rate r_t is the nominal 5-year government bond yield taken from IFS for Canada, and from the Reserve Bank of Australia and the Reserve Bank New Zealand. All variables are seasonally adjusted, except the exchange and interest rates.

Based on our sample, we perform augmented Dickey-Fuller tests and conclude that we are unable to empirically reject the presence of a unit root for all the variables of interest. We next apply the Akaike information criterion, which suggests that the relevant lag structure is $l^* = 3$ for each country.[11] Finally, we perform cointegration tests and find, according to both the maximum eigenvalue and trace tests, that the number of cointegration is $k^* = 2$ for all countries.[12]

[9] The weights associated with each commodity depend on the level of domestic production for Canada, and on the contribution of the commodity to exports for Australia and New Zealand. In 2012, the main constituents of the Australian and Canadian indices are the energy sector (37% and 59%), metals and minerals (52% and 18%), and agriculture (11% and 14%). For New Zealand, the main exported commodities are meat and diary products (36%), forestry (7%), and energy (4%).

[10] Related studies consider either nominal exchange rates (e.g., Chen, Rogoff, and Rossi, 2010, 2014; Ferraro, Rogoff, and Rossi, 2015) or real exchange rates (e.g., Amano and van Norden, 1995, 1998; Chen and Rogoff, 2003; Cashin, Céspedes, and Sahay, 2004). The movements of real and nominal exchange rates are very similar for Australia, Canada, and New Zealand over the sample period that we consider. Yet selecting the nominal exchange rate is preferable to help us understand the performance of carry trade strategies.

[11] The Akaike and Bayesian information criteria are computed for structures involving up to 12 lags. The Bayesian information criterion indicates that $l^* = 1$, whereas the Akaike information criterion reveals that $l^* = 3$. However, the Ljung-Box test indicates that some of the estimated statistical innovations are serially correlated for each country when $l^* = 1$, but not when $l^* = 3$.

[12] The results associated with the augmented Dickey-Fuller test, cointegration tests, and lag structures are available upon request.

3 Main Results

In this section, we start by analyzing the effect of commodity prices on exchange rates in the unconditional case (i.e., obtained without conditioning on financial regimes) and then discuss the main results of the paper, which relate to the exchange rate response obtained under different financial conditions.

3.1 Unconditional analysis

As a starting point, we perform an unconditional analysis to explore the structural relation between commodity prices and exchange rates. This analysis relies on a restricted version of system (2)–(3), which involves a single regime and two cointegration relations. This unconditional case will prove to be a useful benchmark against which we can compare the results from the conditional specification associated with different financial conditions.

Figure 2 displays the responses of commodity prices and exchange rates (in logarithms) following a positive, one standard-deviation, commodity price shock.[13] As a first observation, the impact responses indicate statistically significant increases in commodity prices and appreciations for currencies of Australia, Canada, and New Zealand. This suggests that a long position in high-yield currencies is particularly profitable immediately after an unexpected increase in commodity prices.

Figure 2 [about here]

Also, the dynamic responses imply commodity price reactions that exhibit a persistent positive hump-shaped pattern for all countries; a shock generates subsequent increases in commodity prices in the short-term, which is then followed by a reversal in the longer term. This behavior is consistent with the evidence of positive return momentum in commodity markets that partially reverses over the long term (Moskowitz, Ooi, and Pedersen, 2012). The dynamic responses of exchange rates indicate a currency's appreciation that is persistent for Canada and New Zealand,

[13] The responses of the macroeconomic aggregates are available upon request.

but that dies out rapidly for the Australian dollar as this currency reverts to the pre-shock level within the same year.

Although this unconditional analysis provides some information about the currency reaction to commodity price shocks, it most likely masks the possibility that the reaction varies across different financial conditions. The main focus of this paper is thus to study, through a conditional analysis, the existence of an asymmetry underlying the relation between commodity prices and exchange rates.

3.2 Conditional analysis by financial conditions

We now investigate whether exchange rates react asymmetrically to commodity shocks in periods of financial stress. We explore this hypothesis by comparing currency responses across different financial regimes. We first motivate the choice of our financial indicators, describe our methodology to characterize the different regimes, and then discuss the results.

3.2.1 Definition of the financial regimes

Our analysis considers two types of global financial conditions, using the information provided by the level of funding liquidity and financial uncertainty, and one source of country-specific condition, based on the volatility of each currency.

Funding liquidity As a first measure of global financial conditions, we consider the level of funding liquidity because of its central role in the foreign exchange market. All traders, including the largest participants of this market, namely financial intermediaries, face funding liquidity constraints. Greater difficulty in financing their operations translates into lower liquidity across most currencies (see Banti and Phylaktis, 2015). Currency traders would then be exposed to greater risk, demand a higher illiquidity premium, and eventually reassess their positions in speculative currencies. Consistent with this view, Brunnermeier, Nagel, and Pedersen (2009) find that periods of constrained liquidity coincide with reductions in carry positions and increases in carry trade losses.

We consider the TED spread as an indicator of funding liquidity constraints, which is taken from the Federal Reserve Bank of St. Louis. This measure is defined as the interest rate difference between 3-month euro interbank deposits (LIBOR) and 3-month US Treasury bills. Intuitively, a large spread is associated with reduced banks' willingness to provide funding in the interbank market and therefore with lower liquidity for currency traders. Consistent with this view, Mancini, Ranaldo, and Wrampelmeyer (2013) show that liquidity in the currency market strongly and negatively correlates with the TED spread. In addition, the TED spread is an indicator of flight-to-safety pressure, as it tends to be high when investors chase less risky assets, which are also more liquid, during periods of stress (see Baele, Bekaert, Inghelbrecht, and Wei, 2015). This is important because the US dollar tends to appreciate relative to the high-yield currencies considered in this study, at time when international investors turn to US Treasuries for flight-to-safety (see Krishnamurthy and Vissing-Jorgensen, 2012).

Financial uncertainty Our second measure of global financial conditions relates to the level of uncertainty in financial markets, which we proxy with the VIX. We obtain this index from the Federal Reserve Bank of St. Louis. Our motivation for considering a stock market-based indicator of financial uncertainty follows the evidence that movements of speculative currencies are strongly related to variations in the VIX (see Brunnermeier, Nagel, and Pedersen, 2009; Menkhoff et al., 2012). Indeed, high-yield currencies typically depreciate when uncertainty in global financial markets increases, whereas low-interest rate currencies tend to appreciate due to their safe-haven status. Moreover, Cheng, Kirilenko, and Xiong (2015) use the VIX to proxy for shocks to financial traders' risk appetite and show that an increase in the VIX induces commodity traders and hedge funds to cut their long exposition in commodity futures. Hence, currency and commodity traders appear to respond strongly and asymmetrically to a rise in the VIX.

Currency volatility Our last measure captures country-specific financial conditions related to the volatility in foreign exchange markets. Our choice is motivated by the evidence that times of high currency volatility typically correspond to periods of carry trade reversals in commodity currencies (see Menkhoff et al., 2012). Importantly, currency volatility captures more than the level of uncertainty, as it is itself a strong determinant of a currency's transaction costs, and thus of its trading liquidity (see Bollerslev and Melvin, 1994).

We consider the volatility of each currency's daily returns relative to the US dollar, as in Bakshi and Panayotov (2013). The exchange rates come from the Federal Reserve Bank of St. Louis. For each country, we compute the currency volatility for quarter t as the square root of the realized variance, which is given by

$$RV_t = \sum_{j=1}^{n} \left(q_{t-1+\frac{j}{n}} - q_{t-1+\frac{j-1}{n}} \right)^2, \tag{4}$$

where q_t denotes the logarithmic exchange rate and n is the number of days during the quarter t. This measure follows Andersen, Bollerslev, Diebold, and Eben (2001) and Bollerslev, Tauchen, and Zhou (2009), among others.

3.2.2 State variables and probabilities

This section presents our methodology to classify periods of favorable/unfavorable financial conditions, for each of the measures discussed above, and to compute the probability to be in a given regime. We present the case of funding liquidity in detail and use the same approach for the other two financial measures.

We propose to separately analyze the high and the low liquidity regime through a two-step procedure. In the first step, we estimate the system of Equations (2)–(3) with two regimes and two cointegration relations. The regime 1 is defined as the regime of low funding liquidity, whereas the regime 2 corresponds to the regime when funding liquidity is 'not' low. Here, a low funding liquidity regime is defined as the period in which $P_{1,t}$ (see Equation 1) is greater than 0.8. Practically, we measure the state variable z_t as the (standardized) TED spread and calibrate the parameter γ to 2.5, so that the low funding liquidity regime occurs about 20 percent of the time. Given that the value of γ is positive, the probability of being in this regime, $P_{1,t}$, tends toward one when the (standardized) TED spread, z_t, is very positive, and tends toward zero when the (standardized) TED spread is very negative. Accordingly, our definition of the low funding liquidity regime ($P_{1,t} > 0.8$) matches the frequencies of the top quintile of the TED spread. Each regime thus captures specific information.

In the second step, we estimate the same system but the regime 1 now corresponds to the regime of high funding liquidity, whereas regime 2 is the regime of 'non-high' funding liquidity. Specifically, we are in the high funding liquidity regime when $P_{1,t}$ is greater than 0.8, where z_t is measured by the (standardized) TED spread and $\gamma = -1.6$, such that this regime also occurs about 20 percent of the time. Since the value of γ is negative, the high funding liquidity regime now matches the frequencies of the bottom quintile of the TED spread.[14]

Figures 3 and 4 illustrate the dynamics of the TED spread, the VIX, and the volatility of each currency, as well as the probability of being in the favorable and unfavorable regimes. The comparison of the state variables suggests that all financial condition measures react similarly during the recent financial crisis. However, beyond this rather unusual period, each measure captures a distinct set of information. For example, the probability of facing constrained funding liquidity was particularly high during the end of the eighties, while financial uncertainty seemed to be particularly high during the tech-bubble of early 2000s. In line with this idea, the correlation matrix of the various state variables presented in Table I indicates that the correlation coefficients are positive but most of the time well below one. As a result, it appears particularly relevant to analyze different financial conditions to have a broader picture of the relation between commodity prices and exchange rates during periods of financial distress.

Figures 3 and 4 [about here]

Table II presents the descriptive statistics of currency and commodity price returns conditioned by financial conditions. Currencies tend to depreciate (appreciate) relative to the US

[14]It would be possible to apply a one-step procedure to determine jointly the high and low funding liquidity regimes, but at the cost of greater complexity associated with a three-regime specification.

dollar and commodity prices tend to decrease (increase) during unfavorable (favorable) regimes, that is in times of high (low) funding illiquidity, VIX, and currency volatility.Moreover, Table II indicates that commodity prices and currencies are more volatile during unfavorable financial conditions.

Tables I and II [about here]

3.2.3 Responses of commodity prices and exchange rates

In this section, we report the responses of commodity prices and exchange rates (in logarithms) following a positive, one standard-deviation, commodity price shock occurring under a given financial regime. To ease the interpretation, we construct the responses under the hypothesis that we remain in the same financial regime (either unfavorable or favorable) over the entire horizon (i.e., 20 quarters).

Figures 5 to 7 display the results corresponding to each of the financial regimes described in Section 3.2.2.[15] We present the impact responses in Table III, while Table IV reports the short-run elasticities, which we measure as the ratios of the impact response of currencies relative to the impact response of commodity prices. Further, Table V shows the contribution of commodity price shocks in explaining the short-run currency fluctuations, which we measure by performing a decomposition of the one-quarter forecast error variance of the exchange rates. [16]

We first discuss the results related to periods of financial turmoil. In this unfavorable regime, the impact responses indicate a statistically significant increase in commodity prices and appreciation of the currency following an unexpected positive commodity price shock. This finding holds for all countries and financial distress regimes. Hence, there exists a strong short-run relation between commodity prices and high-yield currencies during adverse global financial con-

[15] The responses following a negative, one standard-deviation, commodity price shock are the mirror images of those presented in Figures 5 to 7.

[16] The contribution of commodity price shocks associated with a forecast horizon of one quarter corresponds to the squared impact response of exchange rate to the commodity price shock divided by the sum of the squared impact responses of exchange rate to each shock involved in system (2)–(3).

ditions – i.e., when TED spread is low or VIX is high – but also in times of uncertainty in the foreign exchange market, analyzed at the country level.

Figures 5, 6, and 7 [about here]

These impact responses are economically important. To illustrate this, a one standard-deviation increase in commodity prices, which respectively equals 4.96%, 8.34%, and 4.72% for Australia, Canada, and New Zealand during unfavorable financial conditions, generates a currency appreciation of 2.87%, 1.89%, and 1.82%, on average. The magnitude of the impact responses implies that the short-run elasticities associated with the various unfavorable financial regimes are always statistically significant and range from -0.48 to -0.73 for Australia, -0.17 to -0.30 for Canada, and -0.35 to -0.45 for New Zealand. Hence, the Australian dollar is the currency exhibiting the strongest short-term sensitivity to fluctuations in commodity prices, whereas the Canadian dollar appears to be the least responsive currency. In addition, the contribution of commodity price shocks to the variance of the one-quarter exchange rate forecast errors is between 12.55% and 28.95% for Australia, 25.09% and 48.53% for Canada, and 7.02% and 12.42% for New Zealand. Consequently, commodity price shocks explain a substantial portion of short-run currency fluctuations in these countries. A comparison across the different financial conditions indicates that, for all countries, the short-term elasticity is the most negative and the variance contribution is greatest in periods of constrained funding liquidity (i.e., high TED spread).

The dynamic responses provide additional insights on the relation between commodity prices and currencies. In financial distress episodes, commodity price responses display a persistent positive hump-shaped pattern that is significant for all countries over the entire horizon. The currency appreciation is persistent for New Zealand but remains only short-lived for Australia and Canada, as the dynamic responses are significant only up to four quarters following a commodity price shock. These results are robust to our various definitions of the financial conditions.

Tables III, IV, and V [about here]

Importantly, these instantaneous and dynamic relations stand in sharp contrast to what we observe during tranquil episodes. First, the impact response of commodity prices during calm periods is always smaller than that found in financial turmoil. Second, the impact responses of currencies and the short-run elasticities are never statistically significant during the tranquil regime. Third, commodity price shocks explain less than 2% of the short-run currency fluctuations under tranquil regimes, except for the case of low financial uncertainty. Hence, commodity price movements have a very limited role in explaining currency fluctuations during most periods of favorable financial conditions.

Furthermore, we find that the dynamic responses of commodity prices imply much shorter-lived effects when a commodity price shock occurs in periods of calm financial markets rather than under financial distress. Most important, the dynamic responses of exchange rates suggest that currencies do not statistically appreciate upon a positive commodity price shock. The only exception to this pattern is the significant appreciation of the New Zealand dollar when funding liquidity is high, although this currency response is much smaller in magnitude than what we obtain in periods of constrained funding liquidity.

Although our focus is essentially on the short-run currency reactions to commodity price shocks, we also explore how the relation between currencies and commodity prices evolves over the long run. To this end, we compute the long-run elasticity of exchange rates with respect to commodity prices from the coefficients of the cointegration relation involving both the exchange rate and commodity price.[17] Interestingly, these elasticities are systematically statistically significant, regardless of the financial regimes (see Table IV). Their value range from -1.07 to -1.16 for Australia, -0.94 to -0.98 for Canada, and -2.80 to -3.31 for New Zealand lunder financial turmoil episodes, whereas the values associated with favorable financial regimes range from -1.07 to -1.21 for Australia, -0.87 to -0.92 for Canada, and -2.42 to -2.77 for New Zealand. As a result, there is no asymmetric effect regarding the equilibrium relation

[17] Recall that there are two cointegration relations. However, given our application of the triangularization approach to identify the coefficients of the cointegration relations, only one of these relations involves both the exchange rate and commodity price.

between commodity prices and high-yield currencies, thereby suggesting that the short run and the long run relations differ substantially.[18]

To sum up, the short-run influence that commodity price fluctuations exerts on currencies appears to vary clearly over financial conditions. For all three countries, the instantaneous relation is asymmetric in that the impact currency appreciation (depreciation) is statistically significant when there is an unexpected increase (decrease) in commodity prices in times of financial stress, but not otherwise. In addition, short-run elasticities are generally more negative and the contribution of commodity price shocks in explaining short-run currency fluctuations is of greater magnitude during unfavorable financial conditions than during favorable ones.

These results confirm the idea that an unconditional specification would mask crucial information regarding the structural short-run relation between currencies and commodity prices. Our unconditional analysis indeed yields responses that closely resemble those obtained under unfavorable financial conditions — which are important but rare episodes — and therefore differ strikingly from those associated with tranquil regimes.

This asymmetry also implies that the prevalent financial conditions greatly matter for understanding the performance of these currencies. In particular, when financial conditions worsen, high-yield currencies become highly sensitive to commodity price news. In fact, our analysis highlights that unexpected decreases in commodity prices contribute substantial to the short-run depreciation of such currencies during financial distress. These findings thus help explain short-lived carry trade reversals observed during turbulent times, which tend to be associated with both a decline in commodity prices and a depreciation of high-yield currencies relative to the US dollar.

[18]The existing literature also analyzes the degree of predictability between exchange rates and commodity prices. Hence, for completeness, we compute Granger causalities from the reduced-form specification associated with system (2)–(3). Commodity prices always statistically Granger cause exchange rates, except for Canada in the unfavorable financial regime. Exchange rates always statistically Granger cause commodity prices for Australia and Canada, but not for New Zealand. These results, available upon request, hold for all measures of unfavorable financial conditions. The Granger-causalities are measured by summing the (1,5) and (5,1) elements of the dynamic feedback matrices: $e_1'(\Phi_{1,1}+\Phi_{1,2}+\Phi_{1,3})e_5$ and $e_5'(\Phi_{1,1}+\Phi_{1,2}+\Phi_{1,3})e_1$, where regime 1 captures either favorable or unfavorable financial conditions and e_j is a selection vector in which the jth element is one and all other elements are zero.

4 Additional Analysis

This section provides two extensions to our main analysis. We first verify that the asymmetry highlighted in this paper is fundamentally related to financial conditions and not to business cycle conditions. With the objective of better understanding the transmission mechanism, we then disentangle the currency responses into direct and indirect effects of commodity price shocks.

4.1 Financial vs economic conditions

The results presented thus far provide evidence that commodity prices affect the performance of commodity currencies and that the effect is concentrated during periods of unfavorable financial conditions. Yet times of financial distress are often associated with recessions, and the recent financial crisis is certainly a good example (see Figure 3). Therefore, one cannot a priori rule out that what drives the asymmetry in the relation is the state of the economy, rather than the current financial conditions.

We now address this issue. Specifically, we aim to investigate the role of financial conditions after controlling for the information contained in the global business cycle. To this end, we use the TED spread as our main proxy for financial conditions and the quarterly GDP growth rate of the G7 countries to capture for level of economic activity. The data come from the Federal Reserve Bank of St. Louis.

The approach that we propose consists in performing a decomposition of the historical dynamics of the TED spread in order to recover the component of this series that is exclusively generated from financial shocks, rather than from business cycle shocks. Details about the procedure are offered in Appendix. The resulting simulated measure of the TED spread is determined entirely by the accumulated effects of financial shocks, as it purges all the effects related to business cycle shocks. We use this simulated component to define the unfavorable and favorable financial regimes, using the approach described in Section 3.2.2, and estimate system (2)–(3).

Figure 8 presents the series of global economic activity, the simulated TED spread, as well as the probabilities of being in the favorable and unfavorable financial regimes. Figure 9 reports the responses associated with each regime. The exchange rate responses are similar to those reported and discussed in Section 3.2.3. Hence, these results reveal that the relation between currencies and commodity prices depends on the degree of financial distress and not on the global business cycle. This exercise provides strong evidence that the interplay between the currency and commodity markets is fundamentally linked to financial conditions.

Figures 8 and 9 [about here]

4.2 Response decomposition

To deepen our analysis of the channels through which commodity price shocks affect exchange rates, we perform a counterfactual exercise to decompose the response of exchange rates (to a commodity price shock) into direct and indirect effects (see Sims and Zha, 2006; Killian and Lewis, 2011; Bachmann and Sims, 2012). The direct effect is defined as the component that cannot be attributable to the adjustments in the price index p_t, output y_t, and interest rate r_t. This effect corresponds to the hypothetical response of the exchange rate, which is constructed by holding p_t, y_t, and r_t fixed at all time periods. We interpret this hypothetical response as the direct (and possibly speculative) demand for currencies following a commodity price shock. In contrast, the indirect effect corresponds to the component of the response of exchange rates that is attributable to the adjustments of p_t, y_t, and r_t, thus reflecting improvements or deteriorations in the country's fundamentals following a commodity price shock.[19] The right columns of Figures 5 to 7 present the results.

The impact currency responses to commodity shocks occur mostly through the direct channel in Canada, as both the direct and the total effects are within the confidence bounds. This finding holds for the unfavorable and favorable financial conditions. The decomposition of the dynamic responses suggests that this result is persistent. Two arguments help grasp the importance of a

[19] See the Appendix for the technical details regarding the decomposition.

direct reaction. First, the US dollar denomination of commodity prices creates a direct demand for commodity currencies. When the price of commodities increases, commodity exporters need to convert a greater amount of US dollars into the country's currency, thus fostering the demand for this currency. Second, the exchange rate incorporates forward-looking information. Currency traders account for the expected improvement in the country's economic performance that arises because of a positive commodity price shock, even though the country's fundamentals only gradually improve over time. The new information is then immediately incorporated in the currency, before the change in the country's fundamentals actually occurs.

In contrast, the dynamic responses of the Australian and New Zealand dollar are sensitive to the adjustment of a country's macroeconomic fundamentals following a commodity price shock. In the case of Australia, the dynamics of the direct effect imply that the currency would initially depreciate upon a negative commodity price shock during unfavorable financial conditions, but would then appreciate after a few quarters. However, the Australian economy also adjusts to this shock, which creates downward pressure on the currency. Overall, both effects offset each other and the Australian dollar does not react in a statistically significant way beyond a few quarters.

The case of New Zealand is different. The decomposition of the dynamic responses indicates that the indirect channel (i.e., the difference between the total and the direct effects) becomes very important after a few quarters, when a commodity price shock occurs in times of unfavorable financial conditions. In contrast, the direct effect tends to die out rapidly. Overall, the persistent depreciation of the New Zealand dollar following an unexpected fall in commodity prices, in times of distress, arises mostly from an adjustment in the country's fundamentals. This analysis therefore suggests that the heterogeneity in the currency responses across countries is associated with different reactions of the economy to a change in commodity prices.

5 Conclusion

In this paper, we examined the impact of commodity price changes on high-yield currencies and explored how this relation varies according to financial conditions. To do so, we compute exchange rate responses following an unexpected change in commodity prices under different financial conditions, which are related to the degree of funding liquidity, financial uncertainty, and currency volatility. Our sample covers three representative developed small-open, commodity-exporting countries, namely Australia, Canada, and New Zealand, over the 1986Q1 to 2012Q4 period.

Our empirical findings reveal that high-yield currencies strongly and statistically appreciate following an unexpected increase in commodity prices, but exclusively during periods of financial distress. This result holds for all countries and for the various measures of financial conditions. Moreover, the variance decomposition suggests that commodity price shocks explain a large fraction of the short-run currency fluctuations in times of low funding liquidity and high currency volatility, but not otherwise. Notably, results remain similar when we consider a simulated measure of financial conditions, obtained by orthogonalizing financial shocks from global business cycles. Furthermore, a counterfactual analysis reveals that the impact currency responses always reflect direct reactions to commodity price shocks, and are thus not attributable to an indirect effect capturing adjustments in the country's key economic fundamentals, such as output, prices, and interest rates. However, there exists heterogeneity across countries regarding the role of these fundamentals beyond a few quarters.

Overall, we find strong support that financial conditions matter to the short-run structural relation between commodity prices and exchanges rates. Our study then sheds new light on the dynamics of high-yield currencies during turbulent financial times and, specifically, on the role of commodity price movements. As such, these findings help enrich our understanding of the behavior of high-yield currencies, which are central ingredients of the carry trade strategy.

Technical Appendix

A MCMC estimation procedure

The MCMC procedure to estimate the parameters of the ST-SVECM relies on a random-walk Metropolis-Hastings algorithm. This algorithm involves the following steps:

Step 1: The starting values $\Upsilon^{(0)}$ of the parameters of the ST-VECM are set to the maximum-likelihood estimates obtained under a single-regime SVECM, such that $\Upsilon_1^{(0)} = \Upsilon_2^{(0)}$, where $\Upsilon = \begin{pmatrix} \Upsilon_1' & \Upsilon_2' \end{pmatrix}'$, $\Upsilon_s = \begin{pmatrix} \Phi_{s,0}' & vec(\Phi_{s,1})' & \cdots & vec(\Phi_{s,l})' & vec(\alpha_s)' & vec(\tilde{\beta}_s)' & vec(\Theta_s)' \end{pmatrix}'$, $\beta_s = \begin{pmatrix} I_k & \tilde{\beta}_s \end{pmatrix}$, and $s = 1, 2$.

Step 2: The candidate parameter values are drawn from the following equation:

$$\Xi^{(n)} = \Upsilon^{(n)} + \upsilon^{(n)}, \tag{A.1}$$

where $\Xi^{(n)}$ contains the candidate parameter values for the chain $n+1$, $\Upsilon^{(n)}$ captures the current parameter values for the chain n, and $\upsilon^{(n)}$ includes shocks that are normally distributed with means zero and a variance-covariance matrix Ω, with $\Omega = diag(\eta|\Upsilon^{(0)'}|)$ and $\eta > 0$.

Step 3: The current parameter values for the chain $n+1$ are generated as follows:

$$\Upsilon^{(n+1)} = \begin{cases} \Xi^{(n)} \text{ with probability } \wp = \min\{1, \exp[\log L(\Xi^{(n)}) - \log L(\Upsilon^{(n)})]\} \\ \Upsilon^{(n)} \text{ otherwise} \end{cases}, \tag{A.2}$$

where $L(\Upsilon^{(n)})$ and $L(\Xi^{(n)})$ are respectively the values of the likelihood functions evaluated at the current parameter values of the chain and at the candidate parameter values.

Step 4: Steps 2 and 3 are computed for $n = 1, \ldots,$100,000. In this exercise, the coefficient η is set such that the acceptance rate for the candidate draws $\wp$ is about 30 percent, as suggested in Gelman, Carlin, Stern, and Rubin (2004).

Step 5: The first 20,000 draws are burned. We use the remaining 80,000 draws in $\hat{\Upsilon} = \frac{1}{80{,}000}\sum_{n=20{,}001}^{100{,}000} \Upsilon^{(n)}$ to compute the estimates of the parameters of the ST-SVECM. Chernozhukov and Hong (2003) show that this procedure yields consistent estimates of Υ under standard regularity conditions of maximum likelihood estimators.

B Computation of the responses

For convenience, we first rewrite the ST-SVECM process (Equation 2) in a more compact form:

$$Y_t = P_{1,t-1}\left[\Gamma_{1,0} + \Gamma_{1,1}Y_{t-1}\right] + P_{2,t-1}\left[\Gamma_{2,0} + \Gamma_{2,1}Y_{t-1}\right] + V_t, \tag{B.1}$$

where $Y_t = \begin{pmatrix} X_t & X_{t-1} & \dots & X_{t-l}\end{pmatrix}'$, $X_t = \begin{pmatrix} c_t & p_t & y_t & r_t & q_t\end{pmatrix}'$, $V_t = \begin{pmatrix} U_t & 0_{(5\times1)} & \dots & 0_{(5\times1)}\end{pmatrix}'$, $E[V_tV_t'] = P_{1,t-1}(\Lambda_1\Lambda_1') + P_{2,t-1}(\Lambda_2\Lambda_2')$, $\Lambda_s = diag\begin{pmatrix}\Theta_s & 0_{(5l\times5l)}\end{pmatrix}$, $\Gamma_{s,0} = \begin{pmatrix}\Phi_{s,0} & 0_{(5\times1)} & \dots & 0_{(5\times1)}\end{pmatrix}'$, and

$$\Gamma_{s,1} = \begin{pmatrix} (\Phi_{s,1} + I_5 + \Pi_1) & (\Phi_{s,2} - \Phi_{1,1}) & \cdots & -\Phi_{s,l} \\ I_5 & 0_{(5\times5)} & \cdots & 0_{(5\times5)} \\ \vdots & \vdots & \vdots & \vdots \\ 0_{(5\times5)} & 0_{(5\times5)} & I_5 & 0_{(5\times5)} \end{pmatrix}.$$

For interpretation purposes, let us consider the case in which the economy stays in regime s over an horizon of $h+2$ periods (i.e., $P_{s,t-1} = 1$ for periods $t-1$ to $t+h$). In this context, system (B.1) implies that

$$Y_{t+h} = \sum_{i=0}^{h} \Gamma_{s,1}^{i}\Gamma_{s,0} + \sum_{i=0}^{h}\Gamma_{s,1}^{i}\Lambda_s W_{s,t+h-i} + \Gamma_{s,1}^{(h+1)}Y_{t-1}, \tag{B.2}$$

where $W_{s,t} = \begin{pmatrix}\varepsilon_{s,t}' & 0_{(1\times5l)}\end{pmatrix}'$, $\varepsilon_{s,t} = \begin{pmatrix}\varepsilon_{s,ct} & \varepsilon_{s,2t} & \varepsilon_{s,3t} & \varepsilon_{s,4t} & \varepsilon_{s,5t}\end{pmatrix}'$ includes the structural shocks associated with regime s, and in particular the shock to commodity prices $\varepsilon_{s,ct}$, and $E[W_{s,t}W_{s,t}'] = diag\begin{pmatrix} I_5 & 0_{(5l\times5l)}\end{pmatrix}$.

Using Equation (B.2), the effects of unexpected changes in commodity prices correspond to:

$$\Psi_{s,h} = \xi \Gamma_{s,1}^{h} \Lambda_s e_1, \tag{B.3}$$

where $\xi = \begin{pmatrix} I_5 & 0_{(5\times 5l)} \end{pmatrix}$, $e_1 = \begin{pmatrix} 1 & 0_{[1\times(4+5l)]} \end{pmatrix}'$, and $\Psi_{s,h}$ captures the impact ($h = 0$) and dynamic ($h > 0$) responses of the various variables of the system in period $t+h$ when a positive, one-standard deviation shock to commodity prices occurs only in period t and in regime s.

We estimate the responses by evaluating expression (B.3) from the consistent estimates $\hat{\Upsilon}$ of the parameters of the ST-SVECM, obtained from the MCMC procedure. We also compute the 90 percent confidence bands of the responses by considering the 5th and 95th percentiles of the generated responses, where the generated responses are obtained by evaluating Equation (B.3) from the MCMC chains $\Upsilon^{(n)}$ with $n = 20,001\ ,\ldots,\ 100,000$.

C Historical decomposition of the TED spread

We decompose the historical dynamics of the TED spread to recover the component of the series that is exclusively generated from financial shocks, rather than from business cycle shocks. To do so, we consider the following bi-variate VAR:

$$Z_t = B_0 + \sum_{i=1}^{m} B_i Z_{t-i} + H_t, \tag{C.1}$$

where $Z_t = \begin{pmatrix} g_t & f_t \end{pmatrix}'$, with g_t and f_t representing global GDP growth and the TED spread, respectively. We set $H_t = A\eta_t$, such that A is a lower triangular matrix and $\eta_t = \begin{pmatrix} \eta_{e,t} & \eta_{f,t} \end{pmatrix}'$ corresponds to the orthogonalized innovations associated with the business cycle shock, $\eta_{e,t}$, and financial shock, $\eta_{f,t}$. We fix the lag structure to $m = 6$, as prescribed by the AIC criterion, compute the estimates $\hat{B}_0$ and $\hat{B}_i$ (where $i = 1, \ldots, m$) by OLS, obtain the estimate $\hat{A}$ by applying a Cholesky decomposition on the estimated covariance matrix of the OLS residuals $\hat{H}_t$, and recover the estimates of the structural shocks in $\hat{\eta}_t = \hat{A}^{-1}\hat{H}_t$.

Next, we simulate the VAR system (C.1) as follows:

$$\tilde{Z}_t = \hat{B}_0 + \sum_{i=1}^{m} \hat{B}_i \tilde{Z}_{t-i} + \tilde{H}_t, \tag{C.2}$$

where the initial conditions of the simulated series are fixed to the actual series, i.e. $\tilde{Z}_t = Z_t$ for $t = 1, \ldots, m$. For the remaining time periods, we construct the simulated series recursively by using the estimates of the financial shocks and by setting the business cycle shocks to zero, i.e. $\tilde{H}_t = \hat{A}\tilde{\eta}_t$ and $\tilde{\eta}_t = \begin{pmatrix} 0 & \hat{\eta}_{f,t} \end{pmatrix}'$ for $t > m$. Importantly, the resulting simulated component of the TED spread is determined entirely by the accumulated effects of financial shocks, as it purges all the effects related to business cycle shocks.

D Decomposition of the responses

To decompose the responses (Equation B.3) into the direct and indirect effects, the first step is to construct hypothetical sequences of shocks in order to force the price index, output, and interest rate to remain constant at each period $t+h$ following a positive, one-standard deviation shock to commodity prices in period t and in regime s. To do so, applying a differential to Equation (B.2) and rearranging the terms yield:

$$dy_{t+h} = \sum_{i=0}^{h} (\zeta \Gamma_{s,1}^{i} \Lambda_s \zeta') dw_{s,t+h-i} + (\zeta \Gamma_{s,1}^{h} \Lambda_s e_1) d\varepsilon_{s,ct} = 0, \tag{D.1}$$

where $y_t = \zeta Y_t = \begin{pmatrix} p_t & y_t & r_t \end{pmatrix}'$, $w_{s,t} = \zeta W_t = \begin{pmatrix} \varepsilon_{s,2t} & \varepsilon_{s,3t} & \varepsilon_{s,4t} \end{pmatrix}'$, $\zeta = \begin{pmatrix} 0_{(3\times1)} & I_3 & 0_{[3\times(1+5l)]} \end{pmatrix}$, $dw_{s,t+h-i} \neq 0$ for $i < h$, and $d\varepsilon_{s,ct} = 1$, whereas all other shocks remain constant. Then, Equation (D.1) is used to compute recursively the hypothetical shocks as follows:

$$dw_{s,t+h} = -(\zeta \Lambda_s \zeta')^{-1} \left[(\zeta \Gamma_{s,1}^{h} \Lambda_s e_1) + \sum_{i=0}^{h} (\zeta \Gamma_{s,1}^{(i+1)} \Lambda_s \zeta') dw_{s,t+h-i-1} \right], \tag{D.2}$$

where $dw_{s,t-1} = 0$.

The second step consists in computing the direct effect associated with a shock to commodity prices. To this end, a differential is applied to Equation (B.2) to assess the responses of each variable of the system for the case where $d\varepsilon_{s,ct} = 1$ and $dw_{s,t+h} \neq 0$, while all other shocks are unaltered. This yields:

$$\Psi^D_{s,h} = \Psi_{s,h} + \sum_{i=0}^{h} (\xi \Gamma^i_{s,1} \Lambda_s \zeta') dw_{s,t+h-i}, \tag{D.3}$$

Note that substituting the terms $\Psi_{s,h}$ and $dw_{s,t+h}$ in expression (D.3) by those computed from (B.3) and (D.2) allows us to construct the direct effects $\Psi^D_{s,h}$; that is, the transmission mechanism of a shock to commodity prices which does not occur through changes in the price index, output, and interest rate.

As the last step, we measure the indirect effect as follows:

$$\Psi^I_{s,h} = \Psi_{s,h} - \Psi^D_{s,h}, \tag{D.4}$$

where $\Psi^I_{s,h}$ extracts the effect of a shock to commodity prices that occur solely through the adjustments of the price index, output, and interest rate.

Empirically, we estimate the direct and indirect effects associated with a postive, one-standard deviation commodity prices shock by evaluating expressions (D.3), (D.4), and (B.3) from the consistent estimates $\hat{\Upsilon}$ of the parameters of the ST-SVECM, obtained from the MCMC procedure.

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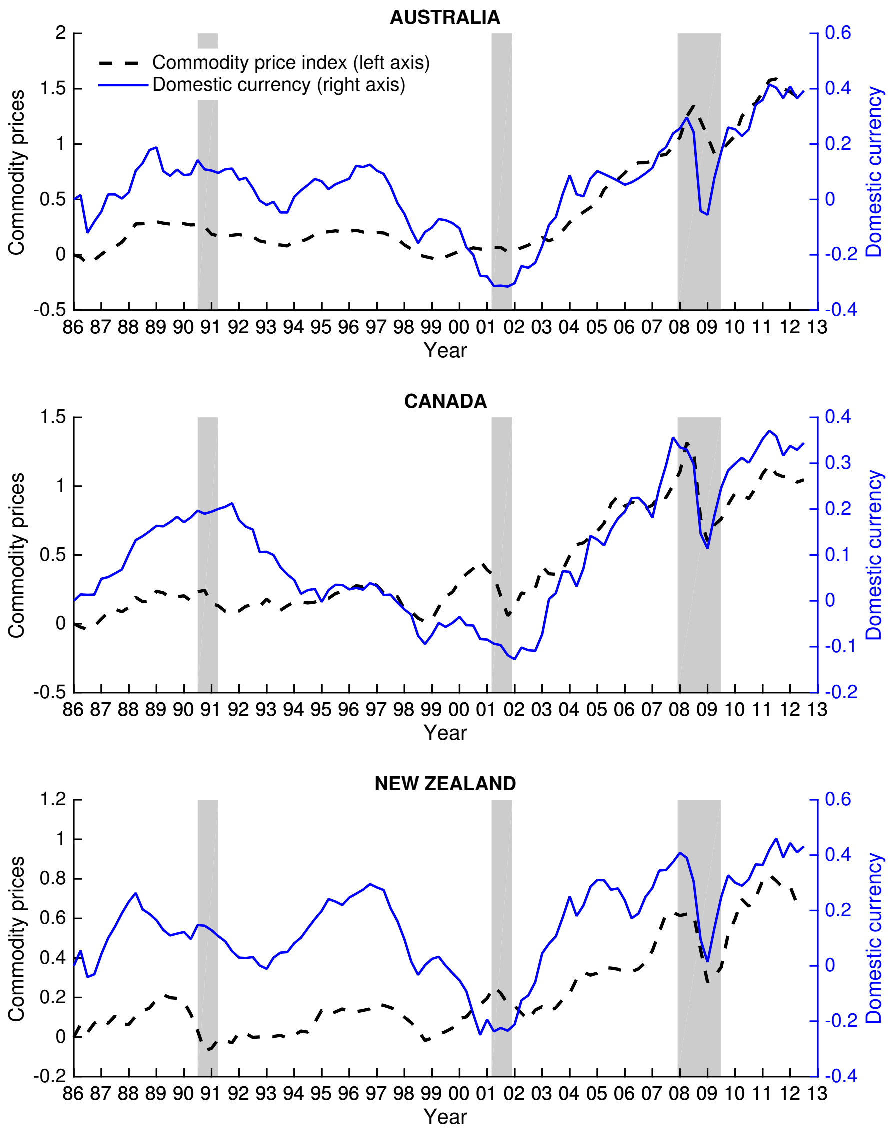

Figure 1: **Commodity prices and exchange rates.** The figure compares the dynamics of each country's commodity price index and the performance of its domestic currency. Exchange rates are relative to the US dollar. All series are normalized at the initial date and reported in logarithm. Grey areas indicate NBER recession periods. The data are described in Section 2.3.

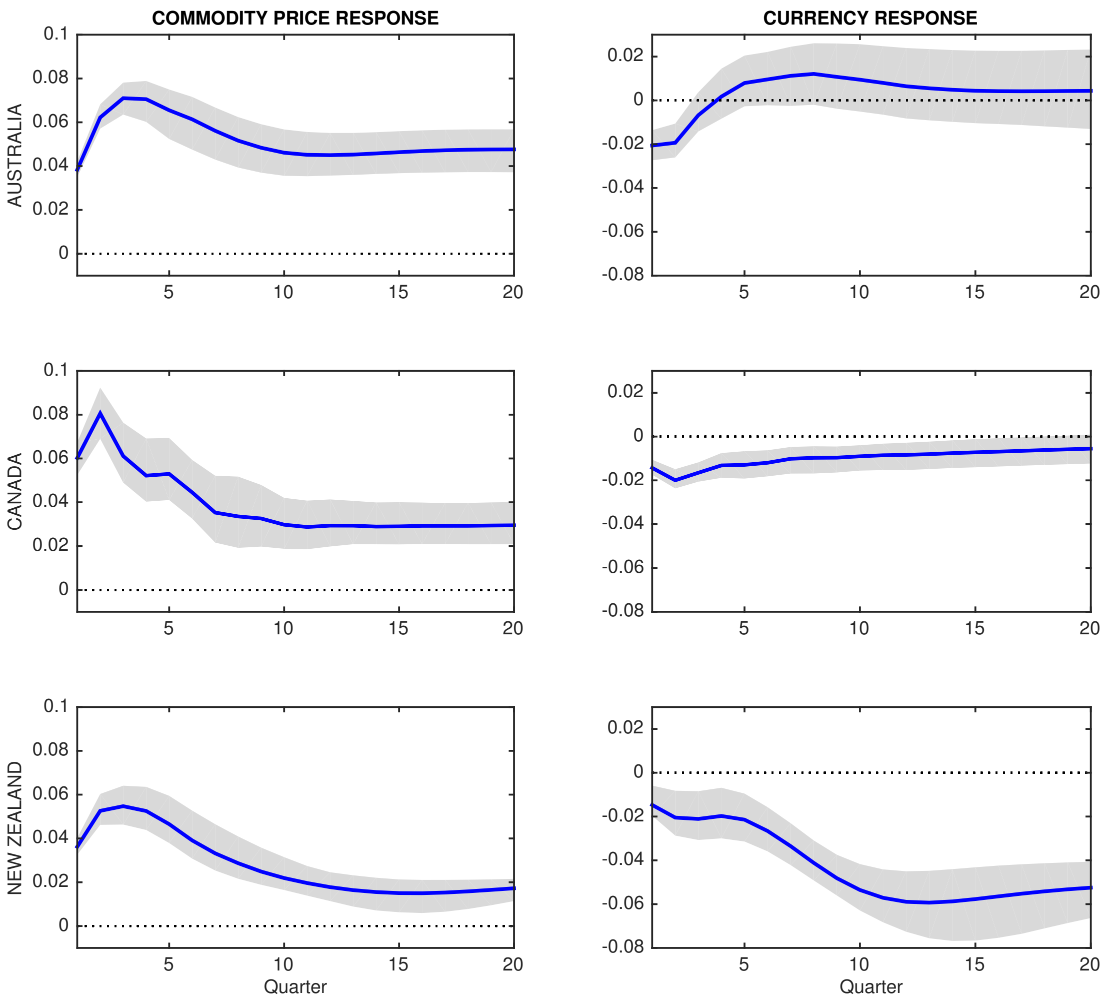

Figure 2: **Unconditional responses to commodity price shocks.** The figure displays the responses of the variables of interest following a positive, one standard-deviation commodity price shock. The left panels present the responses of commodity prices (in logarithm), whereas the right panels show the responses of the domestic currency relative to the US dollar (in logarithm). Grey areas indicate 90 percent confidence intervals. The data are described in Section 2.3.

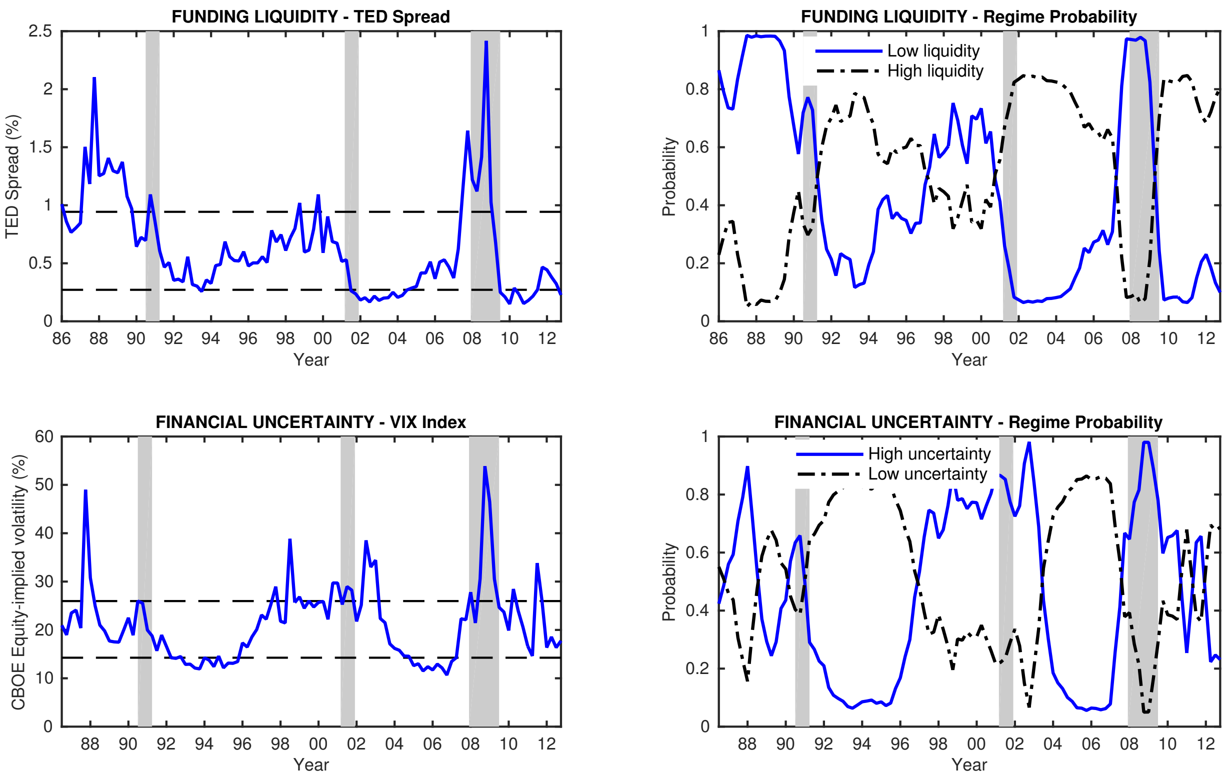

Figure 3: **Global financial conditions.** The figure displays the global financial conditions that we consider to classify periods of favorable and unfavorable regimes. The first row exhibits the TED spread and the probability of being in a low/high funding liquidity regime. The second row displays the VIX and the probability of being in a low/high financial uncertainty regime. Grey areas indicate NBER recession periods. The different measures of financial conditions are discussed in Section 3.2.

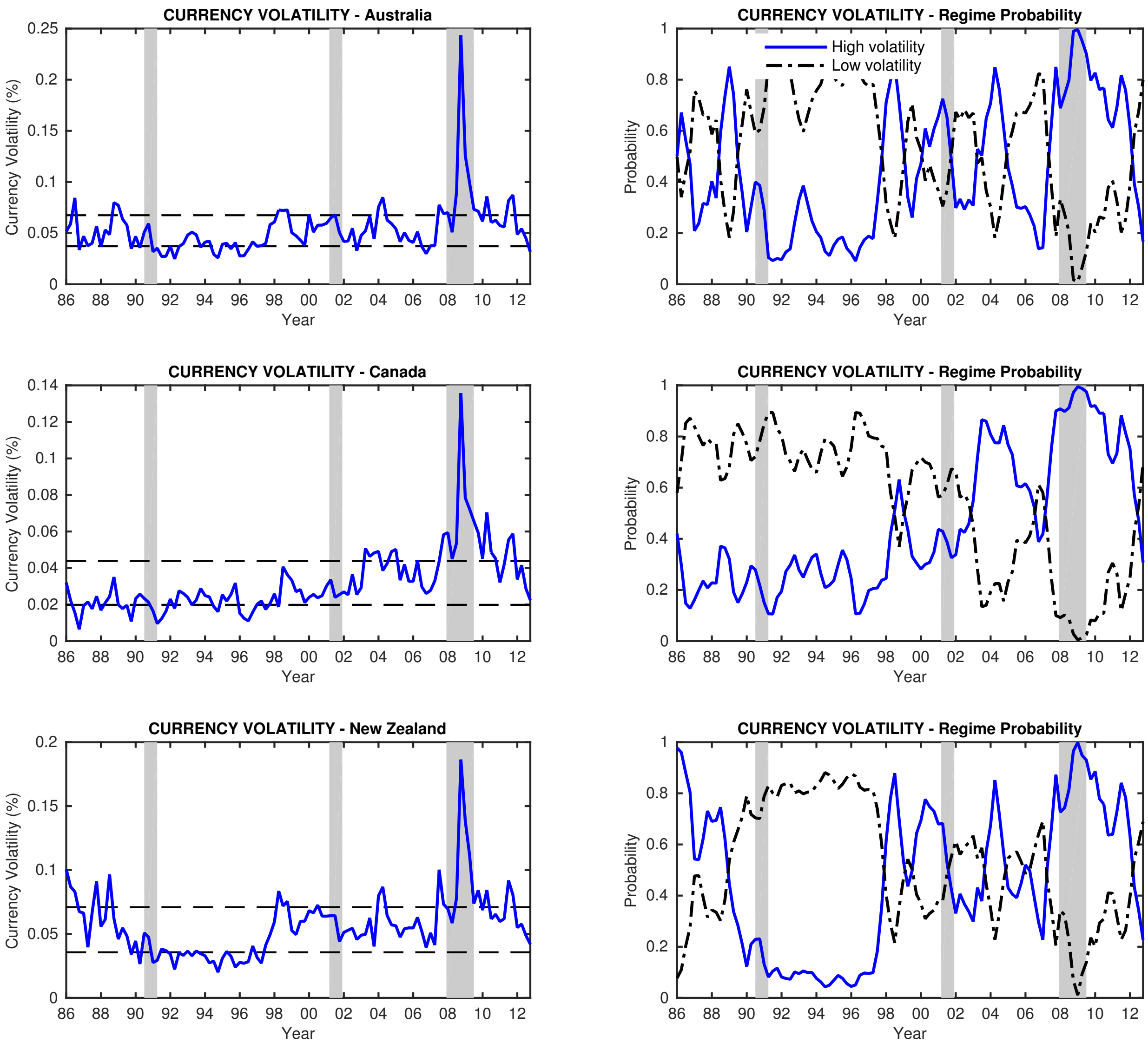

Figure 4: **Country-specific financial conditions.** The figure displays the country-specific financial conditions that we consider to classify periods of favorable and unfavorable regimes. The left column exhibits the quarterly currency volatility for each country computed with daily exchange rate returns (relative to the US dollar). The right column displays the probability of being in a low/high currency volatility regime. Grey areas indicate NBER recession periods. The currency volatility measure is discussed in Section 3.2.

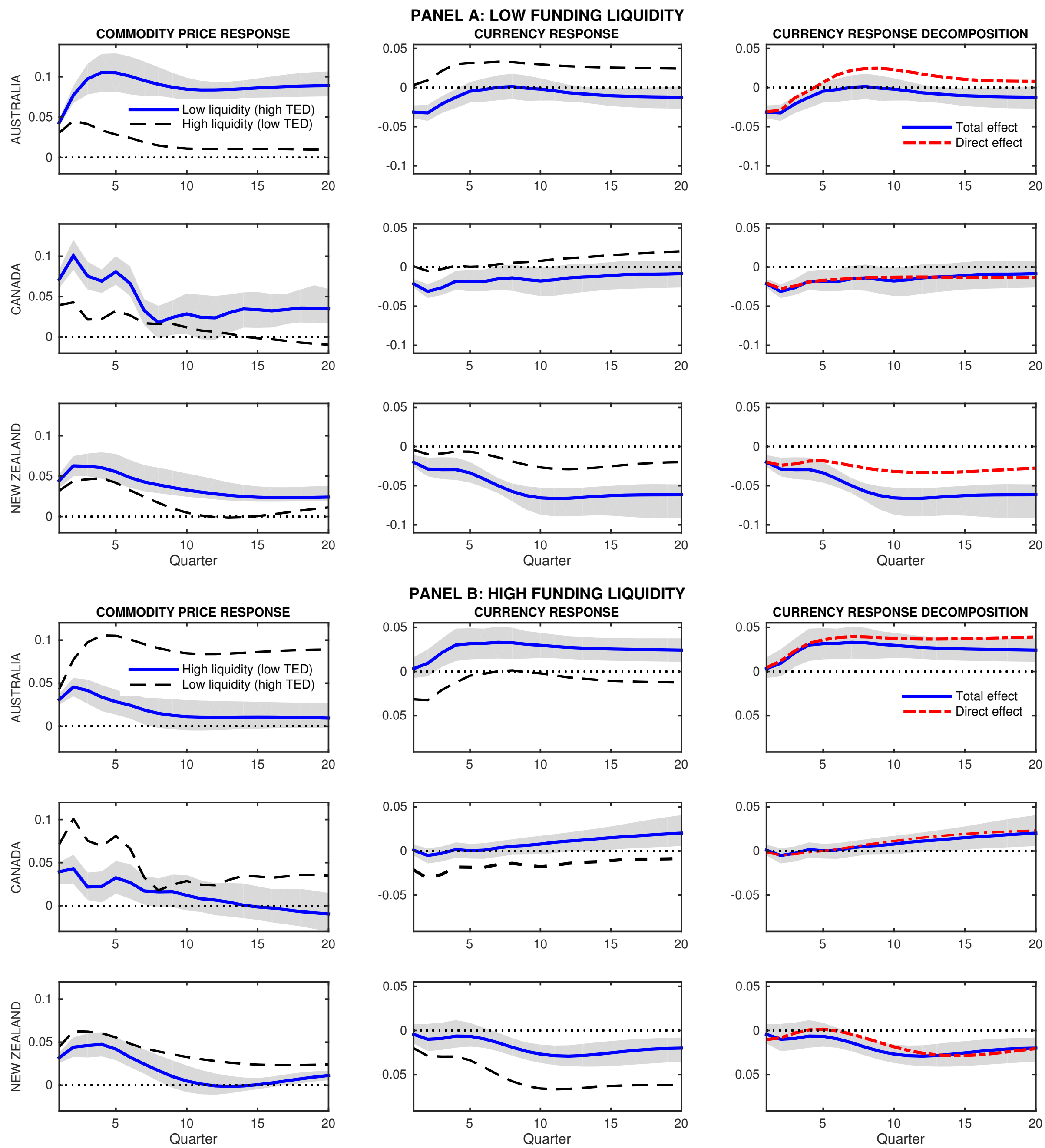

Figure 5: **Conditional responses to commodity price shocks – the role of funding liquidity.** The figure displays the responses of the variables of interest following a positive, one standard-deviation commodity price shock. The left panels present the responses of commodity prices (in logarithm), the middle panels show the responses of the domestic currency relative to the US dollar (in logarithm), whereas the right panels compare the total and the direct effects. The direct effect captures the impact of commodity prices on exchange rates that cannot be explained by variations in the country's macroeconomic fundamentals. Panel A displays the responses when funding liquidity is low (high TED spread), while Panel B presents results when funding liquidity is high (low TED spread). Grey areas indicate 90 percent confidence intervals. The data are described in Section 2.3 and the funding liquidity measure is discussed in Section 3.2.

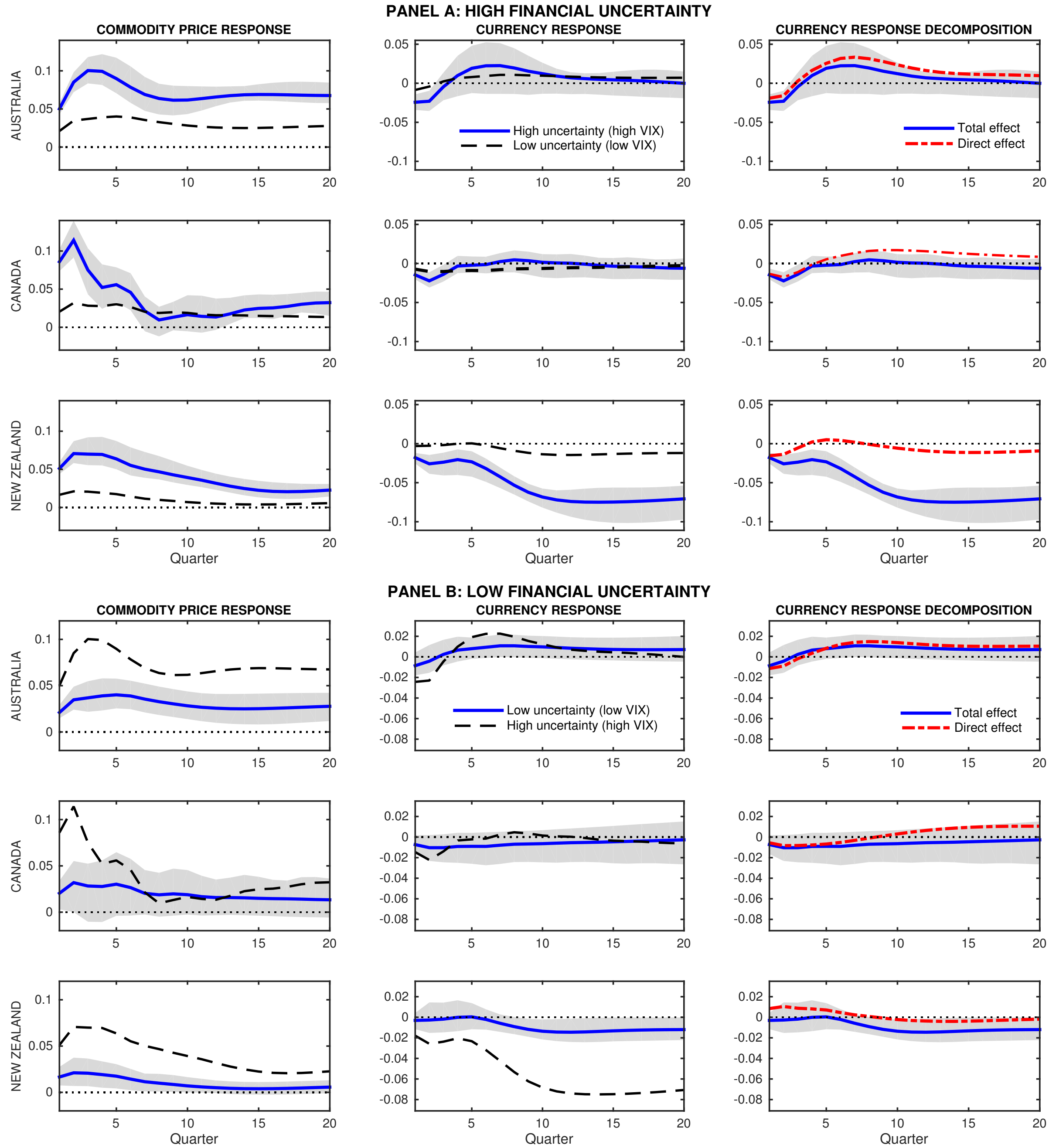

Figure 6: **Conditional responses to commodity price shocks – the role of financial uncertainty.** The figure displays the responses of the variables of interest following a positive, one standard-deviation commodity price shock. The left panels present the responses of commodity prices (in logarithm), the middle panels show the responses of the domestic currency relative to the US dollar (in logarithm), whereas the right panels compare the total and the direct effects. The direct effect captures the impact of commodity prices on exchange rates that cannot be explained by variations in the country's macroeconomic fundamentals. Panel A displays the responses when financial uncertainty (VIX) is high, while Panel B presents results when financial uncertainty (VIX) is low. Grey areas indicate 90 percent confidence intervals. The data are described in Section 2.3 and the financial uncertainty measure is discussed in Section 3.2.

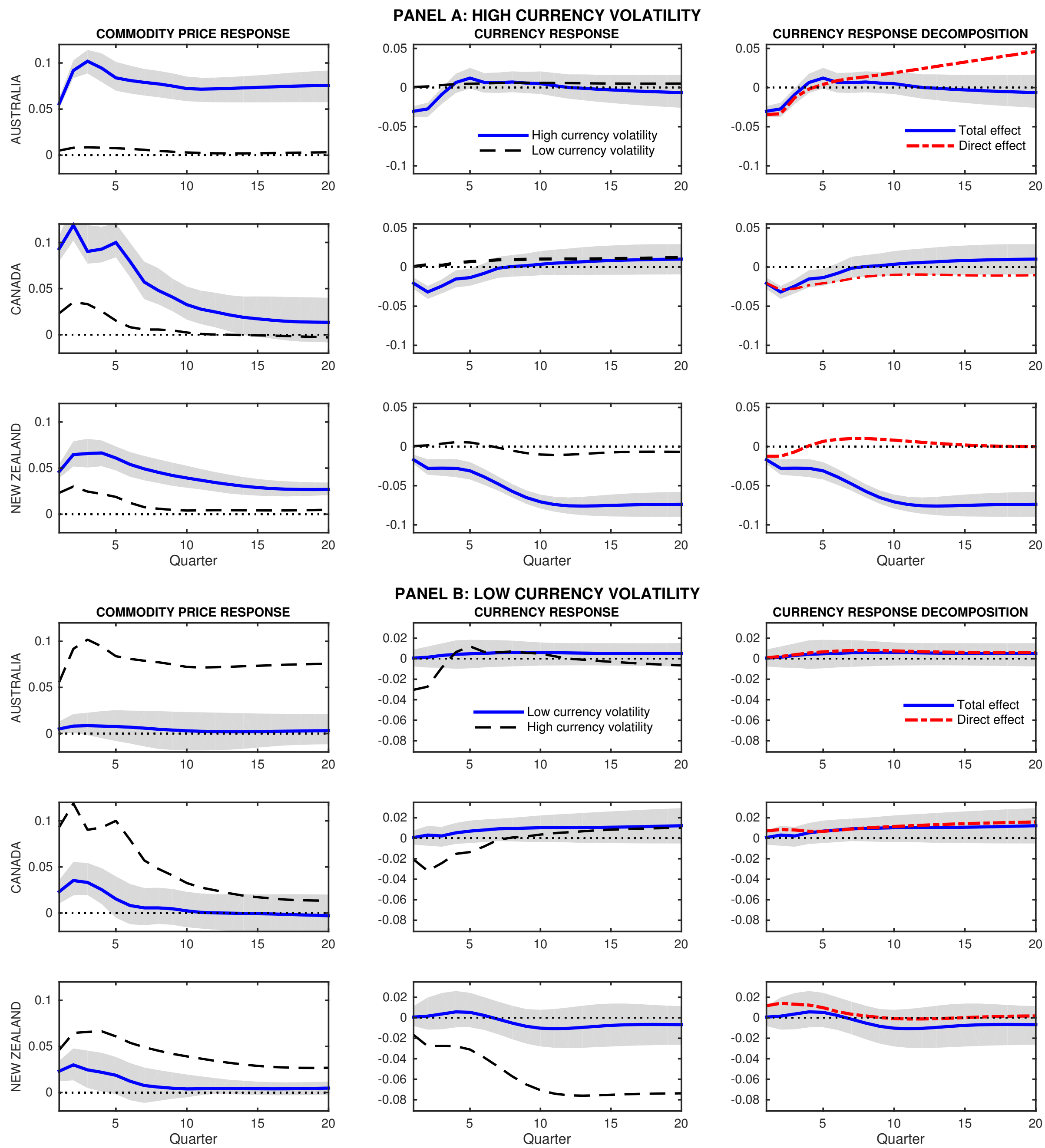

Figure 7: **Conditional responses to commodity price shocks – the role of currency volatility.** The figure displays the responses of the variables of interest following a positive, one standard-deviation commodity price shock. The left panels present the responses of commodity prices (in logarithm), the middle panels show the responses of the domestic currency relative to the US dollar (in logarithm), whereas the right panels compare the total and the direct effects. The direct effect captures the impact of commodity prices on exchange rates that cannot be explained by variations in the country's macroeconomic fundamentals. Panel A displays the responses when a country's currency volatility is high, while Panel B presents results when currency volatility is low. Grey areas indicate 90 percent confidence intervals. The data are described in Section 2.3 and the currency volatility measure is discussed in Section 3.2.

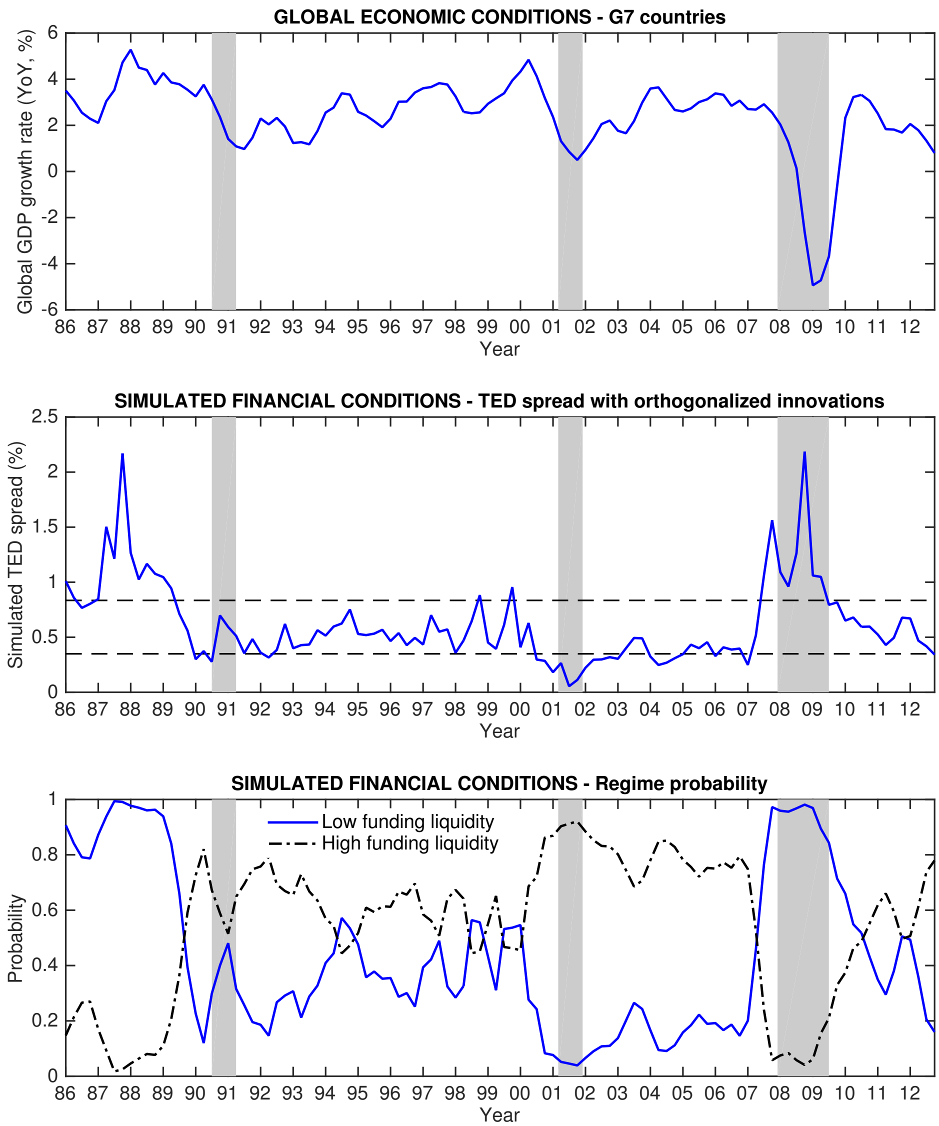

Figure 8: **Simulated financial conditions with orthogonalized innovations.** The figure displays the simulated TED spread that we consider to classify periods of favorable and unfavorable regimes. The upper panel reports data on global economic conditions, as measured with the GDP growth rate of the G7 countries. The middle panel shows the simulated component of the funding liquidity measure, which is obtained by orthogonalizing the innovations of the TED spread from global economic shocks. The bottom panel displays the probability of being in the high/low funding liquidity regime, where the state variable corresponds to the simulated TED spread. Grey areas indicate NBER recession periods. The data are described in Section 2.3 and the simulated TED spread measure is discussed in Section 4.1.

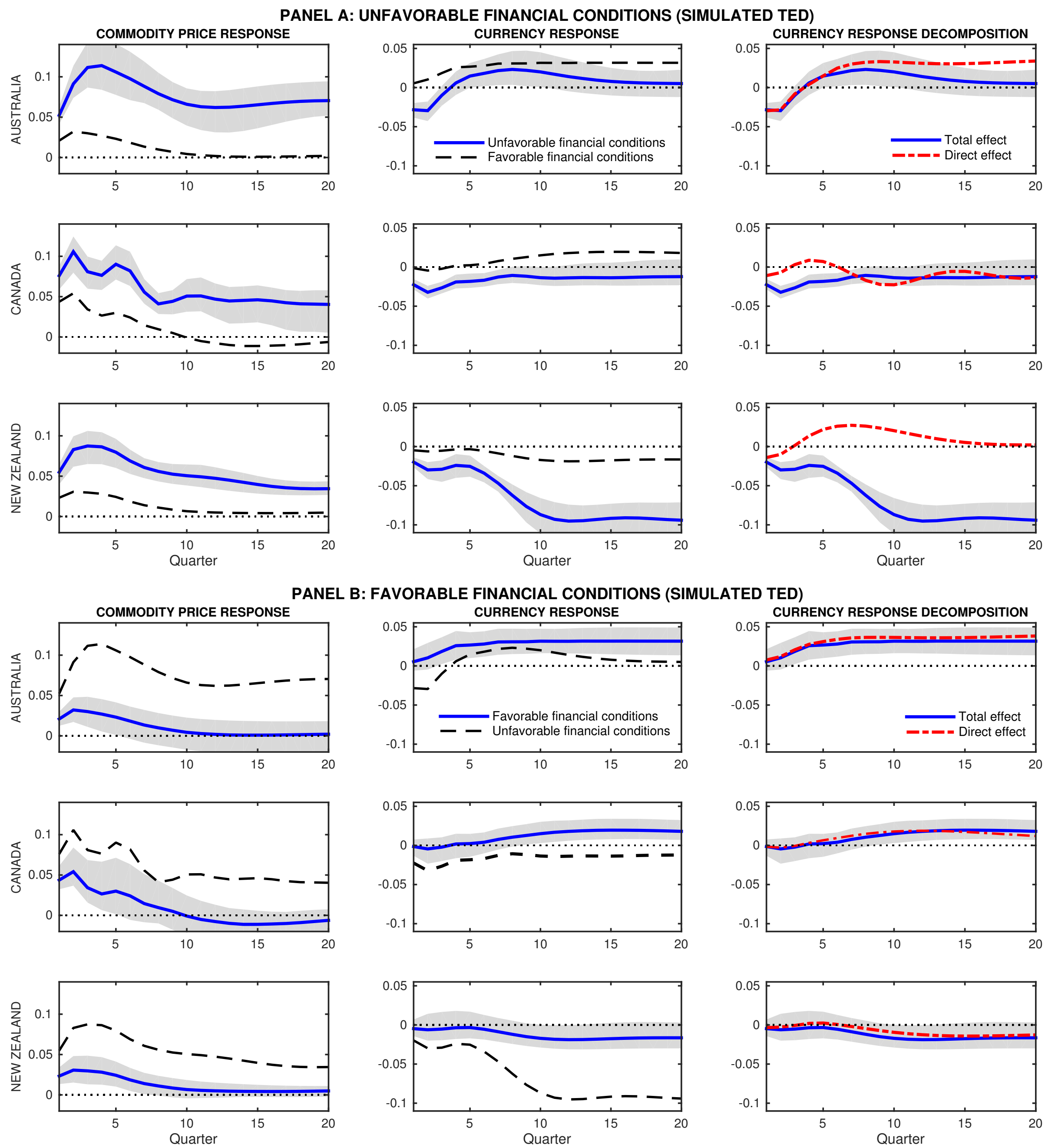

Figure 9: **Conditional responses to commodity price shocks with simulated TED spread.** The figure reproduces the analysis of Figure 5 but with a simulated version of the TED spread. The innovations of this series are orthogonal to those of the global business cycle, as measured with the GDP growth rate of the G7 countries. Panel A displays the responses when the simulated funding liquidity measure is low, while Panel B presents results when this measure is high. Grey areas indicate 90 percent confidence intervals. The data are described in Section 2.3 and the simulated funding liquidity measure is discussed in Section 4.1.

Table I : **Correlations between financial conditions.** This table presents the correlations between the different measures of financial conditions considered in the analysis. These measures are discussed in Section 3.2.

	TED spread	VIX	Currency volatility		
			Australia	Canada	Canada
TED spread	1.000				
VIX	0.355	1.000			
Currency volatility					
Australia	0.388	0.213	1.000		
Canada	0.123	0.113	0.808	1.000	
New Zealand	0.414	0.268	0.853	0.716	1.000

Table II : **Descriptive statistics by country and financial conditions.** This table presents the mean and standard deviation (volatility) of the returns on exchange rates and commodity prices. The statistics are annualized and presented by country and financial regime. The currency is relative to the US dollar. The data are described in Section 2.3 and the different measures of financial conditions are discussed in Section 3.2.

	Funding liquidity		Financial uncertainty		Currency volatility	
	Low	High	High	Low	High	Low
Panel A: Statistics for Australia (%)						
Currency returns						
Mean	2.62	-12.51	7.10	-0.95	3.61	-4.26
Volatility	29.22	17.61	29.51	9.09	34.90	6.89
Commodity returns						
Mean	8.41	13.74	-1.04	8.77	0.51	1.90
Volatility	27.89	16.31	31.95	13.51	33.27	11.68
Panel B: Statistics for Canada (%)						
Currency returns						
Mean	0.55	-5.25	4.66	0.79	-3.33	-2.07
Volatility	16.03	11.12	16.73	7.71	20.40	4.73
Commodity returns						
Mean	-1.87	11.63	-12.44	6.58	2.79	-0.39
Volatility	50.24	31.78	52.35	17.69	54.41	12.81
Panel C: Statistics for New Zealand (%)						
Currency returns						
Mean	5.27	-18.70	2.30	-3.54	6.59	-5.14
Volatility	23.49	25.12	29.27	11.96	32.80	8.34
Commodity returns						
Mean	-4.98	0.44	-7.00	3.76	0.27	3.45
Volatility	24.94	44.14	24.34	8.69	31.80	12.06

Table III : **Currency impact responses to commodity price shocks by financial conditions.** This table presents the impact responses of each country's currency following a negative, one standard-deviation commodity price shock. The table reports, for each currency, the unconditional responses and the responses conditioned by financial conditions. Currencies are relative to the US dollar. The data are described in Section 2.3 and the different measures of financial conditions are discussed in Section 3.2. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Australian dollar	Canadian dollar	New Zealand dollar	Average
Response at impact (%)				
Unconditional	-2.055***	-1.428***	-1.468***	-1.651***
Unfavorable conditions				
Low funding liquidity	-3.1445***	-2.128***	-2.001***	-2.425***
High uncertainty	-2.425***	-1.463***	-1.790***	-1.893***
High currency volatility	-3.033***	-2.069***	-1.678***	-2.260***
Favorable conditions				
High funding liquidity	0.324	0.092	-0.426	-0.003
Low uncertainty	-0.858	-0.731	-0.306	-0.062
Low currency volatility	0.066	0.069	0.067	0.067

Table IV : **Short and long-run elasticities of currencies to commodity prices.** This table presents the elasticities of each country's currency to commodity prices. Panel A reports the short-run elasticities, computed as the ratios of the impact response of currencies relative to the impact response of commodity prices. Panel B shows the long-term elasticities, obtained from the coefficients of the cointegration relation involving both the exchange rates and commodity prices. Currencies are relative to the US dollar. The data are described in Section 2.3 and the different measures of financial conditions are discussed in Section 3.2. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Australian dollar	Canadian dollar	New Zealand dollar	Average
Panel A: Short-run elasticity				
Unconditional	-0.536***	-0.230***	-0.406***	-0.391***
Unfavorable conditions				
Low funding liquidity	-0.732***	-0.300***	-0.450***	-0.494***
High uncertainty	-0.484***	-0.170***	-0.351***	-0.335***
High currency volatility	-0.543***	-0.222***	-0.364***	-0.376***
Favorable conditions				
Low funding liquidity	0.105	0.024	-0.134	-0.002
High uncertainty	-0.409	-0.359	-0.184	-0.317
High currency volatility	0.131	0.029	0.029	0.063
Panel B: Long-run elasticity				
Unconditional	-1.311***	-0.988***	-3.746***	-2.015***
Unfavorable conditions				
Low funding liquidity	-1.162***	-0.962***	-2.958***	-1.661***
High uncertainty	-1.069***	-0.975***	-2.797***	-1.610***
High currency volatility	-1.098***	-0.940***	-3.311***	-1.783***
Favorable conditions				
Low funding liquidity	-1.161***	-0.866***	-2.765***	-1.597***
High uncertainty	-1.069***	-0.919***	-2.696***	-1.561***
High currency volatility	-1.213***	-0.922***	-2.417***	-1.517***

Table V : **Variance decomposition.** This table presents the contribution of commodity price shocks in the explanation of the one-quarter forecast error variance of exchange rates. The table reports, for each currency, the unconditional variance decomposition and the variance decomposition conditioned by financial conditions. The data are described in Section 2.3 and the different measures of financial conditions are discussed in Section 3.2.

	Australian dollar	Canadian dollar	New Zealand dollar	Average
Variance decomposition (%)				
Unconditional	14.86	29.47	9.77	18.03
Unfavorable conditions				
Low funding liquidity	28.95	48.54	12.42	29.97
High uncertainty	12.55	25.09	8.05	15.23
High currency volatility	20.98	34.11	7.02	20.71
Favorable conditions				
High funding liquidity	1.41	0.26	1.77	1.15
Low uncertainty	13.82	21.76	3.74	13.11
Low currency volatility	0.19	0.29	0.09	0.19