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The evolution of commodity market financialization: Implications for portfolio diversification☆

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ABSTRACT

The financialization of commodity markets is a well-documented phenomenon spurred by the massive growth of institutional funds directed into commodity indices from the mid-2000s. More recent research suggests that a subsequent era of de-financialization has coincided with the retreat of institutional investors. This paper uses a latent factor model to examine the dynamic impact of commodity market financialization on spot currency, commodity and equity market linkages, focusing on countries with 'commodity currencies'. The financialization period is characterized by increased interdependence of non-oil and oil commodity markets with each other and with other asset markets, implying reduced diversification potential. We find that commodity markets have become more highly interconnected with currency and equity markets of the large commodity exporters over the most recent sub-sample. We suggest that apparent de-financialization may be attributable to contagion effects from global crisis events, including the Great Recession and the European Debt Crisis of 2012.

1. Introduction

This paper examines the dynamic interconnections between the spot returns of global commodities with the currency and equity markets of countries producing and exporting major commodities at a globally significant level between 1992 and 2020. The aim is to assess the extent of cross-market comovements over a period marking the rise of commodities as an investment asset class (Erb and Harvey, 2006; Gorton and Rouwenhorst, 2006; Main et al., 2018). This phenomenon – dubbed the 'financialization' of commodities (Cheng and Xiong, 2014) – is typically dated to begin in 2004, a year marked by a huge influx of institutional funds (Tang and Xiong, 2012). More recently, some research has noted a reversal of this trend – often referred to as 'de-financialization' or 'post-financialization' – associated with the winding back of fund flows (Adams et al., 2020; Bianchi et al., 2020). This has sparked re-investigation of diversification opportunities associated with commodities and motivates us to investigate the changing nature of commodity market interdependence over these periods using a latent factor model of joint asset price determination. Global commodity market interdependence with the equity and currency markets of large commodity exporters has important economic and policy implications through terms of trade effects on the currency, inflation and interest rates, macroeconomic volatility and transmission of global shocks. From an asset allocation perspective, there are implications for international multi-asset portfolio diversification.

Currency and equity returns for the commodity-exporting countries of Australia, Canada, New Zealand and Norway and the returns of the components of the IMF's commodity indexes are modelled as a function of a common latent factor that affects all

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returns, joint asset class factors that capture comovements between pairs of asset classes, and an idiosyncratic factor that is specific to an individual series. The joint asset class factors allow for a nuanced understanding of asset market comovements and provide insight into channels that underpin cross-market interconnections. These joint asset class factors are a commodity–currency factor, a commodity–equity factor and a currency–equity factor. We include the U.S. equity market to control for general global financial market conditions. All variables are in nominal U.S. dollar terms, implicitly capturing the U.S. investor perspective. The commodity country model is compared to a benchmark model with a sample including Japan, Sweden, Switzerland and the United Kingdom; the countries are selected to represent economies with floating exchange rates and a relatively low primary commodity export share.[1] Our latent factor structure cannot be linked directly to fundamental drivers that are often difficult to measure at a useful frequency but it can determine similarities across asset comovements.

The latent factor models for each set of countries are estimated over three periods aligning with eras identified in the literature as pre-financialization (1992–2003), financialization (2004–2013), and de-financialization (2014–2020). The results illustrate the evolution of commodity market interdependence against the backdrop of commodity market financialization. Estimating the model for large commodity exporters confirms there is increasing comovement between markets over 2004–2014, consistent with the financialization hypothesis. However, the results are not consistent with reduced commodity market interdependence in the de-financialization period dated to 2014. The overall dynamic trend in results is similar for the benchmark countries, although the extent of cross-asset market interconnection of the global commodity returns with both the currency and equity returns is less pronounced, perhaps reflecting differences in the channels connecting markets across the two country groups.

Australia, Canada, New Zealand and Norway are know as 'commodity currency' economies, and, as the name suggests, the commodity sector affects the exchange rates of these economies because of their small and open nature and because of the size of the commodity sector relative to GDP (Amano and Van Norden, 1995; Chen and Rogoff, 2003; Cashin et al., 2004). There is also some evidence that the exchange rates of these countries can affect commodity markets (Clements and Fry, 2008; Chen et al., 2010). For the large commodity exporters, the commodity-currency connection is leveraged for high-frequency currency forecasting (Ferraro et al., 2015; Kohlscheen et al., 2017; Passari, 2017; Zhang et al., 2016) and generates differing carry trade opportunities (Ready et al., 2017) compared to commodity importers. Currency market dependencies with equity markets that are linked to portfolio rebalancing activities of investors (Branson, 1983; Frankel, 1983) may also be distinct for the commodity currency countries (Chaban, 2009; Hau and Rey, 2006). In addition, equity markets of large commodity exporters have been found to have a significant commodity price return beta due to the relative intensity of domestic production (Gagnon et al., 2020).

Whereas commodity markets have more traditionally been linked to currency and financial asset markets through their role as an international conduit for demand and supply shocks (Pavlova and Rigobon, 2007; Peersman et al., 2021) and as a hedging asset (Froot, 1995), mechanisms driving interconnections have expanded. The role of commodities has evolved through time as investors increasingly viewed them as a multi-asset portfolio diversifier, exploiting their low correlation with stocks before 2000 (Gorton and Rouwenhorst, 2006), or as a vehicle for speculation (Boyd et al., 2018; Buyuksahin et al., 2008; Masters, 2008).

Our results contribute to the evidence regarding the implications of financialization for spot asset markets (Basak and Pavlova, 2016). Financialization originates in commodity futures markets and much of the focus in the literature surrounds the extent to which investor behaviour impacts futures prices (Irwin and Sanders, 2012; Singleton, 2014; Hamilton and Wu, 2015). While debate regarding the effects of commodity market financialization on spot markets is not settled, there is evidence that it has underpinned increased comovement within commodity sub-markets (Mayer et al., 2017), and between commodity spot prices with equity prices (Basak and Pavlova, 2016; Tilton et al., 2011) and exchange rates (Boubakri et al., 2019; Wang and Cheung, 2023). Silvennoinen and Thorp (2013) contended that the integration of commodity markets with traditional asset markets would result in common shocks playing a growing role in driving commodity returns. Yet, a de-financialization period has been dated to the closure of global banks' commodity trading units in 2013 (Bianchi et al., 2020). We test the robustness of our results to the demarcation between the financialization and de-financialization periods, recognizing that the 'Shale Revolution', which saw U.S. energy production volumes escalate after 2010, caused a significant structural shift in U.S. equity market and oil market dynamics (Bernanke, 2016; Thorbecke, 2019).

While the common factor accounts for a high proportion of equity return variance for the commodity currency countries across all periods, reflecting long-established linkages between global equity markets, the role of the common and joint asset market factors in the global commodity sector returns evolves. In the pre-financialization period commodity returns variation is largely idiosyncratic, confirming the presence of significant investor diversification opportunities. During the financialization period, the common factor drives increased linkages between the commodity market and the currency and equity returns of the large commodity exporters. At the same time, the joint commodity–equity factor drives significant within-commodity market linkages across sectors and generates some further linkages to the equity markets.

We do not find evidence that the hypothesized 'de-financialization' era ushered in a period of increased independence of spot commodity markets with currency and equity markets of the large commodity exporters. Instead, the common factor still connects the commodity sectors – particularly oil – with the equity market. The prominence of the common factor in the oil market in the de-financialization period is consistent with Bianchi et al. (2020), who finds that the financialization of this sector is persistent. The results are not sensitive to dating the de-financialization period once we control for globally significant events such as the Global

[1] Distinguishing between country groups facilitates comparison while allowing for distinct within-market and cross-market interconnections for the commodity exporters. For instance, using a factor model of international currencies, Aloosh and Bekaert (2022) find a significant currency–commodity factor comprising Australia, Canada, New Zealand and Norway.

Financial Crisis in 2009; Black Monday in 2011; the Great Recession and European Debt Crisis of 2012; and Chinese equity market turbulence in 2016. Failure to control for periods of major global tumult yields less evidence of commodity market interdependence in the de-financialization period, suggesting that diversification opportunities through commodities arose during crisis episodes within the most recent sub-period. Rudimentary tests of financial market contagion during the crisis periods provide evidence supporting this view. This finding contributes to literature on the direction of impact that crisis episodes have on the strength of equity and commodity market linkages (Gagnon et al., 2020; Gorton and Rouwenhorst, 2006; Tang and Xiong, 2012).

The paper proceeds as follows. Section 2 sets out the econometric framework. Section 3 describes the data for the commodity-exporting and benchmark countries. Section 4 presents the empirical results and discusses dynamic market interdependence and implications for international diversification. Section 5 describes the robustness of the results to the dating of the financialization and de-financialization eras. Section 6 concludes.

2. The econometric framework

The latent factor framework is adopted to analyse the interactions between commodity, currency and equity markets for 1) the group of large commodity exporters; and 2) the group of benchmark countries. Latent factor models attribute comovement among time series variables to a limited number of unobserved factors common to the observable series.[2]

An advantage of the model is that it does not require explicit identification of relevant observable independent variables nor entail the associated modelling of the relationship these have with the dependent variables. In practice, this is useful for asset return models as it is challenging to observe all the variables affecting returns, and a failure to capture a comprehensive set of drivers may obscure existing links between markets. This section outlines the return specifications.

Several unobservable factors are used to specify the return series: a common factor that affects all countries and asset markets; a joint commodity–currency returns factor common to all commodities and currencies; a joint commodity–equity returns factor common to all commodities and the non-U.S. equities of the sample countries; a joint currency–equity returns factor common to all currencies and the non-U.S. equities of the sample countries; and idiosyncratic factors, which are unique to each asset market return in each country. The U.S. equity market return is modelled as a function of the common factor and an idiosyncratic factor, and its inclusion helps identify the common factor. The U.S. currency is included implicitly as the U.S. dollar is the numeraire currency.

2.1. Commodity returns specification

Commodity price returns, $P_{i,t}$, are specified as follows

$$P_{i,t} = \lambda_i V_t + \theta_i PC_t + \gamma_i PE_t + \sigma_i U_{i,t}, \quad i = 1, \dots, m \tag{1}$$

where i is the index for the $m = 4$ commodity return variables, V_t is the common factor that affects returns of all asset markets in all countries, and U_t captures idiosyncratic variation in each series. PC_t is the joint commodity–currency market factor that affects only commodity and currency returns, and PE_t is the joint commodity–equity factor that affects only commodity and equity returns. The impact of the common factor, joint commodity–currency factor, joint commodity–equity factor, and idiosyncratic factors on the commodity returns are captured by the factor loadings λ_i, θ_i, γ_i and σ_i, respectively.

2.2. Currency returns specification

Currency returns, $C_{j,t}$, are specified as follows

$$C_{j,t} = \lambda_j V_t + \theta_j PC_t + \beta_j CE_t + \sigma_j U_{j,t}, \quad j = 1, \dots, n \tag{2}$$

where j is the index for the $n = 4$ currency return variables, PC_t is the joint commodity–currency market factor, and CE_t is the joint currency–equity market factor that affects only currency and equity returns. The impact of the common factor, joint commodity–currency factor, joint currency–equity factor, and idiosyncratic factors on the currency returns are captured by the factor loadings λ_j, θ_j, β_j and σ_j, respectively.

2.3. Equity returns specification

Equity returns, $E_{k,t}$, are specified as follows

$$E_{k,t} = \lambda_k V_t + \gamma_k PE_t + \beta_k CE_t + \sigma_k U_{k,t}, \quad k = 1, \dots, v \tag{3}$$

where k is the index for the $v = 4$ equity returns variables, PE_t is the joint commodity–equity market factor, and CE_t is the joint currency–equity returns factor. The impact of the common factor, joint factors and idiosyncratic factors on the commodity returns are captured by the factor loadings λ_k, γ_k, β_k, and σ_k, respectively.

[2] Factor models have been adopted to examine comovement among a cross-section of commodity prices (see, e.g. Delle Chiaie et al., 2022; West and Wong, 2014; Yin and Han, 2015) and comovement with additional economic or financial variables (see, e.g. Byrne et al., 2019; Daskalaki et al., 2014). Factor models have also been utilized since the 1990s to examine the behaviour of currency, equity and interest rates, frequently in the context of international contagion (see, e.g. Diebold and Nerlove, 1989; Dungey, 1999; Dungey et al., 2006; Ng et al., 1992).

2.4. US equity returns specification

The U.S. equity return $E_{USE,t}$ is a function of the common factor and an idiosyncratic factor specified as

$$E_{USE,t} = \lambda_{USE} V_t + \sigma_{USE} U_{USE,t}. \tag{4}$$

2.5. The complete factor model

The measurement equations in (1) through (4), which describe the relationship between the return series and the latent factors, are summarized in matrix form as

$$Y_t = \Lambda F_t + W_t, \tag{5}$$

$$F_t = \Delta F_{t-1} + \Sigma_t, \tag{6}$$

where Y_t is the Nx1 column vector of return series observed at time t; F_t is the Kx1 vector of latent factors; Λ is the NxK matrix of factor loadings that link the return variables to the factors; F_{t-1} is the Kx1 vector of autoregressive factors; and Δ is the KxK matrix of parameter loadings on the autoregressive factors. In this case, $N = 13$ and $K = 17$. The disturbances in the measurement equations are zero, i.e., $W_t = 0$. This assumption allows the idiosyncratic movements in the returns to be treated as latent factors and analyzed alongside the common factors.[3]

The disturbances in the transition equation are distributed as

$$\Sigma_t \sim N(0, Q), \tag{7}$$

where Q is KxK. For identification purposes, $Q = E\left[\Sigma_t \Sigma_t'\right] = I_K$, which reflects an assumption that the factors are independent of each other. The complete factor model is estimated directly using the Kalman filter, with the parameters estimated by quasi-maximum likelihood (QMLE) to account for non-normality in the financial market data.[4]

2.6. Assessing the extent of market interdependence

The central focus is to ascertain the asset market comovements' importance, particularly the role of commodity markets. This is done through two means: assessing the magnitude of common and joint asset market factors in their contribution to the variance decomposition of the returns; and hypothesis testing to determine whether the parameters attached to the common and joint asset market factors are non-zero.

The assumption that factors are independent enables the interpretation of results in terms of the proportionate contribution each factor makes to the variance of each asset. For each asset market, the relative contribution of the factors to return variance is found by squaring both sides of the relevant Eq. (1) to (3) and taking expectations. In the case of commodity returns, this implies

$$E[P_{i,t}^2] = \lambda_i^2 + \theta_i^2 + \gamma_i^2 + \sigma_i^2, \quad i = 1, \ldots, m \tag{8}$$

where λ_i^2 is the contribution of the common factor to commodity return variance and θ_i^2 and γ_i^2 are the shares of variance accounted for by the joint commodity–currency and commodity–equity factors, respectively. The share of the variance due to the idiosyncratic factor is σ_i^2 for each commodity variable.

Apart from the relative magnitude of the effects of the factors, the following hypotheses regarding the joint significance of the factor loadings on the common and joint asset market factors are outlined and tested:

Hypothesis 1. No joint commodity–currency factor
$H_0 : \theta_i = \theta_j = 0, \quad \forall \quad i=1, \ldots, m \quad \text{and} \quad j=1, \ldots, n$

Hypothesis 2. No joint commodity–equity factor
$H_0 : \gamma_i = \gamma_k = 0, \quad \forall \quad i=1, \ldots, m \quad \text{and} \quad k=1, \ldots, \text{v}$

Hypothesis 3. No joint currency–equity factor
$H_0 : \beta_j = \beta_k = 0, \quad \forall \quad j=1, \ldots, n \quad \text{and} \quad k=1, \ldots, v$

Hypothesis 4. No joint asset factors
$H_0 : \theta_i = \theta_j = \gamma_i = \gamma_k = \beta_j = \beta_k = 0, \quad \forall \quad i=1, \ldots, m, \quad j=1, \ldots, n \quad \text{and} \quad k=1, \ldots, v$

Hypothesis 5. No common factor
$H_0 : \lambda_i = \lambda_j = \lambda_k = \lambda_{USE} = 0, \quad \forall \quad i=1, \ldots, m, \quad j=1, \ldots, n \quad \text{and} \quad k=1, \ldots, v$

[3] Alternatively, the measurement equation could specify a disturbance term.

[4] For details on the Kalman filter algorithm, see Hamilton (1994).

A joint test of each null hypothesis is conducted using the likelihood ratio (LR) test. Under the null hypothesis, the LR statistic is

$$2[L(\hat{\theta}) - L(\tilde{\theta})] \sim \chi^2(p), \tag{9}$$

where $L(\hat{\theta})$ denotes the value of the unrestricted log likelihood function, $L(\tilde{\theta})$ denotes the value of the restricted log likelihood function. The LR statistic has a χ^2 distribution with degrees of freedom equal to the number of restrictions, p.

3. Data

Data is collected for a set of large primary commodity exporters comprising Australia, Canada, New Zealand and Norway and a set of benchmark countries comprising Japan, Sweden, Switzerland and the United Kingdom, as well as for the United States. The distinguishing feature between country groups is the ratio of primary commodity exports to total exports, which is substantially higher for countries designated as large commodity exporters. Table A.1 in Appendix A provides a breakdown of primary commodity export shares across sample countries.

International Monetary Fund (IMF) International Financial Statistics (IFS) global commodity price indices for agricultural raw materials, food, metals, and oil are selected to cover major commodity categories. Nominal exchange rate data comes from the IMF IFS database. The exchange rates are expressed as foreign currency units per USD, so an increase in the exchange rate represents a foreign currency depreciation. The country-specific equity price indices are those compiled by Morgan Stanley Capital International (MSCI).[5] Commodity and equity price indices are in nominal USD terms. The monthly data reflects the frequency available for the IMF IFS commodity price index and accords with empirical evidence related to the portfolio rebalancing activities of international investors (Hau and Rey, 2006). The returns for each series are calculated by taking log differences of the nominal monthly price index.[6] All data used in the analysis is sourced through Thomson Reuter's DataStream. See Table B.1 in Appendix B for data sources and codes.

The sample start date is February 1992, and the end of the sample period is February 2020. The start date corresponds to the IMF IFS food price index availability beginning January 1992. The end date is chosen to exclude the period of anomalous market conditions driven by the COVID-19 pandemic and associated policy responses. The sample period is broken into three sub-periods to investigate changing dynamics in inter-market connections: February 1992 to December 2003; January 2004 to December 2013; and January 2014 to February 2020. The first sample captures the period before the financialization of commodity markets. The second sample corresponds to the financialization of the commodities sector, while the third period corresponds to the potential de-financialization period. The beginning date of the financialization period is uncontroversial with Tang and Xiong (2012), Baur (2013), Cheng and Xiong (2014), Gagnon et al. (2020) and Natoli (2021) all finding in favor of 2004. There is some consensus on the start date of the de-financialization period. Zhang et al. (2017), Bianchi et al. (2020), Adams et al. (2020) and Natoli (2021) all take 2014 as the start of the de-financialization period based on the closure of large banks' commodity trading businesses in 2013 (Bianchi et al., 2020), the retrenchment of financial investors from commodity instruments in 2014 (Natoli, 2021) and the oil price decline in 2014 (Zhang et al., 2017; Adams et al., 2020). Gagnon et al. (2020) and Boubakri et al. (2019) refers to a de-financialization phase dating from 2008. Section 5 contains a sensitivity to the dating of the transition between the second and third periods.

Several dummy variables are included in the model to account for financial market disruption. Dummy variables are included for the last three months of 2008 to control for the global financial crisis, in August 2011 to control for Black Monday, the first six months of 2012 to account for the worst of the Great Recession and the European Debt Crisis, and in January 2016 when equity and oil markets plunged in response to the Chinese equity market turbulence.

Summary statistics for the returns variables for the full sample period are provided in Table 1. The means across all commodity, currency and equity return variables are generally close to zero. While returns are broadly higher for equity markets, the mean is less than 1% in magnitude in all cases. The most volatile series is the oil price return with a standard deviation of 8.3%, whereas the volatility for agricultural materials and for food is much lower at around 2.9%. Generally, the equity returns are more volatile than commodity and currency returns, with a standard deviation ranging between 4.2% (United States) and 7.5% (Norway). The skewness, kurtosis and Jarque–Bera tests provide evidence that all series have non-normal return distributions.

4. Empirical results

This section presents and discusses the results obtained from estimating the latent factor model of currency, commodity and equity returns for the commodity exporting countries and the benchmark countries over three periods: pre-financialization; financialization; and de-financialization. The focus is on analysing the dynamic roles of the various factors in driving commodity returns in order to gain insight into the extent and nature of financialization and the implications for portfolio diversification. Results can also be considered more broadly in the context of existing research investigating the nature and implications of asset market interconnections and, more specifically, the extent to which these interconnections are distinct for small open countries with commodity currencies.

[5] The MSCI Indices measure the performance of the large and mid-cap segments of each country's market, covering approximately 85% of the free float-adjusted market capitalization.

[6] Currency and equity returns are computed using an end-of-month price index. IMF IFS publishes the commodity price indices as a monthly average.

Table 1
Descriptive statistics of monthly returns for commodity, currency and equity returns, February 1992–February 2020.

Country	Mean	Min	Max	SD	Skew	Kurt	JB stat	P-value
Panel A. Commodity returns								
Agriculture	0.105	−11.684	8.479	2.928	−0.204	1.008	58.250	0.000
Food	0.115	−12.913	9.317	2.945	−0.125	1.160	48.590	0.000
Metals	0.278	−22.003	14.931	4.679	−0.059	1.530	30.624	0.000
Oil	0.189	−50.686	20.793	8.333	−1.274	4.752	134.636	0.000
Panel B. Currency returns								
Australia	0.057	−8.531	17.982	3.191	0.589	2.707	20.787	0.000
Canada	0.056	−8.874	12.384	2.335	0.380	3.187	8.649	0.013
Japan	−0.043	−15.009	11.392	2.901	−0.282	2.577	7.011	0.030
New Zealand	−0.031	−10.042	12.573	3.377	0.480	1.224	57.405	0.000
Norway	0.150	−8.057	13.760	3.150	0.299	1.119	54.886	0.000
Sweden	0.161	−10.022	17.211	3.283	0.486	2.499	16.844	0.000
Switzerland	−0.118	−12.870	10.930	2.989	−0.020	1.308	40.347	0.000
United Kingdom	0.109	−8.586	12.769	2.544	0.801	3.252	36.995	0.000
Panel C. Equity returns								
Australia	0.259	−29.530	15.702	6.077	−0.963	3.299	53.517	0.000
Canada	0.368	−31.683	19.067	5.720	−1.105	4.479	99.542	0.000
Japan	0.012	−18.129	16.204	5.302	−0.026	0.633	78.965	0.000
New Zealand	0.280	−25.620	14.477	6.268	−0.626	1.196	67.922	0.000
Norway	0.226	−40.586	16.968	7.473	−1.193	4.768	124.168	0.000
Sweden	0.528	−31.000	20.549	7.037	−0.534	1.840	35.006	0.000
Switzerland	0.633	−17.108	13.477	4.587	−0.620	1.069	74.163	0.000
United Kingdom	0.115	−21.229	12.435	4.657	−0.664	1.875	42.658	0.000
United States	0.550	−18.931	10.285	4.186	−0.912	1.948	62.417	0.000

Variance decompositions and joint tests of significance speak to the relative size and importance of the common factor, (V_t), and joint asset market factors — that is, the joint commodity–currency factor (PC_t), the joint commodity–equity factor (PE_t), and the joint currency–equity factor (CE_t). Parameter estimates reveal the direction of return series' comovement attributable to a given factor and speak to the significance of the factor loadings for each variable. The joint tests of the significance of each joint factor are presented first, in Section 4.1. A comparative overview of key findings for both country groups is presented in Section 4.2.

4.1. Significance of the joint factors

The results of likelihood ratio tests conducted for the null hypotheses in Section 2.6 applied to the commodity-exporting and benchmark country models over the January 1992–December 2003, January 2004–December 2013 and January 2014–February 2020 sample periods are displayed in Panels A to C of Table 2, respectively. The null hypotheses, which involve joint tests of relevant parameter loadings being zero, can be rejected in each case with at least a 1% level of significance. Having established the statistical significance of the joint factors for both economy types, it is pertinent to examine the variance decompositions to gain perspective on their economic significance.

4.2. Dynamic market interdependence and implications for international diversification

The variance decompositions for each return series for the factor models of large commodity exporters and the benchmark countries are summarized in Figs. 1 and 2, respectively. More detailed tables displaying percentage variance contributions for each factor are contained in Table C.1 of Appendix C for the large commodity and in Table D.1 of Appendix D for the benchmark countries. Panels (a), (b) and (c) display the results for the periods February 1992–December 2003; January 2004–December 2013; and January 2014–February 2020, respectively. The variance decompositions are considered in conjunction with parameter estimates, contained in Tables E.1–E.3 of Appendix E for the large commodity exporters and Tables F.1–F.3 of Appendix F for the benchmark countries. Individual series' factor loadings are classified as significant if the associated p-values are less than 0.05. Together, the variance decompositions and parameter estimates speak to the extent, significance and direction of common and joint asset market effects and allow for inferences regarding diversification opportunities. This sub-section starts with discussion of results for the large commodity exporters before contrasting the results for the benchmark countries.

For the large commodity exporters, a key result is corroboration of distinct pre-financialization and financialization eras, as evidenced by the evolution of the common and joint asset market factors shown in Panels (a) and (b) of Fig. 1. The common factor played a greater role in driving all four global commodity returns over the 2004–2013 period compared to the 1992–2003 period.

International equity markets were already highly connected through the common factor during the pre-financialization period, reflecting extensive global stock market interdependence that had accelerated throughout the 1990s (Ayuso and Blanco, 2001). The common factor explained equity return variation ranging from between 34% (New Zealand) and 92% (Canada), and drove some currency return variation (up to 14% in the case of Canada). Yet, there was limited interconnection of the commodity market with the equity or currency market through the common or joint asset market factors. The exception was the metals

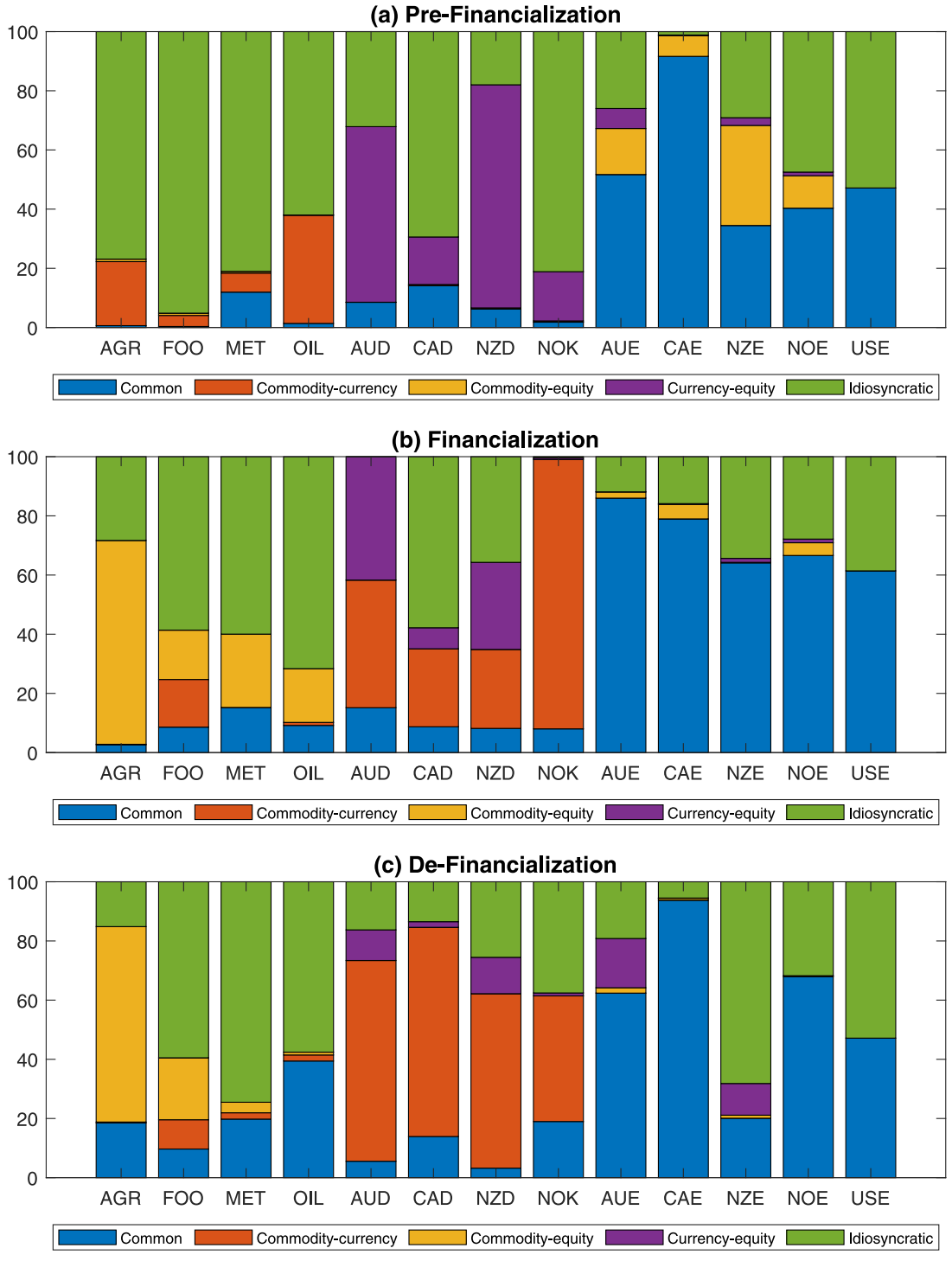

Fig. 1. Variance decompositions for the commodity country latent factor model.
Notes: Estimates of the return variance contribution by factor, expressed in percentage points, obtained from estimating the latent factor model for the commodity countries using return data over the three samples are reported. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE); and the U.S. (USE).

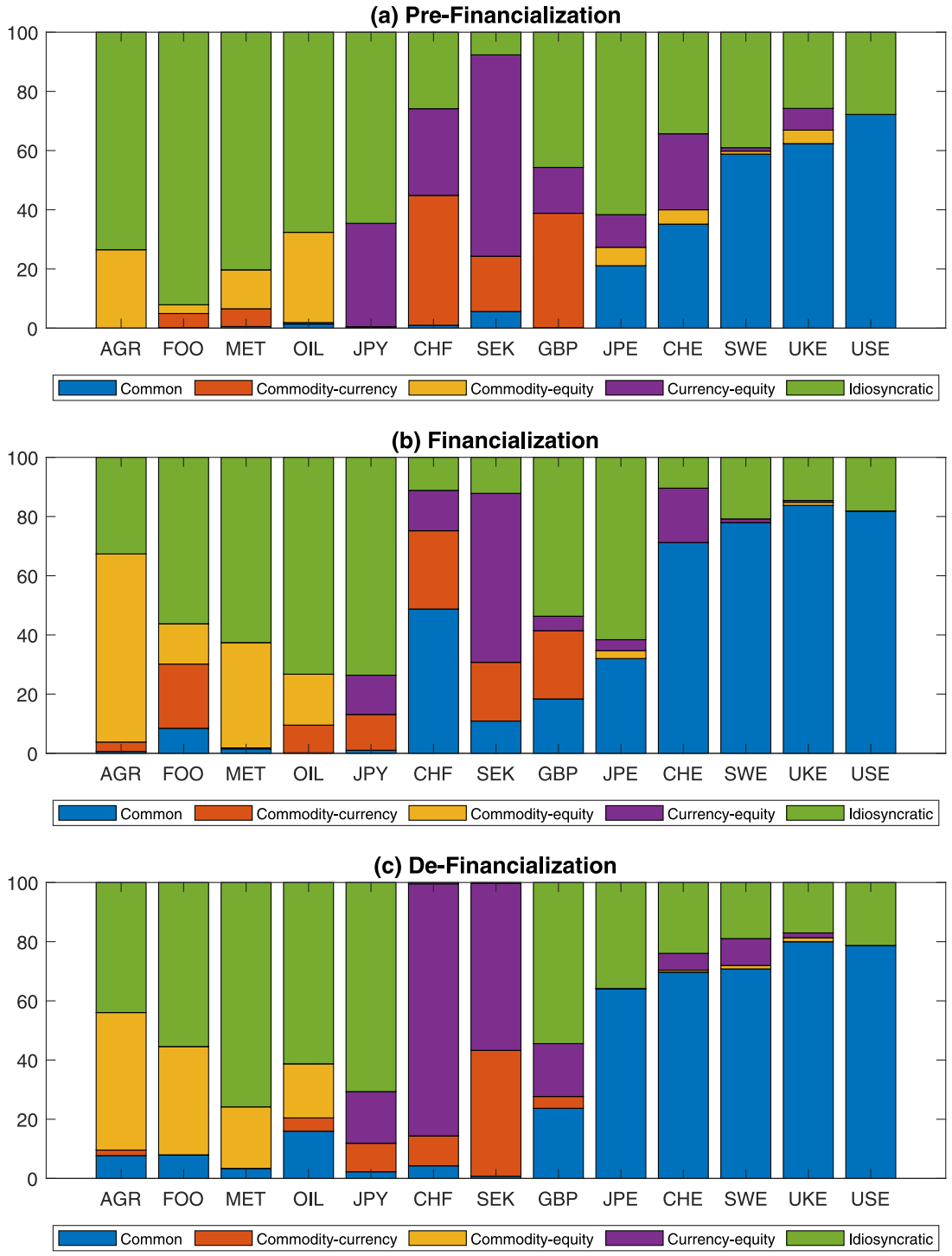

Fig. 2. Variance decompositions for the benchmark latent factor model.
Estimates of the return variance contribution by factor, expressed in percentage points, obtained from estimating the latent factor model for the benchmark countries using return data over the three samples are reported. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Japan (JPY); Switzerland (CHF); Sweden (SEK); and the UK (GBP). Equity returns are Japan (JPE); Switzerland (CHE); Sweden (SWE); UK (UKE); and the U.S. (USE).

Table 2
Hypotheses testing: Joint asset market effects in the commodity country and benchmark models.

Hypotheses: No joint asset market factors	Commodity exporters		Benchmark	
	Statistic	*p*-value	Statistic	*p*-value
Panel A. January 1992–December 2003				
H_0: no commodity–currency factor	20.79	0.008	33.09	0.000
H_0: no commodity–equity factor	53.11	0.000	47.76	0.000
H_0: no currency–equity factor	38.50	0.000	77.02	0.000
H_0: no joint asset factors	224.65	0.000	337.77	0.000
Panel B. January 2004–December 2013				
H_0: no commodity–currency factor	32.70	0.000	165.03	0.000
H_0: no commodity–equity factor	41.67	0.000	85.59	0.000
H_0: no currency–equity factor	27.61	0.001	106.12	0.000
H_0: no joint asset factors	252.30	0.000	301.36	0.000
Panel C. January 2014–February 2020				
H_0: no commodity–currency factor	24.34	0.002	22.86	0.004
H_0: no commodity–equity factor	21.32	0.006	23.29	0.003
H_0: no currency–equity factor	24.85	0.002	29.22	0.000
H_0: no joint asset factors	130.50	0.000	129.62	0.000

Notes: Likelihood ratio tests for the four null hypotheses associated with the latent factor model estimated for the commodity exporter and benchmark countries using data over three samples are reported. For each null hypothesis the associated test Statistic and *p*-value are shown.

sector, for which the common factor accounted for 12% of return variation. Over this first sub-period, commodity prices were driven largely by idiosyncratic shocks, which accounted for return variation of between 62% for oil prices to 95% for food prices. This confirms extensive diversification opportunities through commodities before the financialization era. The commodity–currency factor operated as a single market factor, generating linkages between commodity sectors. The other joint asset market factors also chiefly served as single market factors, with the commodity–equity market factor driving linkages between equity returns and the currency–equity factor being an important driver for currency returns.

During the financialization period, encapsulated in Panel (b) of Fig. 1, global commodity markets became increasingly linked to the currency and equity returns of the large commodity exporters. Although institutional investors sought diversification through commodities futures, the model results confirm increased interdependence between spot asset returns throughout this period. The common factor explained return variation of 15% for metals, 9% for oil, 9% for food, and 3% for agriculture. The common factor also played a larger role in the variance of almost all individual equity and currency return series, except for Canada. A common shock which drove up commodity returns also drove up equity returns and appreciated the exchange rates. Joint asset market factors served to drive additional significant interconnections between commodity sectors, with the commodity–equity factor underpinning high variation in returns to agriculture (69%), metals (25%), oil (18%) and food (17%) and driving returns in tandem. Together, the results reflect lower diversification opportunities offered by commodity sectors during the financialization period.

Contrary to the assertion that interdependence of commodity markets has unwound, we find that global commodity sectors increasingly comove with equity and currency markets of the large commodity exporters over the most recent sub-period, shown in Panel (c) of Fig. 1. The common factor drives higher return variation in oil (39%), metal (20%), agriculture (19%) and food (10%) compared to the preceding financialization sub-period. The equity return variance attributable to the common factor remains high across all series. As in the financialization period, the common factor drives commodities and equities in the same direction. The common factor has a variable effect on currencies, but is significant for Canada and Norway (accounting for 14% and 19% of return variation, respectively), and drives these exchange rates in tandem with commodity returns and equity returns. The commodity–currency factor, which drove substantial commodity sector inter-linkages during financialization, plays a much smaller role in the metal and oil market in the recent sub-period. A key implication of these results are that diversification opportunities for commodity markets have not been renewed in the hypothesized de-financialization era. The increased interconnection of the oil market is consistent with findings in Bianchi et al. (2020) and Zhang et al. (2017). This result is also consistent with Thorbecke (2019), who find that shifting sectoral dependencies connected to the Shale Revolution has led to increased positive connection between the oil price and U.S. equity market after 2010.

As was the case for the large commodity exporters, global commodity markets are not highly connected to the currency and equity returns of the benchmark countries in the pre-financialization period, as seen from Panel (a) of Fig. 2. This is evidenced by the high proportion of return variance attributable to the idiosyncratic factor, which ranges from 68% in the case of oil to 92% in the case of food. The common factor also drove a high proportion of equity market return variation between the benchmark countries in the pre-financialization period, accounting for variance ranging from 21% for Japan to 62% for the U.K., but played a smaller role in currency returns compared to the large commodity exporters. The commodity–equity and commodity–currency and factors drove within market linkages between the commodity returns and the equity returns, respectively. However, the currency–equity joint market factor drove linkages across the exchange rates as well as some connection between the currency and equity markets.

In contrast to the results for the large commodity exporters, the role of the common factor in driving commodity sector returns does not increase markedly between the pre-financialization and financialization periods, as seen from Panel (b) of Fig. 2. The common factor generally accounts for higher variation in equity and currency returns over this period, and accounts for 8% of food

price variation, but explains less than 2% of return variation across the other commodity sectors. The commodity–equity joint market factor does not drive cross-market comovement in this period. This suggests there was greater opportunity to utilize commodities as an equity diversifier for the benchmark countries compared to the large commodity exporters in the financialization era. However, over this period, there was a substantial increase in commodity and currency market interdependence forged by the respective joint asset market factor, which drove positive comovement in cross-market returns. The direction of comovement is consistent with Passari (2017), who explains that despite commodity price increases causing a depreciation in importer country currencies through the terms of trade channel, the exchange rates will typically appreciate against the USD. This is due to the status of the U.S. as a comparatively larger importer causing it to suffer a commensurately larger terms of trade deterioration.

Panel (c) of Fig. 2 shows that the common factor catalyzed increased equity and commodity markets interdependence in the most recent sub-period, although the effect is not as profound as for the large commodity exporters. The common factor accounted for return variation of up to 16% for the oil market, 8% for agriculture and food and 3% for metals. The common factor loadings are significant for agriculture, food and oil returns and drive them in tandem with equity returns, for which the common factor continues to be important. The common factor accounts for a relatively small share of return variation in currencies, except in the case of the pound. As in the financialization period, the commodity–equity factor effectively functions as a commodity factor, generating comovement between commodity sectors but having little impact on the equity returns. The factor loadings are significant for commodities and move returns in the same direction. The commodity–currency and currency–equity market factors mainly drive interconnections within the currency market.

5. Robustness to the de-financialization dating

Section 4 shows little evidence of de-financialization reflected in the relationship between spot commodity, currency and equity markets from 2014 onwards. This section explores the robustness of these results to the dating of the financialization period. The experiments contained in this section informed the model specification of Section 2, particularly relating to the treatment of extreme periods in the data, such as the global financial crisis, Black Monday in 2011, the Great Recession and the European debt crisis period in 2012 and Chinese equity market turbulence in 2016.

Motivated by the documented shift in global energy export composition and the U.S. equity market and oil market relationship after 2010 (Thorbecke, 2019), we re-run the models assuming the period beginning January 2011 – rather than January 2014 – encompasses the de-financialization era. Fig. 3 compares the variance decompositions obtained for the commodity sector price returns when we estimate the factor model for the large commodity exporting countries using these alternate demarcations between financialization and de-financialization periods. When we adopt 2011 as the start of the third period, the relative contribution of the common factor to the commodity price return variance decreases for all but the oil market after the financialization era, consistent with the concept of de-financialization.[7] The contrast between this result and the lack of evidence for de-financialization when using 2014 to delineate the sample period warrants further investigation.

To determine why the results differ we repeatedly re-ran the latent factor model for the large commodity exporters as we increased the starting date of the de-financialization period by six monthly increments from January 2011. In doing so, we identified changes in the model parameters over the first half of 2012, coinciding with the worst of the Great Recession and the European Debt crisis. To control for the influence of these outliers, we defined dummy variables for the financial crisis episodes in the data as described in Section 3. Fig. 4 presents results, in the form of the common factor contribution to return series variance, from the subsequent model estimations using the rolling financialization and de-financialization dating. The legend indicates the date when the de-financialization period is assumed to begin, which equates to the month after the financialization period is assumed to end. Controlling for the Great Recession and European Debt crisis yields much more coherence across results regardless of the adopted end date for the financialization period, and supports the key finding of no de-financialization in Section 4. The consistency of results shown in the common factor is similarly found for the joint asset market factors.

These findings suggest the apparent attenuation of financialization identified in the literature may be reflecting the impacts of financial market crises and contagion on commodity, currency and equity returns. Although such analysis is usually performed using high frequency data, a rudimentary test of whether or not it could be global crises affecting markets is performed. The test builds on the Chow version of the Forbes and Rigobon (2002) test for contagion presented in Dungey et al. (2005), which, unlike most other contagion tests, can be performed using monthly data.[8] The tests are performed assuming that global crises transmit via the U.S. equity market, and, as an alternative, through the oil market. A multivariate model of contagion for the commodity sector is to set out in a 4 equation system for $P_{i,t}$, which is augmented by dummy variables. The system is

$$P_{i,t} = \alpha_{0,i} + \alpha_{1,i} E_{USE,t} + \delta_{0,i} d_t + \delta_{1,i} E_{USE,t} d_t + \tau_{0,i} E_{USE,t-1} + \tau_{1,i} P_{i,t-1} + \eta_{i,t}, \quad i = 1, \ldots, m \tag{10}$$

where a slope dummy, d_t, is defined as

$$d_t = \begin{cases} 1: & Crisis \\ 0: & \text{otherwise} \end{cases} \tag{11}$$

where $Crisis$ refers to the crisis dates defined in Section 3.

[7] The commodity-equity factor effectively operates as a commodity market factor.

[8] This version of the contagion test is invariant to the scaling of the data, unlike the Forbes and Rigobon (2002) test.

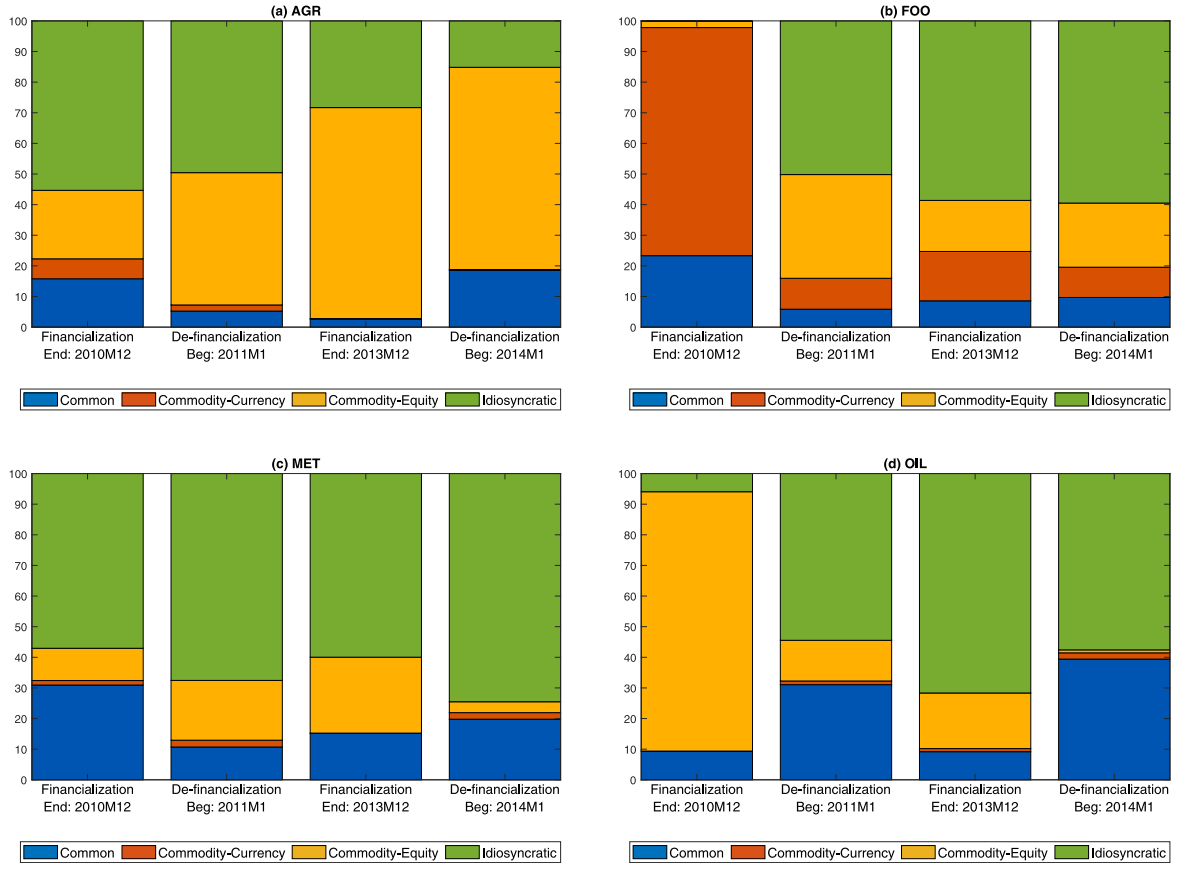

Fig. 3. Comparison of common and joint factors influence on commodities in the financialization and de-financialization periods when de-financialization begins 2011 or, alternatively, 2014.
Notes: Estimates of the return variance contribution by factor, expressed in percentage points, obtained from estimating the latent factor model for the commodity countries over the finalization and de-financialition periods using alternate dating of the start of de-financialization era: January 2011 and January 2014. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL.

Each commodity return $P_{i,t}$ is expressed as a function of a constant $\alpha_{0,i}$, U.S. equity returns at time t, $(E_{USE,t})$, lagged U.S. equity and lagged own returns. The dummy variable captures the effects of the financial crisis episodes and enters the equation in two places. The first captures a break in the constant term in the parameter $\delta_{0,i}$. The second is through the interaction term of the dummy variable with the U.S. equity returns. Here, the parameter $\delta_{1,i} \neq 0$ in (11), captures the effect of contagion. It represents the additional contribution of U.S. equity returns in a crisis on commodity returns in addition to the normal influence that U.S. equity returns have. If there is no change in the relationship the dummy variable provides no new additional information during the crisis period, resulting in $\delta_{1,i} = 0$.

A multivariate test of no contagion across the commodity return is a test of the null hypothesis

$$H_0 : \alpha_{1,i} = 0, \qquad \forall i. \tag{12}$$

implemented using a standard multivariate Wald test. A general test of a crisis not sourced in the U.S. is a test of the parameters $\alpha_{0,i}$. The results displayed in Table 3 show that there is evidence that crisis episodes jointly affect the commodity markets, with each commodity except for oil a recipient of financial market contagion. In the alternate model where contagion transmits via the oil market, all commodities are jointly affected, as are agriculture and food, but not metals.

6. Conclusion

This paper estimates a latent factor model of spot currency, commodity and equity returns of commodity-exporting countries to examine the evidence for commodity market financialization, as well as the subsequent de-financialization said to have occurred over the past decade. The commodity-exporting countries are Australia, Canada, New Zealand and Norway, which are characterized as small open economies with large commodity-exporting sectors. The factor model consists of common, joint asset market and idiosyncratic factors. We estimate an analogous model using the economies of Japan, Sweden, Switzerland and the United Kingdom in order to benchmark our results.

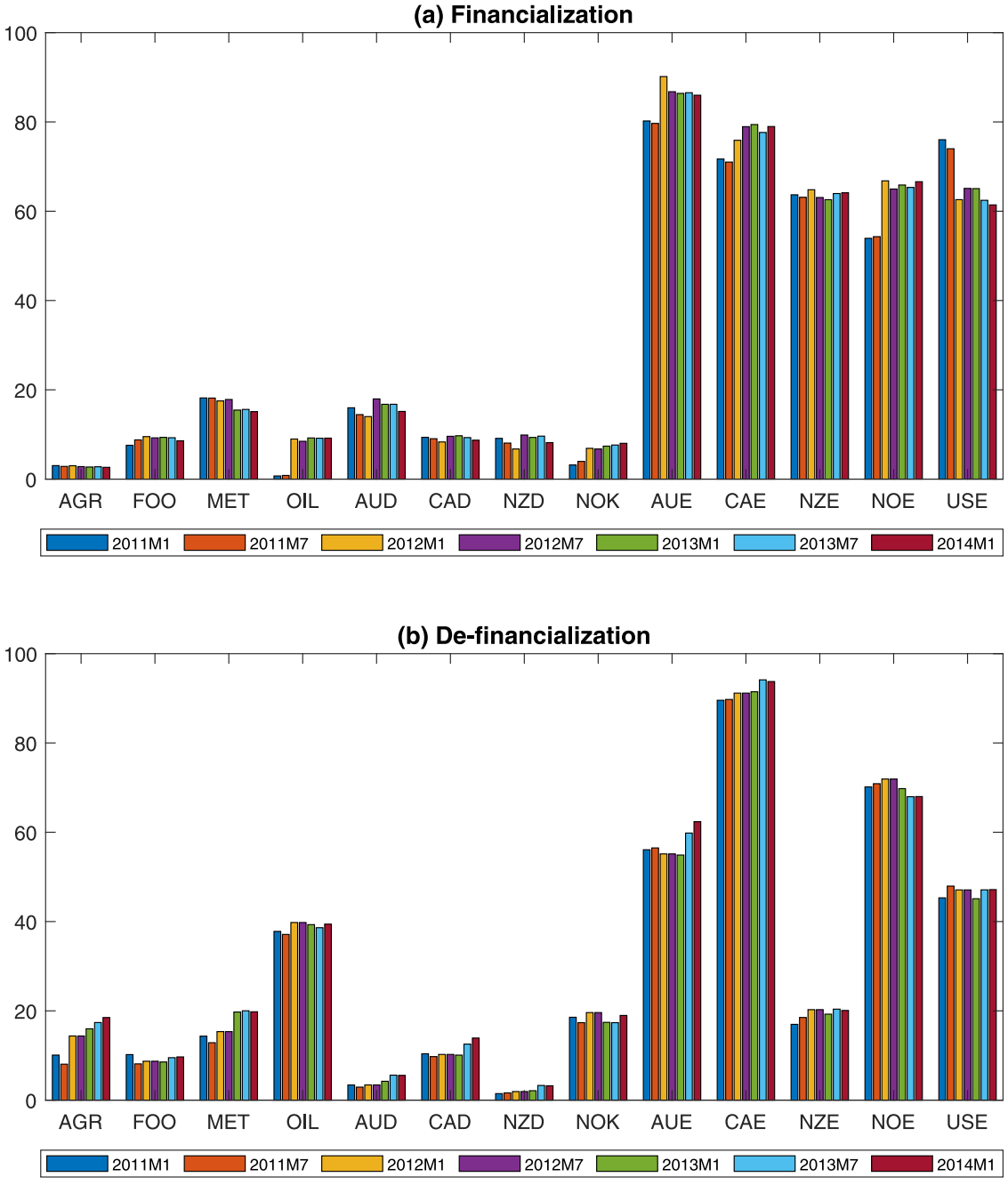

Fig. 4. Comparison of the return variance contributed by the common factor over rolling dating of the de-financialization period between January 2011 to January 2014, with controls for market turmoil.
Notes: Estimates of the return variance contribution by common factor, expressed in percentage points, obtained from estimating the latent factor model for the commodity countries using return data over rolling dating of the de-financialization period start (shown in the legend). The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE); and the U.S. (USE).

The contribution of the common and joint asset market factors to the returns of the global commodity markets and the equity markets and currencies of the large commodity exporters differs across the three periods and is consistent with the characteristics expected through the evolution of commodity market financialization. Results demonstrate that commodity markets were a valuable asset class for diversification before financialization, as idiosyncratic and general commodity market movements drove returns. Over 2004–2013, there was increased global commodity market interdependence both within commodity sectors and between the

Table 3
Tests for crisis and contagion.

Test	Test Statistic	dof	p-value
Panel A: Source - U.S. equity returns			
Test of joint crisis on commodities	13.89	4	0.008
Test for joint contagion to agriculture, food, metals, oil	4.78	1	0.029
Tests for contagion to:			
Agriculture	8.93	1	0.003
Food	3.93	1	0.047
Metals	3.37	1	0.067
Oil	1.78	3	0.620
Panel B: Source - oil returns			
Test for joint crisis dummy on commodities	1.78	3	0.620
Test for joint contagion to:			
Commodities	8.90	3	0.031
Agriculture	4.53	1	0.033
Food	5.40	1	0.020
Metals	2.25	1	0.134

Notes: Commodities in panel B exclude oil.

commodity market with equity and currency markets. In contrast to recent literature suggesting an era of de-financialization dating to 2014, we find the common factor drives increased within- and across- market linkages for all commodity sectors, especially oil, over this period. Further investigation of this result using rolling sub-sample analysis and tests for contagion suggests that apparent evidence of de-financialization may be attributable to episodes of market turmoil.

The overall trend is similar for the benchmark countries, although there is less pronounced evidence of global commodity market interdependence with equity markets through common factor effects in the financialization and de-financialization periods. In the financialization era, substantial linkages between the commodity market and currencies of the benchmark countries were driven by the joint asset market factor. The relevance of the commodity–currency factor for the benchmark economies can be attributed to exchange rate movements relative to the U.S. dollar through terms of trade effects.

The results speak to the evolution of diversification opportunities available to investors in either commodity currency countries or the benchmark countries, before, during, and after financialization. Overall, we find that increased commodity market comovement with equity markets and currency markets may suggest eroded opportunities to use commodities to diversify. However, there are sectoral and country group differences to appreciate, with global commodity markets more highly interconnected with the equity and currency markets of large commodity exporters. Within the commodity market, the oil market is the most tightly linked to equity and currency returns of both large commodity exporters and the benchmark countries.

CRediT authorship contribution statement

Renée Fry-McKibbin: Conceptualization, Methodology, Software, Validation, Writing – original draft, Review & editing , Visualization, Formal analysis, Data curation, Investigation. **Kate McKinnon:** Conceptualization, Methodology, Software, Validation, Writing – original draft, Review & editing, Visualization, Formal analysis, Data curation, Investigation.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Appendix A. Commodity share of exports

See Table A.1.

Appendix B. Data sources

See Table B.1.

Appendix C. Variance decompositions for the commodity-exporting countries

See Table C.1.

Appendix D. Variance decompositions for the benchmark countries

See Table D.1.

Appendix E. Parameter estimates for the commodity-exporting countries

See Tables E.1–E.3.

Appendix F. Parameter estimates for the benchmark countries

See Tables F.1–F.3.

Table A.1
Primary commodity share of total exports for sample countries.

Country	1992–2003	2004–2013	2014–2020
	Panel A. Commodity currency countries		
Australia	72.49%	76.54%	79.22%
Canada	32.50%	41.10%	48.52%
New Zealand	67.57%	68.23%	75.57%
Norway	68.94%	77.63%	78.19%
	Panel B. Benchmark countries		
Japan	2.73%	4.86%	7.10%
Sweden	13.18%	17.18%	21.75%
Switzerland	9.64%	10.66%	30.74%
United Kingdom	18.08%	21.80%	27.05%
	Panel C. United States		
United States	17.03%	18.83%	26.00%

Notes: Reported are average percentage of primary commodity exports to total exports over three periods: 1992–2003; 2004–2013; and 2014–2020. Calculations are based on data from UN Comtrade.

Table B.1
Datastream source codes for the commodities, currencies and equity indices.

Category	Commodities	Country	Currencies	Equities
Agricultural raw materials	WDCAMPIMF	Australia	AUI..AE.	MSAUST$(PI)
Food	WDCFOPIMF	Canada	CNI..AE.	MSCNDA$(PI)
Metals	WDCMEPIMF	New Zealand	NZI..AE.	MSNZEA$(PI)
Oil	WDCACPIMF	Japan	JPI..AE.	MSJPAN$(PI)
		Norway	NWI..AE.	MSNWAY$(PI)
		Sweden	SDI..AE.	MSSWDN$(PI)
		Switzerland	SWI..AE.	MSSWIT$(PI)
		United Kingdom	UKI..AE.	MSUTDK$(PI)
		United States		MSUSAML$(PI)

Table C.1
Variance decompositions for the commodity country latent factor model.

Variable	Common factor	Joint factors			Idio factor
		Commodity-currency	Commodity-equity	Currency-equity	
	Panel A. January 1992–December 2003				
AGR	0.62	21.64	0.84		76.90
FOO	0.34	3.74	0.76		95.16
MET	11.94	6.44	0.58		81.04
OIL	1.38	36.57	0.07		61.98
AUD	8.51	0.03		59.33	32.13
CAD	14.13	0.40		16.06	69.41
NZD	6.21	0.41		75.39	17.99
NOK	1.80	0.43		16.63	81.14
AUE	51.70		15.55	6.76	26.00
CAE	91.63		7.00	0.23	1.15
NZE	34.48		33.81	2.61	29.10
NOE	40.33		10.95	1.24	47.48
USE	55.92				44.08

(*continued on next page*)

Table C.1 (*continued*).

Variable	Common factor	Joint factors			Idio factor
		Commodity-currency	Commodity-equity	Currency-equity	
	Panel B. January 2004–December 2013				
AGR	2.64	0.16	68.88		28.32
FOO	8.59	16.11	16.68		58.62
MET	15.12	0.13	24.79		59.96
OIL	9.18	1.01	18.16		71.65
AUD	15.16	43.13		41.71	0.00
CAD	8.72	26.35		7.11	57.82
NZD	8.18	26.68		29.43	35.71
NOK	8.02	91.05		0.53	0.40
AUE	85.98		2.11	0.02	11.90
CAE	78.97		4.89	0.27	15.87
NZE	64.14		0.15	1.35	34.37
NOE	66.61		4.30	1.23	27.85
USE	61.42				38.58
	Panel C. January 2014–February 2020				
AGR	18.50	0.31	66.03		15.16
FOO	9.68	9.89	20.94		59.49
MET	19.79	2.14	3.56		74.51
OIL	39.42	2.03	0.97		57.58
AUD	5.55	67.85		10.34	16.26
CAD	13.91	70.69		1.90	13.50
NZD	3.22	58.96		12.29	25.54
NOK	18.98	42.46		0.99	37.58
AUE	62.37		1.81	16.64	19.18
CAE	93.76		0.65	0.10	5.50
NZE	20.09		1.03	10.71	68.18
NOE	67.99		0.00	0.26	31.75
USE	47.16				52.84

Notes: Estimates of the return variance contribution by factor, expressed in percentage points, obtained from estimating the latent factor model for the commodity countries using return data over the three samples are reported. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE); and the U.S. (USE).

Table D.1
Variance decompositions for the benchmark country latent factor model.

Variable	Common factor	Joint factors			Idio factor
		Commodity-currency	Commodity-equity	Currency-equity	
	Panel A. January 1992–December 2003				
AGR	0.02	0.02	26.47		73.49
FOO	0.23	4.71	2.96		92.11
MET	0.54	6.00	13.16		80.30
OIL	1.38	0.51	30.49		67.62
JPY	0.33	0.12		34.95	64.60
CHF	0.97	43.89		29.28	25.86
SEK	5.60	18.71		68.02	7.67
GBP	0.16	38.66		15.49	45.69
JPE	21.09		6.22	11.04	61.65
CHE	35.15		4.83	25.69	34.33
SWE	58.81		1.00	1.15	39.04
UKE	62.36		4.55	7.34	25.76
USE	72.20				27.80
	Panel B. January 2004–December 2013				
AGR	0.62	3.17	63.57		32.64
FOO	8.45	21.69	13.65		56.21
MET	1.49	0.34	35.58		62.59
OIL	0.16	9.36	17.20		73.28
JPY	1.02	12.08		13.28	73.61
CHF	48.75	26.46		13.63	11.17

(*continued on next page*)

Table D.1 (*continued*).

Variable	Common factor	Joint factors			Idio factor
		Commodity-currency	Commodity-equity	Currency-equity	
SEK	10.89	19.86		57.08	12.17
GBP	18.37	23.06		4.90	53.68
JPE	32.02		2.66	3.70	61.62
CHE	71.16		0.06	18.36	10.41
SWE	77.94		0.02	1.24	20.81
UKE	83.77		1.04	0.62	14.57
USE	81.86				18.14
	Panel C. January 2014–February 2020				
AGR	7.71	1.88	46.47		43.94
FOO	7.86	0.12	36.60		55.42
MET	3.38	0.01	20.79		75.82
OIL	15.97	4.49	18.28		61.26
JPY	2.24	9.67		17.44	70.65
CHF	4.26	10.11		85.18	0.45
SEK	0.74	42.54		56.41	0.31
GBP	23.69	4.00		17.85	54.45
JPE	64.13		0.02	0.01	35.83
CHE	69.71		0.65	5.69	23.95
SWE	70.80		1.18	9.07	18.95
UKE	80.00		1.33	1.63	17.04
USE	78.72				21.28

Notes: Estimates of the return variance contribution by factor, expressed in percentage points, obtained from estimating the latent factor model for the benchmark countries using return data over the three samples are reported. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Japan (JPY); Switzerland (CHF); Sweden (SEK); and the UK (GBP). Equity returns are Japan (JPE); Switzerland (CHE); Sweden (SWE); UK (UKE); and the U.S. (USE).

Table E.1
Parameter estimates for commodity country model, February 1992–December 2003.

Variable	λ	θ	γ	β	σ
AGR	0.079	0.465	0.092		0.877
	(0.084)	(0.235)	(0.108)		(0.125)
FOO	0.059	−0.194	0.088		0.977
	(0.080)	(0.189)	(0.093)		(0.075)
MET	0.345	0.254	0.076		0.900
	(0.074)	(0.137)	(0.106)		(0.062)
OIL	0.117	0.604	−0.027		0.786
	(0.083)	(0.296)	(0.103)		(0.207)
AUD	−0.290	−0.017		0.766	0.564
	(0.135)	(0.152)		(0.138)	(0.188)
CAD	−0.376	−0.063		0.401	0.833
	(0.100)	(0.153)		(0.121)	(0.073)
NZD	−0.248	−0.064		0.862	−0.421
	(0.149)	(0.206)		(0.197)	(0.313)
NOK	−0.134	−0.065		0.407	0.899
	(0.104)	(0.203)		(0.151)	(0.082)
AUE	0.715		0.392	−0.258	0.507
	(0.087)		(0.082)	(0.067)	(0.066)
CAE	0.958		−0.265	0.048	0.107
	(0.075)		(0.123)	(0.109)	(0.164)
NZE	0.584		0.579	−0.161	0.537
	(0.101)		(0.113)	(0.135)	(0.081)
NOE	0.634		0.330	0.111	0.687
	(0.088)		(0.123)	(0.104)	(0.050)
USE	0.744				0.661
	(0.084)				(0.047)

Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE) and the U.S. (USE).

Table E.2
Parameter estimates for commodity country model, January 2004–December 2013.

Variable	λ	θ	γ	β	σ
AGR	−0.146	−0.036	−0.743		−0.476
	(0.103)	(0.102)	(0.200)		(0.289)
FOO	−0.249	−0.341	−0.347		−0.651
	(0.103)	(0.071)	(0.084)		(0.056)
MET	−0.349	0.032	−0.446		−0.694
	(0.109)	(0.104)	(0.096)		(0.055)
OIL	−0.250	−0.083	−0.351		−0.698
	(0.100)	(0.075)	(0.163)		(0.079)
AUD	0.331	0.558		−0.549	0.000
	(0.086)	(0.140)		(0.133)	(0.041)
CAD	0.264	0.460		−0.239	−0.681
	(0.118)	(0.097)		(0.117)	(0.056)
NZD	0.255	0.461		−0.485	−0.534
	(0.096)	(0.133)		(0.136)	(0.034)
NOK	0.244	0.821		0.063	0.054
	(0.079)	(0.064)		(0.189)	(0.143)
AUE	−0.769		−0.120	0.011	0.286
	(0.076)		(0.093)	(0.069)	(0.049)
CAE	−0.665		−0.166	−0.039	−0.298
	(0.073)		(0.109)	(0.050)	(0.037)
NZE	−0.687		−0.033	−0.099	−0.503
	(0.094)		(0.104)	(0.076)	(0.053)
NOE	−0.645		−0.164	−0.088	0.417
	(0.083)		(0.153)	(0.068)	(0.042)
USE	−0.580				0.460
	(0.080)				(0.037)

Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE) and the U.S. (USE).

Table E.3
Parameter estimates for commodity country model, January 2014–February 2020.

Variable	λ	θ	γ	β	σ
AGR	−0.425	−0.055	−0.802		−0.384
	(0.410)	(0.154)	(0.410)		(1.200)
FOO	−0.307	−0.310	−0.452		−0.761
	(0.227)	(0.110)	(0.396)		(0.204)
MET	−0.440	−0.145	−0.187		−0.854
	(0.141)	(0.108)	(0.278)		(0.091)
OIL	−0.600	−0.136	−0.094		−0.725
	(0.130)	(0.174)	(0.473)		(0.069)
AUD	0.234	0.819		0.320	0.401
	(0.158)	(0.112)		(0.344)	(0.099)
CAD	0.368	0.830		−0.136	−0.363
	(0.096)	(0.171)		(0.273)	(0.221)
NZD	0.176	0.754		0.344	−0.496
	(0.154)	(0.114)		(0.248)	(0.103)
NOK	0.430	0.643		0.098	−0.605
	(0.136)	(0.102)		(0.284)	(0.053)
AUE	−0.775		0.132	−0.400	0.430
	(0.152)		(0.305)	(0.205)	(0.143)
CAE	−0.932		0.077	−0.031	0.226
	(0.116)		(0.390)	(0.132)	(0.089)
NZE	−0.442		−0.100	−0.323	−0.815
	(0.143)		(0.114)	(0.201)	(0.108)
NOE	−0.800		0.000	−0.050	0.547
	(0.127)		(0.473)	(0.121)	(0.061)
USE	−0.667				0.706
	(0.112)				(0.064)

Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Australia (AUD); Canada (CAD); New Zealand (NZD); and Norway (NOK). Equity returns are Australia (AUE); Canada (CAE); New Zealand (NZE); Norway (NOE) and the U.S. (USE).

Table F.1
Parameter estimates for the benchmark country model, February 1992–December 2003.

Variable	λ	θ	γ	β	σ
AGR	0.013	−0.013	−0.513		0.855
	(0.070)	(0.099)	(0.141)		(0.078)
FOO	0.047	−0.215	0.170		0.950
	(0.082)	(0.118)	(0.121)		(0.065)
MET	0.074	−0.246	−0.363		0.898
	(0.079)	(0.161)	(0.117)		(0.072)
OIL	−0.117	0.071	−0.550		0.818
	(0.087)	(0.111)	(0.141)		(0.083)
JPY	−0.057	−0.034		0.586	0.797
	(0.127)	(0.199)		(0.285)	(0.192)
CHF	−0.097	0.652		0.533	0.501
	(0.103)	(0.242)		(0.197)	(0.176)
SEK	0.233	0.426		0.812	0.273
	(0.095)	(0.253)		(0.269)	(0.440)
GBP	−0.040	0.618		0.391	0.672
	(0.113)	(0.215)		(0.194)	(0.115)
JPE	0.456		−0.248	−0.330	0.780
	(0.112)		(0.106)	(0.303)	(0.102)
CHE	0.591		0.219	−0.505	0.584
	(0.111)		(0.135)	(0.068)	(0.065)
SWE	0.765		−0.100	−0.107	0.623
	(0.087)		(0.109)	(0.091)	(0.072)
UKE	0.786		0.213	−0.270	0.505
	(0.077)		(0.100)	(0.121)	(0.077)
USE	0.845				0.524
	(0.100)				(0.090)

Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Japan (JPY); Switzerland (CHF); Sweden (SEK); and the UK (GBP). Equity returns are Japan (JPE); Switzerland (CHE); Sweden (SWE); UK (UKE) and the U.S. (USE).

Table F.2
Parameter estimates for the benchmark country model, January 2004–December 2013.

Variable	λ	θ	γ	β	σ
AGR	0.071	−0.326		0.342	−0.804
	(0.122)	(0.222)		(0.117)	(0.073)
FOO	0.252	−0.464		0.333	0.301
	(0.121)	(0.1)		(0.268)	(0.111)
MET	0.110	−0.429		0.727	0.336
	(0.153)	(0.449)		(0.383)	(0.264)
OIL	0.033	−0.427		0.197	0.651
	(0.091)	(0.236)		(0.509)	(0.102)
JPY	0.095	0.160	−0.718		0.514
	(0.122)	(0.339)	(0.392)		(0.419)
CHF	−0.630	0.404	−0.321		0.651
	(0.109)	(0.176)	(0.152)		(0.059)
SEK	−0.318	0.053	−0.537		0.712
	(0.19)	(0.135)	(0.272)		(0.191)
GBP	−0.381	0.253	−0.343		0.708
	(0.158)	(0.22)	(0.138)		(0.09)
JPE	0.493		−0.142	−0.168	0.684
	(0.09)		(0.197)	(0.104)	(0.065)
CHE	0.733		−0.022	−0.372	0.280
	(0.104)		(0.136)	(0.085)	(0.184)
SWE	0.723		−0.010	−0.091	0.374
	(0.08)		(0.128)	(0.127)	(0.043)
UKE	0.745		−0.083	−0.064	−0.311
	(0.088)		(0.183)	(0.216)	(0.043)
USE	0.751				0.353
	(0.082)				(0.078)

Notes: Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Japan (JPY); Switzerland (CHF); Sweden (SEK); and the UK (GBP). Equity returns are Japan (JPE); Switzerland (CHE); Sweden (SWE); UK (UKE) and the U.S. (USE).

Table F.3
Parameter estimates for the benchmark country model, January 2014–February 2020.

Variable	λ	θ	γ	β	σ
AGR	0.276	0.306		0.412	0.828
	(0.129)	(0.516)		(0.396)	(0.104)
FOO	0.276	−0.319		0.926	0.067
	(0.137)	(1.223)		(0.201)	(2.269)
MET	0.181	0.626		0.721	−0.054
	(0.103)	(0.763)		(0.772)	(0.172)
OIL	0.379	−0.197		0.417	0.727
	(0.122)	(0.361)		(0.254)	(0.078)
JPY	0.148	−0.136	0.677		0.659
	(0.125)	(0.348)	(0.171)		(0.112)
CHF	−0.207	0.034	0.597		0.734
	(0.139)	(0.46)	(0.136)		(0.091)
SEK	−0.082	0.011	0.450		0.859
	(0.193)	(0.427)	(0.159)		(0.098)
GBP	−0.480	0.201	0.406		0.742
	(0.102)	(0.137)	(0.174)		(0.11)
JPE	0.763		−0.014	−0.011	0.570
	(0.125)		(0.111)	(0.227)	(0.058)
CHE	0.797		−0.077	−0.228	0.467
	(0.102)		(0.11)	(0.189)	(0.05)
SWE	0.815		−0.105	−0.292	0.422
	(0.093)		(0.108)	(0.073)	(0.048)
UKE	0.870		0.112	−0.124	0.401
	(0.095)		(0.115)	(0.09)	(0.055)
USE	0.859				0.447
	(0.114)				(0.048)

Notes: Quasi maximum likelihood coefficient estimates obtained from estimating the latent factor models are reported. Standard errors in parentheses are based on the Hessian matrix. The commodity returns are agriculture (AGR); food (FOO); metals (MET); and OIL. The currency returns are Japan (JPY); Switzerland (CHF); Sweden (SEK); and the UK (GBP). Equity returns are Japan (JPE); Switzerland (CHE); Sweden (SWE); UK (UKE) and the U.S. (USE).

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