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What drives the commodity-sovereign risk dependence in emerging market economies?

Hannes Boehm [a,b], Stefan Eichler [a,b,*], Stefan Giessler [a]

[a] Halle Institute for Economic Research (IWH), Germany
[b] TU Dresden, Germany

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ABSTRACT

Using daily data for 34 emerging markets in the period 1994–2016, we find robust evidence that higher export commodity prices are associated with lower sovereign default risk, as measured by lower EMBI spreads. The economic effect is especially pronounced for heavy commodity exporters. Examining the drivers, we find that, first, commodity dependence is higher for countries that export large volumes of commodities, whereas other portfolio characteristics like volatility or concentration are less important. Second, commodity-sovereign risk dependence increases in times of recessions and expansionary U.S. monetary policy. Third, the importance of raw material prices for sovereign financing can likely be mitigated if a country improves institutions and tax systems, attracts FDI inflows, invests in manufacturing, machinery and infrastructure, builds up reserve assets and opens capital and trade accounts. Fourth, the country's government indebtedness or amount of received development assistance appear to be only of secondary importance for commodity dependence.

1. Introduction

Global commodity price cycles have been among the most influential drivers of sovereign defaults in history (Reinhart et al., 2016). Higher export commodity prices improve sovereign solvency by spurring economic growth and tax revenues, by increasing the profitability of state-owned commodity enterprises and by generating inflows of foreign exchange thus increasing the government's ability to service its external debt. Fluctuations in commodity prices are therefore important business cycle drivers, in particular for emerging market economies (Fernández et al., 2018; Fernández et al., 2017), while also comprising political considerations: In the upturn of the commodity cycle, especially autocratic regimes with poor institutions tend to build up unsustainable debt levels, which can lead to debt overhangs and default in the downturn of the cycle (Arezki and Brückner, 2012).

Commodity cycles matter, as during the 2013–2017 period, 102 out of 189 countries in the world were considered to be commodity-dependent according to UNCTAD (2019). Both the literature and policy reports often make commodity-

* Corresponding author.
E-mail addresses: hannes.boehm@iwh-halle.de (H. Boehm), stefan.eichler@tu-dresden.de (S. Eichler), stefan.giessler@iwh-halle.de (S. Giessler).

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dependence responsible for creating vulnerabilities: Globally determined raw material prices steer the economic performance and the costs to borrow money on financial markets of commodity-dependent countries beyond their control.[1] Despite its relevance, a comprehensive study of the economic drivers of commodity-sovereign risk dependence is lacking in the literature.

We contribute to the literature by analyzing the magnitude and determinants of commodity-sovereign risk dependence from the viewpoint of daily financial market investors. To this end, we build a daily panel of 34 emerging market economies from January 1, 1994 to December 31, 2016. We measure commodity-sovereign risk dependence as the relationship between a country's sovereign creditworthiness (measured by changes in the Emerging Market Bond Index (EMBI) yield spread relative to US Treasuries) and the returns of its export-weighted commodity price index. We control thoroughly for global developments on financial markets and most importantly for a country's general stock return which should account for major economic movements each day. Any impact of commodity prices on sovereign creditworthiness beyond these controls is likely due to raw material prices affecting the fiscal situation, investment possibilities and general economic outlook of a country and hence imply commodity dependence.

We find that an increase in our commodity performance measure by one standard deviation is associated on average with a reduction of the EMBI yield spread of 33 basis points (bps) (which corresponds to 3.5% of the EMBI spread's standard deviation and indicates a decrease in sovereign risk). For countries with a commodity export share on total exports equal or above the 90th percentile,[2] a one standard deviation increase in export commodity prices is associated with a 47.5 bps decrease in the EMBI spread (corresponding to 5% of the EMBI's standard deviation). Although we can only explain a modest fraction of bond price movements in absolute terms, the standardized effect of export commodity prices on EMBI bond yield spreads are around 40% as large as for the VIX or the U.S. corporate bond spread and are thus relatively important in pricing emerging market bonds.

Our second contribution focuses on the heterogeneous nature of commodity-sovereign risk-dependence. To the best of our knowledge, we are the first to examine a broad set of possible conditioning factors shaping the size of this dependence such as a country's commodity exporting structure, its macroeconomic conditions, and the implementation of policy measures that might reduce commodity dependence. We find strong heterogeneous effects that differentiate the average magnitude of commodity dependence reported above.

Looking at the structure of the country's commodity export industry, we find that countries with greater commodity exports on total export shares are significantly more commodity-dependent (pointing to a higher relevance of commodity price fluctuations for economic growth, tax revenues or direct cash flows from the commodity sector due to public stakes or royalties). When analyzing specializations into different commodity subgroups, we observe that countries which export predominantly energy face larger, while countries focusing on industrial metals are subject to smaller commodity dependence. We do not find significant evidence that the volatility of exported commodities and the degree of diversification of commodity exports affect the commodity-sovereign risk dependence.

When analyzing the impact of macroeconomic factors on commodity-sovereign risk dependence, we find that the reliance on commodities for sovereign funding increases in economic recessions (lower GDP growth) and, likely associated therewith, when public or private sectors lack fiscal resources (lower tax revenues or corporate profits). We find no statistically significant connection between commodity dependence and GDP per capita or the inflation rate. A surprising coefficient is the interaction of commodity performance and public debt, which suggests higher commodity dependence at lower debt levels, however, the coefficient is only weakly significant.

We find only weak evidence that commodity dependence increases in times of sovereign debt crises. However, we uncover that the repayment history of a sovereign matters insofar as countries with a distant or no incidents of sovereign default display lower commodity dependence.

Beyond national macroeconomic factors, we find that commodity dependence of emerging markets increases significantly in times of more expansionary U.S. monetary policy. This observation is in line with findings in the literature that an accommodative U.S. monetary weakens the dollar, which tends to boost commodity prices (Akram, 2009). Moreover, U.S. interest rates affect demand and supply conditions in commodity markets (Frankel, 2006) and lower U.S. interest rates lead to lower risk aversion, rising capital flows and foreign lending activities into emerging markets (Bräuning and Ivashina, 2019; Ahmed and Zlate, 2014; Temesvary et al., 2018).

When turning to policy measures that are likely able to mitigate commodity dependence, we find clear support that countries with stronger institutions are significantly less reliant on the price performance of their main commodity exports for their sovereign creditworthiness. Improving institutional quality, measured with control of corruption, rule of law, political stability or more progressive tax systems, likely makes sure that clear ownership rights for extracted raw materials exist, that rent extraction is limited or that gains from commodity exports are efficiently distributed.[3] Some papers stress that lar-

[1] An article by the World Economic Forum from 17 May 2019 entitled *"We must help developing countries escape commodity dependence"* says: *"When a country's economy is not diversified and relies heavily on basic products, it puts itself at the mercy of international market prices. When prices go down, employment, exports and government revenue suffer. (. . .) [P]utting too many eggs in one basket renders the country vulnerable."*

[2] Affected countries are Ecuador, Ghana, Kazakhstan, Nigeria, Peru and Venezuela.

[3] For instance, Frankel (2010) discusses the successful fiscal rule of Chile that is also mentioned in an article in The Economist from 5th October 2017 entitled *"Commodities are not always bad for you"*: *"Resource-rich economies need equally resourceful macroeconomic policies. One of the best examples is Chile. Its fiscal rule curbs government spending when the copper price exceeds its long-term trend, as judged by an independent committee of experts. During good times, fiscal restraint makes room for mining to boom without unduly squeezing the rest of the economy. During bad times, it leaves scope for fiscal easing to offset the damage."*

ger endowments of natural resources make it more difficult to improve institutional quality (Arezki and Brückner, 2011a; Gylfason, 2001). We take this issue into account by limiting our estimation to those countries that are heavy commodity exporters. Our main results continue to hold, suggesting that even among strong commodity exporters, those with better institutions fare better in terms of lower commodity dependence, which is also in line with Bhattacharyya and Hodler (2010), Mehlum et al. (2006) and Arezki and Brückner (2011b).

Further measures that are associated with alleviating commodity dependence are attracting more FDI inflows, investing in physical capital and infrastructure, and building larger manufacturing sectors. We conclude from these results that fostering downstream production technologies and diversifying economic activities can be successful ways for countries to reduce commodity dependence. On the other hand, we find only limited evidence that speaks in favor of mitigating commodity dependence by means of development assistance or loans.

Countries that build up higher reserve assets in relation to GDP face significantly lower commodity dependence by reducing their reliance on foreign exchange inflows via commodity exports. This result suggests that low official reserve buffers make emerging markets particularly vulnerable to international commodity price fluctuations. Lastly, we find that countries with shielded trade and financial accounts are subject to a significantly stronger commodity dependence.

Our work builds on seminal papers in the literature such as Deaton (1999), Sachs and Warner (1995) and Sachs and Warner (2001) that highlight the tight connection between GDP growth and commodity prices of raw material exporting countries, and which is also shown in more recent work by Drechsel and Tenreyro (2018) and Fernández et al. (2017). Several papers discuss the implications of the "resource curse" of developing countries (see Frankel, 2010 for an overview) which is, however, disputed by other authors (James, 2015; Alexeev and Conrad, 2009; Davis, 1995).

Several papers study the relevance of commodity prices for determining sovereign risk. Arezki and Brückner (2011b) study the effect of windfall gains from commodity price shocks on sovereign bond yield spreads. They find that higher commodity prices reduce sovereign yield spreads in democratic regimes and increase yield spreads in autocratic regimes, pointing to the resource curse in countries with poor institutions. Similar results are found for countries' external debt ratios in Arezki and Brückner (2012). Hilscher and Nosbusch (2010) use export commodity prices to instrument terms of trade and their effect on sovereign bond spreads at an annual frequency. They find that the level and volatility of terms of trade explain a huge fraction of the annual variation of sovereign yield spreads. Aizenman et al. (2016) find that higher volatility of commodity terms of trade is associated with an increase in sovereign CDS.[4]

We contribute to this literature by studying the channels shaping the commodity dependence of sovereign default risk (such as the size, volatility or diversification of the country's commodity exporting regime, the stance of the domestic economy, monetary policy, capital controls, as well as institutional and policy factors). Thereby, we aim at explaining the heterogeneity of the effects of commodity price shocks to sovereign solvency across different emerging markets which informs the policy debate on how to curb the commodity-sovereign risk-nexus. Furthermore, we use daily data instead of quarterly or yearly averages. Daily variation in sovereign bond and commodity prices is less susceptible to endogenously formed policy decisions: On a yearly basis, policy makers might adjust e.g. institutions with respect to longer-term commodity price changes. On a daily basis, institutional quality is given and cannot be adjusted to cushion, for instance, the impact of a negative commodity price shock hitting a country on this day.

The rest of this article is organized as follows: In Section 2, we describe the data we use in order to isolate commodity dependence. Section 3 presents our empirical strategy and reports our baseline results. Following on this, Section 4 investigates the drivers of commodity dependence and discusses the effect of policy measures to tackle it. We conduct encompassing robustness checks in Section 5. Section 6 concludes.

2. Data, variables and summary statistics

2.1. Dependent variable: sovereign default risk

Our sovereign default risk measure is drawn from the Emerging Market Bond Index (EMBI) provided by J.P. Morgan. Sovereign bonds that are issued by emerging markets and included in the EMBI are US dollar-denominated which rules out exchange rate risk. Issued debt must furthermore have more than one year to maturity and exceed an outstanding face value of $500 million to be eligible for the EMBI. For these reasons, EMBI returns are a well standardized, widely-used and liquid measure to track the daily performance of emerging market sovereign debt. For our analysis, we use EMBI Global data as it covers more instruments than the original EMBI + index and has better data availability.

The introduction of the EMBI Global at the end of 1993 determines the beginning of our estimation period which is set from January 1, 1994 to December 31, 2016, though some countries enter only at later points in time. We collect EMBI Global data for a panel of 34 countries which can be found in Table 1. Though more countries with EMBI data exist, data availability with respect to other variables, in particular stock returns, restricts our sample to the set of the countries listed below. To

[4] A related literature shows that commodity prices determine the value of commodity currencies, by shaping terms of trade and the generation of foreign exchange revenues (Chen and Rogoff, 2003; Cashin et al., 2004; Kohlscheen et al., 2017).

Table 1
Summary statistics by country (winsorized at 1st and 99th percentile).

Region	Country	Mean ΔEMBI	Mean ΔCommodityPerformance	Number of ΔEMBI and ΔCommodityPerformance observations in baseline regression
Africa	Egypt	−0.0215	0.00292	3910
	Ghana	−0.0967	0.0125	1665
	Ivory Coast	0.839	0.00503	1937
	Morocco	−0.187	0.0177	3349
	Nigeria	−0.240	0.0142	3658
	South Africa	−0.0733	0.00888	4149
	Tunisia	-.00262	0.0224	2255
Americas	Argentina	0.316	0.0108	5975
	Brazil	−0.405	0.00502	5833
	Chile	−0.0173	0.0181	4519
	Colombia	−0.145	0.0135	5142
	Ecuador	−0.136	0.0263	4746
	Jamaica	0.0173	0.0212	2186
	Mexico	−0.133	0.0217	5971
	Panama	−0.118	0.0135	2137
	Peru	−0.169	0.0103	5116
	Venezuela	−0.0985	0.0393	4826
Asia	China	−0.0126	0.00739	5796
	Indonesia	−0.139	0.0187	3225
	Kazakhstan	−0.109	0.0128	2436
	Malaysia	−0.0250	0.0219	5131
	Pakistan	−0.192	−0.000387	3243
	Philippines	−0.0937	0.00231	4889
	Russia	−0.125	0.0155	4928
	Sri Lanka	−0.0458	0.0236	2328
	Thailand	−0.153	0.0183	2209
	Turkey	−0.185	0.00126	5315
	Vietnam	−0.0810	0.0137	2573
Europe	Bulgaria	−0.306	0.0109	2229
	Croatia	−0.169	.0153	2374
	Hungary	−0.0385	−0.00276	4641
	Poland	−0.0748	0.0114	5681
	Serbia	−0.0909	0.0102	2229
	Ukraine	−0.171	0.00612	2715

make sure every country included has sufficient variation, we include a country if it has liquid EMBI data for at least nine years, i.e. at least since 2008.[5]

Data is drawn on a daily frequency to exploit maximum data variation and give our estimation strategy the perspective of market participants that incorporate daily news into their investment behavior. Our dependent variable is the daily first difference of a country's EMBI yield spread (relative to the U.S. treasury rate), so that positive changes in the EMBI spread indicate declining sovereign creditworthiness (or increasing sovereign risk).

While all other data is winsorized at the 1st and 99th percentile, we winsorize EMBI spread data on the 5th and 95th percentile because the raw spread differences have occasionally extreme values. We account for episodes with temporarily illiquid country EMBI indices by dropping observations with zero changes in the EMBI spread that occur for more than two consecutive trading days. In a robustness check, we also remove all countries exhibiting such periods of low liquidity and find results in line with our main specification.

2.2. Deriving country-specific commodity performance

We construct the daily export-weighted commodity performance by weighting commodity price returns with the country's commodity export shares. In order to determine which commodities are to be included in the export portfolio of each country, we refer to the commodities comprising the Goldman Sachs Commodity Index (GSCI) provided by S&P. The GSCI provides daily spot index data of 24 commodities in the main index. Each commodity can be grouped either under agriculture, livestock, industrial metals, precious metals or energy. Each of these sub-groups also has its own aggregated group price index. The GSCI includes commodity types based on global production values and the availability of active and liquid futures markets. Commodities in the index are therefore frequently traded and priced in U.S. dollar which is in contrast to many regional commodity price data sources that often suffer from periods of poor liquidity. By using GSCI data, we make sure

[5] Though we could also choose a ten year inclusion rule, the countries Ghana, Jamaica, Kazakhstan and Sri Lanka start reporting EMBI data in 2007. Also, Thailand reports a nine year EMBI period from 1997 to 2006. To include these countries, we set the threshold at nine years.

that our commodity portfolio measures include both highly relevant and globally-priced commodities. Table 3 contains a list of all commodities.

We match commodity prices to commodity export data derived from the UN's Comtrade Database and ITC's Trade Map. Most commodity export volumes can be directly matched to their corresponding prices. However, some price series start after the beginning of our sample period in 1994 or have only a roughly corresponding export match. This issue concerns energy and petroleum-based commodity prices which are included in the GSCI as WTI crude oil, Brent crude oil, gas oil, heating oil, gasoline and natural gas. As there is no perfect export match for all of these commodities, for instance, if a crude oil export is classified under WTI or Brent standards, and because price data for Brent crude oil and gas oil starts only after 1994, we aggregate these commodities under their sub-group price index, i.e. energy. The matching export data includes all crude oil and petroleum gas exports. Since all price returns within the energy group are highly correlated, we believe that this sub-group-level aggregation is the most precise way to capture and price petroleum-based exports and to avoid a potentially biasing match between not fully overlapping price and export data.

We further aggregate the GSCI price series Kansas wheat and CBOT wheat under the aggregated price series "All Wheat" and the series for feeder cattle and live cattle under the aggregated spot index of "All Cattle". Table 3 reports the final match between commodity price and export data.

Export volumes for different commodities are available on a yearly (y) frequency only. We therefore calculate the share of each commodity on the total commodity exports of each country as a yearly-varying weighting factor. For many countries, the mix of exported commodities remained relatively stable throughout our sample (such as the dominant role of copper in Chile, energy in Colombia, Ecuador, Venezuela, or Kazakhstan, and cotton for Pakistan). For some countries, the mix changed (e.g. the varying importance of copper in Bulgaria or gold in Panama). In a robustness check in Section 5, we also report results with constant commodity weights observed at the beginning of the sample, which leads to robust conclusions.

Each daily commodity price return is then multiplied by its country-specific weighting factor. However, we lag the export weights by one year in order to rule out commodity prices mechanically affecting commodity export weights. We aggregate the weighted commodity returns over all commodities c on a daily basis t for each country i, arriving at a country-specific commodity return measure in which the largest commodity exports have the greatest weight: $CommodityPerformance_{it} = \sum_{c} CommodityExportShare_{icy_{-1}} * \Delta CommodityPrice_{ct}$.

We will also test different versions of the commodity performance index to control for world-market relevant exporters, a dummy-version, and net- instead of gross-exports in the alternative specification section.

2.3. Set of control variables

In order to isolate the impact of country-specific commodity performance on sovereign risk, we introduce a broad set of explanatory variables to capture international and national financial market developments.

To distinguish the effects of country-specific commodity price shocks from general economic fluctuations affecting a country, we control for a country's daily stock market returns. Stocks returns should partly capture the effects of commodity prices either via stock prices of commodity-exporting companies or by signaling the overall stance of the economy. Controlling for stock returns, we aim to measure the impact of exported commodity prices on sovereign risk beyond these effects. Deriving daily, liquid stock market data for emerging markets can be challenging and therefore restricts our sample as described above. We draw equity returns from either MSCI, Datastream or S&P, depending on which provider has the longest and most complete series. We handle liquidity concerns the same way as we did for EMBIs by setting zero returns to missing if they occur for more than two consecutive trading days. All of our series are in U.S. dollar in order to match with EMBI and GSCI returns. Introducing EMBI and contemporaneous stock returns could lead to reverse causality concerns. We therefore lag the stock returns by one day, though our results do not depend on this choice. We expect higher lagged stock market returns to have a negative effect on sovereign risk.

As a second country-specific control variable, we introduce exchange rate returns of each country's currency towards the U.S. dollar. Higher commodity prices could lead to an appreciation of a country's currency which could affect the export performance of non-commodity exporting firms and therefore impact sovereign risk. Exchange rate movements are measured as a daily percentage change and drawn from Thomson Reuters. We again lag the returns by one day as higher EMBI spreads could otherwise drive the exchange rate of the same day. Higher values indicate a depreciation of the domestic currency against the U.S. dollar.

We further control for daily changes in the VIX to capture the implied volatility of U.S. equity markets. Also, we include the U.S. corporate credit spread which is the yield difference between the S&P U.S. high yield corporate bond index and the corresponding S&P investment grade corporate bond index. Both variables capture volatility and risk premiums in U.S. financial markets that could easily spill-over to emerging market financing conditions, given the importance of global factors for sovereign creditworthiness (Longstaff et al., 2011). We expect them to enter with a positive sign in describing EMBI spreads of a country. We also control for the U.S. term spread, i.e. the yield difference between a 10-year U.S. treasury bond and a 3-month U.S. T-Bill. The term spread approximates the premium investors receive for long-term investments. We furthermore control for changes in the yield of 10-year U.S. treasury bonds to approximate the general interest rate environment. Lastly, we want to control for general effects in the market for government debt. We do so by including the daily return of the BofA Merrill Lynch global government bond index and expect a negative correlation with emerging market sovereign risk.

All variables we use are winsorized at the 1st and 99th percentile to alleviate the impact of outliers. Summary statistics for all daily variables in our baseline estimation can be found in Table 2, all precise variable definitions and sources can be found in Table 14.

3. Empirical strategy

3.1. Baseline specification and results

We estimate the following OLS panel regression model using daily data for 34 countries from t = January 1, 1994 to December 31, 2016:

$$\Delta EMBI_{it} = \beta_1 \Delta CommodityPerformance_{it} + \beta_x \Delta Controls_{(i)t} + \alpha_i + \delta_{m_t} + \epsilon_{it} \quad (1)$$

$\Delta EMBI_{it}$ measures daily changes in the EMBI Global Spread of country i relative to U.S. Treasuries. Higher EMBI spreads indicate rising sovereign risk. $\Delta CommodityPerformance_{it}$ is the right-hand-side variable of interest and captures export-weighted commodity price returns of each country, as described in Section 2.2. We expect a negative β_1, i.e. higher prices of a country's key commodity exports are associated with lower sovereign risk.

$\Delta Controls_{(i)t}$ encompasses all control variables introduced in the previous section, i.e. lagged stock returns, lagged exchange rate returns, global government bond index returns and changes in the VIX, U.S. corporate spread, U.S. term spread and the 10-year U.S. treasury yield. α_i are country fixed effects which account for time-invariant country-specific unobservable factors, such as permanent market structures in a country's commodity exports. We also include time fixed effects δ_{m_t} for every month to capture time-specific, market-wide developments that have a common effect on all countries. We cluster standard errors at the country level to allow for the correlation of unobserved factors in the error terms within countries.

The results are reported in Table 4. Model (1) uses neither control variables, nor fixed effects. Model (2) includes fixed effects. Baseline model (3) uses the full set of control variables and fixed effects. Model (4) interacts the commodity price index with a dummy variable indicating whether the country is a heavy commodity exporter, which is defined as having a share of commodity exports on total exports equal or above the 90th percentile. This percentile starts at a commodity export share of 56.5% and applies to Ecuador, Ghana, Kazakhstan, Nigeria, Peru and Venezuela. In all specifications, we can reject the null hypothesis of a zero effect of commodity price returns on sovereign bond returns at the 1% level of statistical significance. Investors appear to anticipate an increase in sovereign risk when the prices of a country's exported commodities deteriorate. This result has a strong footing in the literature, for example, Hilscher and Nosbusch (2010) show that commodity prices are a key determinant of a country's terms of trade, which are known to affect sovereign risk.

Turning to the economic significance, an increase in the commodity performance variable by one standard deviation is associated with a 33.2 bps (0.2488×1.3328) increase in EMBI spread differences on average which corresponds to roughly 3.5% of the standard deviation of EMBI differences ($0.3316 \div 9.4332$) which is economically meaningful (column (3)). For heavy commodity exporters (with a commodity share on total exports equal or above the 90th percentile, see column (4)) we find that a one standard deviation increase in export commodity price returns is associated with a 47.5 bps increase in EMBI spread differences (corresponding to 5% of the EMBI's standard deviation). This amount equals around 40% of the standardized effects of the VIX and the corporate bond spread. Commodity price changes are therefore a key driver of the sovereign debt performance of emerging markets in the daily perspective of financial markets.

Regarding the remaining control variables, we find signs and significance levels broadly in line with our expectations. Stock market returns enter with a negative sign in the regression and are both statistically and economically highly significant. Positive changes in the VIX, the corporate spread and exchange rate depreciations are associated with higher EMBI spreads, whereas rising global government bond returns and U.S. treasury bond yields enter with a negative sign and all with statistically significant coefficients. The term spread carries a positive sign but is not statistically significant. Our evidence for the importance of these global variables is well-embedded in the literature (Longstaff et al., 2011).

3.2. Alternative specifications

In this section, we address possible concerns in our empirical specification to test the robustness of our benchmark results.

First, we consider the effects of market power of domestic commodity exporters. Most papers argue that commodity prices traded at highly centralized world markets are exogenous to domestic fundamentals (e.g. Chen and Rogoff, 2003). Still, the largest exporters of a commodity may not have to take global commodity prices as given, but can strategically manipulate raw material spot rates through their domestic production decisions (see also Clements and Fry, 2008). If so, domestic concerns such as deteriorating sovereign creditworthiness could impact commodity production which would then affect global commodity prices and thus entail a reversal effect in our econometric inference. We therefore specify a version of our commodity portfolio variable that is more precise in affecting only price takers of a raw material. To do so, we construct the shares of each country's commodity exports on the global export volume of this specific commodity. We then remove a commodity in the weighted portfolio of a country if this country has at any point in our sample period a global export share of more than 10% for the respective commodity. This threshold is fairly low and almost every commodity is affected by one

Table 2
Summary statistics of daily-varying variables used in our baseline estimation (all variables winsorized at 1st and 99th percentile, except for EMBI returns which are winsorized at 5th and 95th percentile); definitions and sources in Table 14.

Variable	Obs.	Mean	Median	Std. Dev.	Min	Max
ΔEMBI	148,973	−0.0808	−0.0808	9.433	−21	21.00
ΔCommodityPerformance	175,583	0.0130	0.0130	1.333	−5.226	5.108
ΔStockIndex	165,407	0.00902	0.00902	1.623	−5.478	5.187
ΔExchangeRate	196,316	0.0203	0.0203	0.543	−1.906	2.197
ΔVIX	6000	−0.00248	−0.00248	1.315	−3.875	4.755
ΔGlobalGovernmentBondIndex	6000	0.0177	0.0177	0.377	−1.004	1.048
ΔTermSpread	6000	−0.000149	−0.000149	0.0591	−0.161	0.186
ΔCorporateSpread	6000	−2.30e-05	−2.30e-05	0.0811	−0.246	0.285
Δ10YearTreasuryYield	6000	−0.000595	−0.000595	0.0560	−0.150	0.164

Table 3
Match between commodity prices (from GSCI) and export quantities (from UN's Comtrade Database and ITC's Trade Map). We use each commodity export and its corresponding single GSCI price index to construct our weighted commodity performance measure. Exceptions are for the sub-groups wheat, cattle and energy, which are in bold type, and for which we use the GSCI sub-group price index.

GSCI single commodity index	GSCI sub-group index	GSCI group index	Matching commodity export
Cocoa			1801: Cocoa beans
Coffee			090111: Coffee (excluding roasted and decaffeinated)
Corn		Agriculture	1005: Maize or corn
Cotton			52: Cotton
Soybeans			1201: Soya beans, whether or not broken
Sugar			1701: Cane or beet sugar and chemically pure sucrose
Wheat (CBOT)	**All wheat**		1001: Wheat and meslin
Wheat (Kansas)			
Lean Hogs			0103: Live swine
Feeder Cattle	**All cattle**	Livestock	010229: Live cattle
Live Cattle			
Brent Crude Oil			2709: Petroleum oils and oils obtained from bituminous minerals, crude 2711: Petroleum gas and other gaseous hydrocarbons
WTI Crude Oil			
Gas Oil		**Energy**	
Heating Oil			
RBOB Gasoline			
Natural Gas			
Aluminum			2606: Aluminium ores and concentrates 7601: Unwrought aluminium
Copper			2603: Copper ores and concentrates 7402: Copper, unrefined
Lead		Industrial Metals	2607: Lead ores and concentrates 7801: Unwrought lead
Nickel			2604: Nickel ores and concentrates 7502: Unwrought nickel
Zinc			2608: Zinc ores and concentrates 7901: Unwrought zinc
Gold		Precious Metals	7108: Gold, (...) unwrought or not further worked than semi-manufactured or in powder form
Silver			261610: Silver ores and concentrates 7106: Silver, (...) unwrought or in semi-manufactured forms, or in powder form

or more of such dominant global exporters, but results also hold for a 15% threshold (unreported). If a commodity is removed from a country's portfolio due to this procedure, the remaining commodity weights are re-adjusted so that they add to one. We repeat our benchmark estimation with this world market-adjusted commodity performance version. The estimated coefficient of the market power adjusted commodity variable remains statistically highly significant and is even somewhat larger than the baseline version (column 1). This result could indeed suggest that there is strategic behavior in price-setting decisions. Nevertheless, this specification underlines our main result that emerging markets' sovereign creditworthiness is commodity-dependent, and, if anything, price-taking commodity exporters are even stronger affected.

Second, we want to make sure that the variation in our export-weighted commodity variable is not driven by re-exported commodities. Should raw materials actually be imported from other countries and then get re-exported, we would falsely classify countries as commodity exporters even though actual net exports are much lower. A related issue could be that countries are net-importers of certain commodities and that price increases of key import goods could dominate favorable

Table 4
Baseline results: commodity performance and sovereign risk.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI
ΔCommodityPerformance	−0.855***	−0.812***	−0.249***	−0.202***
	(0.0688)	(0.0669)	(0.0439)	(0.0434)
HighComExport				0.322**
				(0.147)
ΔCommodityPerformance				−0.357**
× HighComExport				(0.158)
ΔStockIndex			−0.221***	−0.223***
			(0.0348)	(0.0351)
ΔExchangeRate			0.545***	0.551***
			(0.0863)	(0.0868)
ΔVIX			0.891***	0.882***
			(0.139)	(0.138)
ΔGlobalGovernmentBondIndex			−0.349**	−0.363**
			(0.137)	(0.137)
ΔTermSpread			1.084	0.967
			(0.808)	(0.849)
ΔCorporateSpread			15.26***	15.10***
			(1.169)	(1.161)
Δ10YearTreasuryYield			−46.32***	−46.39***
			(3.465)	(3.428)
Constant	−0.0692*	−0.0697***	−0.101***	−0.135***
	(0.0381)	(0.000844)	(0.00356)	(0.0155)
Observations	143,075	143,075	129,316	128,031
R-squared	0.016	0.040	0.217	0.219
Time & Country FE	No	Yes	Yes	Yes
Number of Countries	34	34	34	34

This table shows results from OLS-panel regressions of the daily first difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. HighComExport is a dummy variable being 1 if a country's share of commodity exports on total exports is equal or above the 90th percentile of countries in the panel and 0 otherwise. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

price fluctuations of important export products. To address these concerns, we construct a portfolio variable capturing the net export values of commodity sales. To this end, we first multiply a country's absolute export value (in U.S. dollars) of each commodity with its daily price change. This measure indicates the extra export revenue generated or lost due to the commodity's price change. We do the same procedure for absolute import values (in U.S. dollars) and aggregate revenue changes for imports and exports for each country on a daily basis. Second, we subtract the import-weighted price changes from the export-weighted price changes. The resulting variable gives us the net-export values we are after by allowing for negative net-exports and hence negative returns, for instance, if a country that imports more energy commodities than it exports faces rising energy prices. Lastly, we need some form of scaling for the derived net returns since larger countries also have larger absolute exports or imports. We do so by dividing the net-export return variable by each country's GDP in U.S. dollars. In sum, this variable adjusts the original commodity performance by taking the price fluctuations of a country's most important import commodities into account. In this way, the variable approximates the commodity-specific terms of trade of a country, which were shown to matter for sovereign risk in Hilscher and Nosbusch (2010). Results in column (2) of Table 5 illustrate that the derived variable has a negative effect on sovereign risk that is statistically significant at the 1% level. Commodity prices are therefore, even when only regarding net exports, affecting sovereign debt performance of emerging markets.

Lastly, we want to test an alternative way how variation in the exported commodity prices spills over to sovereign yield spreads. Our baseline models (plausibly) assume a continuous price impact so that a one unit change in commodity prices results in a given impact on yield spreads (no matter how large the price change in commodities). In the following robustness check, we assume that investors' attention is rather focused on trading days with large price changes in commodity prices rather than a continuous pricing. To do so, we change our commodity performance variable in a way that takes both the economic importance of exported commodities (affectedness) and key price events (treatment) into account. To this end, we mark the (at most) five commodities in a country's portfolio that have the greatest weight as long as this weight share is over 10% of total commodity exports (results also hold for 15%). No country has a higher number of commodities than five for which this criterion applies. These commodities are coded with 1, other commodities with 0. We then mark all trading days in which a commodity had a positive price shock which is defined as having a price change above the respective 75th percentile (positive shock). We do the same for negative shocks, defined as a price change below the 25th percentile. We multiply the dummies for a country's most important commodities with their respective positive and negative price shock variables, separately. The resulting country-specific and daily-varying variable for each commodity is 1 if the commodity

Table 5
Alternative specification results.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI
ΔCommodityPerformance: Excluding world-market-relevant Exporters	-0.259***		
	(0.0423)		
ΔCommodityPerformance: Adjusting for Imports		−1.872***	
		(0.556)	
ΔCommodityPerformance: NetShockIndicator			−0.187***
			(0.0335)
Observations	129,901	126,483	129,901
R-squared	0.216	0.219	0.216
Number of Countries	34	34	34
Time & Country FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily first difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Column (1) excludes a commodity from a country's portfolio if the country had in any point in time a world market share of more than 10% for this commodity. Column (2) takes imported commodities in the calculation of ΔCommodityPerformance into account. Column (3) dummifies both relevant commodities for each country and daily price events and aggregates them to a net-shock index. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, U.S. 10-year treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

is economically important for the respective country and has a positive price shock event on this day. We then aggregate these dummies over all commodities, separately for the positive and negative price shocks. The resulting positive-shock variable can take values from 0 (no price shock for economically important commodities) to 5 (all economically important commodities for a country are subject to a positive price shock on the same day). Finally, we subtract the aggregated negative shocks from the aggregated positive shocks and arrive at a net-shock-indicator that ranges between −5 (all important negative shocks materialize) and + 5 (all important positive shocks materialize). Note that a value of e.g. 0 on a given day can imply that either no price shock that mattered for the respective country took place or that occurring positive and negative shocks just canceled each other out. We use the net-shock-indicator as our new commodity performance measure in our baseline. Column (3) reports a statistically significant effect at the 1% level. Economically, if the indicator increases by 1 unit, the EMBI spread differences decrease by roughly 18.7 bps.

4. Drivers of the commodity-sovereign risk dependence

We now turn to investigate potential drivers of the spillover of export-weighted commodity price changes to sovereign risk. If emerging markets are commodity-dependent, as the previous section indicated, it is important for policy makers to know what affects this dependency and which macroeconomic factors or policy measures can potentially reduce commodity dependence. These policy-parameters are so far hardly explored. For instance, Bouri et al. (2017) find that the spillover of commodity prices on sovereign risk varies across countries and over time, which the authors argue to be due to politically, economically or monetary policy related factors. We intend to identify these driving factors. We differentiate between channels approximating for commodity-related factors (4.1), macroeconomic and international factors (4.2), and a range of possible policy measures to limit commodity dependence (4.3). For each channel under investigation we estimate the baseline regression (1) and interact, in order to rule out reverse effects, with the yearly-, quarterly-, monthly- or daily-lagged value of the respective channel unless stated otherwise:[6,7]

$$\begin{aligned}\Delta EMBI_{it} = \; & \lambda_1 \Delta CommodityPerformance_{it} \times Channel_{it-1} + \lambda_2 Channel_{it-1} + \\ & \lambda_3 \Delta CommodityPerformance_{it} + \lambda_x \Delta Controls_{(i)t} + \alpha_i + \delta_{m_t} + \epsilon_{it}\end{aligned} \tag{2}$$

We expect channels that increase the commodity dependence of emerging markets to enter with a negative sign for the respective interaction term, while channels that could mitigate the spillover to have a positive interaction coefficient.

Following Nizalova and Murtazashvili (2016) and Bun and Harrison (2018), we argue that our interaction coefficients are consistently estimated, as long as one variable in the interaction term is exogenously determined. This assumption holds plausibly for weighted commodity prices which are largely world-marked determined. Furthermore, we demonstrated in Section 3.2 that potentially biasing effects are small in size and do not disturb our main results. Therefore, even if some chan-

[6] Since we use an emerging market panel, not all countries have full data on all interaction variables. We report on this when it becomes an issue. Definition and sources of all variables can be found in Table 14

[7] In order to ensure correct specification, interaction models also contain the single linear terms of interacted variables (Brambor et al., 2006).

nels could be endogenous with respect to sovereign creditworthiness, we argue that the interaction terms allow for exogenous interpretation.

4.1. Commodity-related factors

A natural starting point is to check if countries that have a larger share of commodity exports on their total export volume also face a more forceful commodity price spillover. We interact with the share of total commodity exports on total exports of each country. As expected, the interaction coefficient is negative and statistically significant at the 5% level as reported in Table 6, column (1). The margin plot depicted in Fig. 1 shows the marginal effect of increasing commodity performance on sovereign risk depending on the level of the commodity-export share. It suggests that commodity price changes turn statistically significant in impacting sovereign risk at an export share of roughly 5% and increase their impact further beyond this threshold.[8] Thus, a larger commodity export industry increases the commodity-sovereign risk dependence. Possible explanations for this result may be that a larger commodity export industry is associated with a more pronounced impact of commodity prices on economic growth and thus fiscal revenues and public expenditures. A larger commodity export industry should also increase potential direct cash flows to the government via publicly owned commodity firms or royalties to the government.

We next test if a higher volatility of a country's export commodity prices is associated with a more intense commodity-sovereign risk dependence. To do so, we calculate the rolling standard deviation of each country's export-weighted commodity returns on a 23-day basis, which is roughly the number of trading days each month. The respective interaction coefficient is, however, statistically insignificant (column (2)). In addition, the resulting margin plot reported in Fig. 1, does not lead to the conclusion that with more volatile price fluctuations of a country's key commodities in the previous month, current price changes have stronger effects on sovereign risk.

Having a high concentration in just one commodity could be associated with a stronger commodity dependence of a country since it has no diversification benefits in case of a shock to its key raw material. We test this hypothesis by constructing the yearly Hirschman-Herfindahl-Index (HHI), i.e. the sum of squared commodity export weights for each country. The HHI varies from roughly 0.15 for well-diversified export countries such as Poland, to almost 1 for oil-exporting countries such as Nigeria or Venezuela. The interaction of the contemporaneous HHI with the commodity portfolio yields a coefficient with positive sign that is, however, small and statistically insignificant (Table 6, column (3)). This ambiguous relationship is also confirmed in the margin plot depicted in Fig. 1 and was also found similarly in the latest report by UNCTAD (2019). One explanation of this result could be that as long as a country is commodity-dependent, it does not matter much if this dependency is towards several or only one raw material. We therefore conclude that the volatility, variety or concentration of commodities is only of secondary importance for understanding commodity-sovereign risk dependence of emerging markets.

Next, we test if exporting certain commodities entails stronger commodity dependence than others. We focus on the commodity subgroup level depicted in Table 3. We define a country as being specialized in a certain commodity subgroup if this subgroup has a share of total exports above the 10% ratio (results also hold for 15%). This criterion has the advantage that more diversified countries can be specialized in several commodity subgroups. Also, we capture economically critical specialization patterns. Interacting with the 5 dummies representing the subgroups, we find that commodity price dependence is slightly larger for countries specializing in energy with the interaction term statistically significant at the 10% level (column (4)). Bouri et al. (2017, 2018) find a similar effect. On the other hand, countries specializing in exporting industrial metals reveal statistically significantly lower commodity dependence at the 5% level. One reason could be that industrial metal sectors could facilitate the fostering of manufacturing sectors and other downstream technologies, which we show to be important drivers in reducing commodity dependence in the following sections. Another explanation could be that the public sector share of energy exports (such as crude oil) is larger compared to the public sector share in exporting industrial metals.

4.2. Macroeconomic and international factors

We turn to investigate the impact of broader macroeconomic factors with respect to the commodity dependence of emerging markets. We start by interacting the export-weighted commodity portfolio with lagged GDP growth, measured on a quarter-to-quarter basis. The resulting interaction term, reported in column (1) of Table 7, enters with a positive sign that is statistically significant at the 10% level. The margin plot in Fig. 2 additionally confirms that prices of exported commodities matter more for countries if they are in a business cycle downturn. Commodity price spillovers turn insignificant at a quarterly GDP growth level of roughly 4%. This result fits into the general finding in the literature, that asset price co-movement is intensified during crisis periods (see, e.g., Hartmann et al., 2004).

We dig deeper into the importance of the business cycle, first, by interacting with the tax revenues of a government scaled by GDP. Since tax revenues vary positively with the business cycle but also, if higher, make a country less dependent on export gains from commodities, we would also expect a positive coefficient for the interaction term of lagged tax revenues and weighted commodity price changes. We find some confirmation for this with the positive margin plot in Fig. 2 in which

[8] The GSCI, from which we derive the included commodities, covers the most important but not all commodities. It is unlikely that our results are biased because of this, nevertheless, calculated ratios such as commodity export shares are not comparable one-to-one with those reported e.g. in UNCTAD (2019).

Table 6
Drivers of commodity-sovereign risk dependence: commodity-related factors.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI
ΔCommodityPerformance	−0.0824	−0.290***	−0.351**	−0.151***
	(0.0656)	(0.0751)	(0.142)	(0.0548)
CommodityExportShare	0.0157*			
	(0.00784)			
ΔCommodityPerformance	−0.00599**			
× CommodityExportShare	(0.00284)			
CommodityStandardDeviation		−0.318***		
		(0.0833)		
ΔCommodityPerformance		0.0217		
		(0.0485)		
CommodityStandardDeviation				
CommodityHHI			−0.170	
			(0.249)	
ΔCommodityPerformance			0.158	
× CommodityHHI			(0.253)	
SpecializationAgriculture				−0.00725
				(0.0902)
ΔCommodityPerformance				−0.190
× SpecializationAgriculture				(0.161)
SpecializationEnergy				0.324
				(0.239)
ΔCommodityPerformance				−0.193*
× SpecializationEnergy				(0.0981)
SpecializationIndustryMetals				−0.0364
				(0.154)
ΔCommodityPerformance				0.393**
× SpecializationIndustryMetals				(0.181)
SpecializationPreciousMetals				0.523**
				(0.194)
ΔCommodityPerformance				−0.510
× SpecializationPreciousMetals				(0.331)
Observations	128,478	128,097	128,031	128,031
R-squared	0.220	0.218	0.218	0.219
Number of Countries	34	34	34	34
Time & Country FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily first difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Interaction terms of ΔCommodityPerformance with CommodityExportShare ((1), share of commodity exports on total exports), CommodityStandardDeviation ((2), rolling standard deviation of ΔCommodityPerformance of past 23 business days), CommodityHHI ((3), concentration index of export weights in ΔCommodityPerformance), specialization in different commodity subgroups ((4) subgroup exports are at least 10% of total exports) are estimated. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

commodity shocks become statistically insignificant in explaining sovereign risk at higher levels of tax revenues. The corresponding coefficient in column (2) is positive but not statistically significant. One further measure for business cycle effects are profits achieved in the corporate sector. We therefore interact our commodity variable with the lagged ratio of corporate sector profits to GDP which is, however, only available for 16 countries in our sample. The resulting coefficient has the expected positive sign and is statistically significant at the 10% level (column (3)). In addition, the margin plot depicted in Fig. 2 lends support to the hypothesis that with higher corporate profits, commodity price spillovers eventually matter less than in times of lower private profits. Taking the reduced sample size into account, we interpret these first three estimations as evidence that commodity price shocks hit countries harder if their business cycle is in downturn and if both private and public sectors have less capacity in terms of profits or tax revenues to fend off negative shocks. Our result is connected to Aizenman et al. (2013) who find a country's fiscal space to be important for its sovereign risk level.

The indebtedness of a country could be important for its reliance on commodities. Export gains from raw materials might matter more for a country as an income source to stabilize debt ratios if sovereign debt is larger which would speak for increased commodity dependence. When interacting with the lagged debt-to-GDP ratio of a country, we find, however, a positive interaction coefficient that weakly statistically significant (column (4)). A possible explanation for this surprising result may be that countries with on average higher public debt ratios are less reliant on commodity exports because they can issue even more debt to buffer commodity price shocks due to their higher fiscal capacities. On the contrary, countries

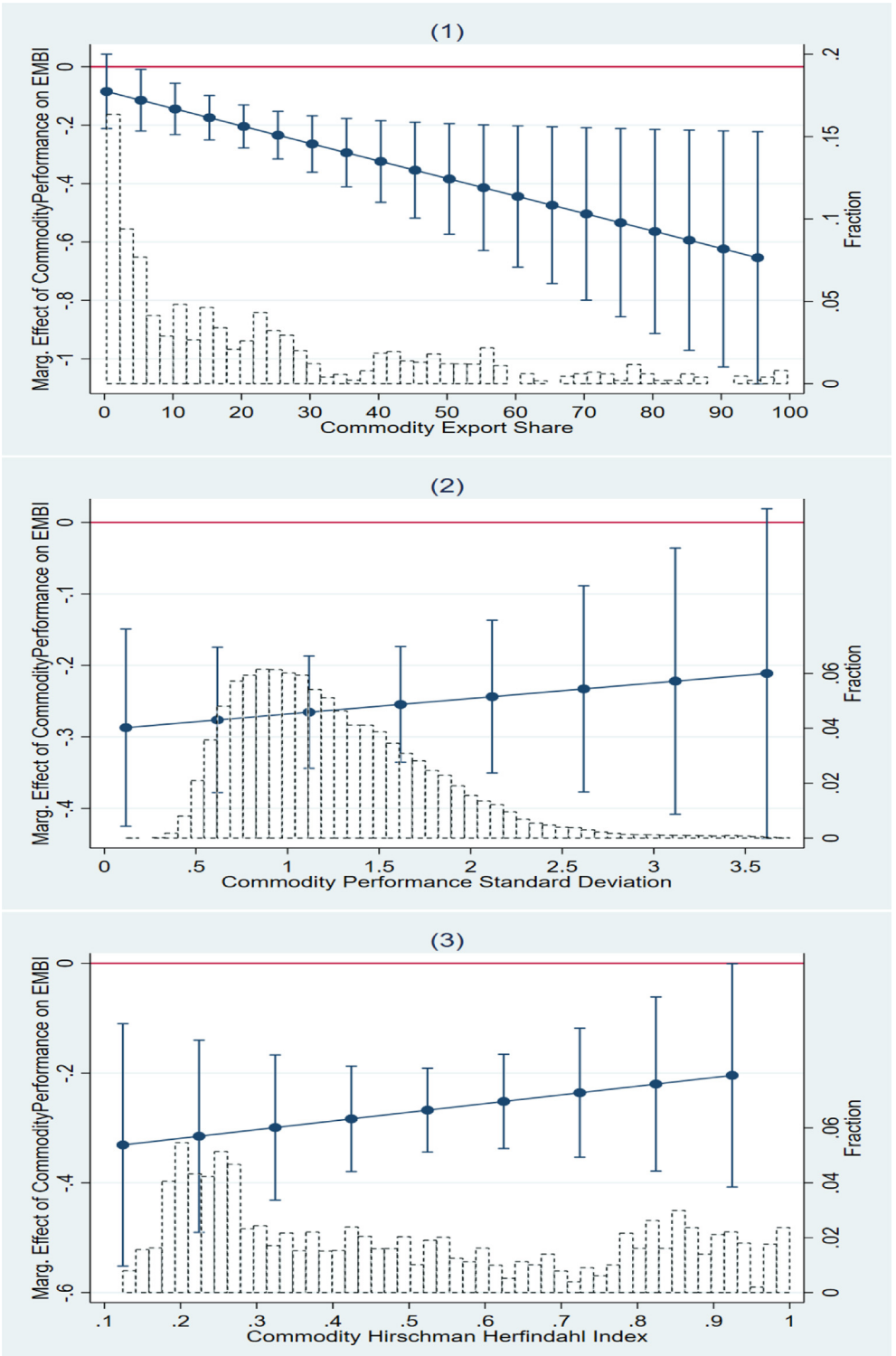

Fig. 1. Marginal effects of commodity performance on EMBI spread returns interacted with commodity-related factors. Bars indicate 95% confidence intervals. Distribution of interaction variable is shown. The results of the corresponding regressions are in Table 6.

with low debt ratios may already have reached their country-specific critical debt levels and may therefore not be able to issue new debt.

Table 7
Drivers of commodity-sovereign risk dependence: macroeconomic and international factors.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI	(5) ΔEMBI	(6) ΔEMBI	(7) ΔEMBI	(8) ΔEMBI	(9) ΔEMBI
ΔCommodityPerformance	−0.278***	−0.399**	−0.506***	−0.464***	−0.211**	−0.244***	−0.402***	−0.0757	−0.356***
	(0.0508)	(0.156)	(0.114)	(0.142)	(0.0825)	(0.0447)	(0.0863)	(0.115)	(0.0676)
GDP-Growth	−0.00802								
	(0.0181)								
ΔCommodityPerformance × GDP-Growth	0.0343*								
	(0.0181)								
TaxRevenueToGDP		0.0307							
		(0.0208)							
ΔCommodityPerformance × TaxRevenueToGDP		0.0108							
		(0.0100)							
CorporateProfitToGDP			−2.020*						
			(1.042)						
ΔCommodityPerformance × CorporateProfitToGDP			0.821						
			(0.482)						
DebtToGDP				0.00473					
				(0.00642)					
ΔCommodityPerformance × DebtToGDP				0.00508*					
				(0.00283)					
Inflation					0.000909				
					(0.000559)				
ΔCommodityPerformance × Inflation					−0.000565				
					(0.00655)				
SovereignDebtCrisis					−0.000565				
					(0.00655)				
SovereignDebtCrisis × ΔCommodityPerformance						−0.229			
						(0.219)			
YearsSinceLastRestructuring							0.0426***		
							(0.00797)		
ΔCommodityPerformance × YearsSinceLastRestructuring							0.00708*		
							(0.00383)		
GDP-PerCapita								3.42e-06	
								(4.31e-05)	
ΔCommodityPerformance × GDP-PerCapita								−2.65e-05	
								(2.04e-05)	
Federal Funds Rate									0.217
									(0.210)
ΔCommodityPerformance × FederalFundsRate									0.0562***
									(0.0147)
Observations	129,316	108,238	72,211	120,928	128,478	129,316	129,316	129,316	129,316
R-squared	0.217	0.226	0.208	0.229	0.219	0.217	0.217	0.217	0.217
Number of Countries	34	33	16	33	34	34	34	34	34
Time & Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Interaction terms of ΔCommodityPerformance with GDP-Growth (1), TaxRevenueToGDP ((2), government tax revenue to GDP), CorporateProfitToGDP ((3), corporate sector profits to GDP), DebtToGDP ((4), gross government debt to GDP), Inflation ((5), consumer price index increase), SovereignDebtCrisis ((6), dummy for Laeven and Valencia (2018) sovereign debt crisis), YearsSinceLastRestructuring ((7), number of years since last sovereign debt restructuring, 40 if no restructuring occurred), GDP-PerCapita (8) and FederalFundsRate ((9), U.S. federal funds rate) are estimated. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

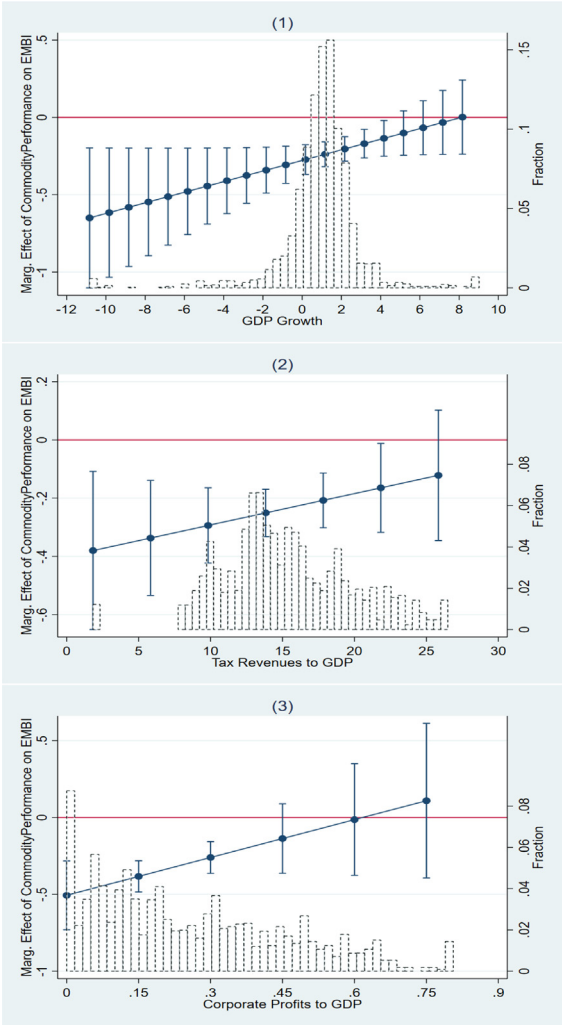

Fig. 2. Marginal effects of commodity performance on EMBI spread returns interacted with macroeconomic and international factors. Bars indicate 95% confidence intervals. Distribution of interaction variable is shown. The results of the corresponding regressions are in Table 7.

Next, we test the hypothesis that higher rates of inflation could be linked to commodity price spillovers of emerging markets. If money loses its purchasing power through inflation, income gains from commodities which are measured in U.S. dollar might matter more to stabilize sovereign creditworthiness. However, we find no empirical confirmation for this hypothesis. We report an estimated interaction term with lagged annual inflation (column (5)) that is negative but statistically insignificant. The margin plot depicted in Fig. 2 supports this finding. Though other papers like Aizenman et al. (2016) find inflation to be an important determinant of sovereign risk, it could be the case that inflation dynamics do not work through commodity prices in achieving this impact.

Related to the previous interactions, we test if commodity dependence increases if a country suffers a sovereign debt crisis. To this end, we exploit the systemic banking crises database by Laeven and Valencia (2018). We interact commodity performance with a contemporaneous dummy that indicates the year in which a country had a sovereign debt crisis. However, with results shown in column (6), we find only weak confirmation that commodity price shocks have a stronger spillover on sovereign creditworthiness during a sovereign debt crisis. While we find the expected negative interaction coefficient, it is statistically insignificant. One reason for this could be measurement error in that the crisis dummy is on a yearly basis which is too imprecise given the daily frequency of our data.

Digging deeper into the sovereign repayment history of a country and using an approach that is less susceptible to the data issue above, we interact with a continuous variable that measures the number of years since the last debt restructuring event occurred. We also include those restructuring events that happened before the start of our sample period in 1994. Overall, 22 countries in our sample negotiated at least one sovereign debt restructuring. The highest number of years since the last restructuring event is 36. For the twelve non-defaulters, we therefore set the variable to 40 as a measure for a sover-

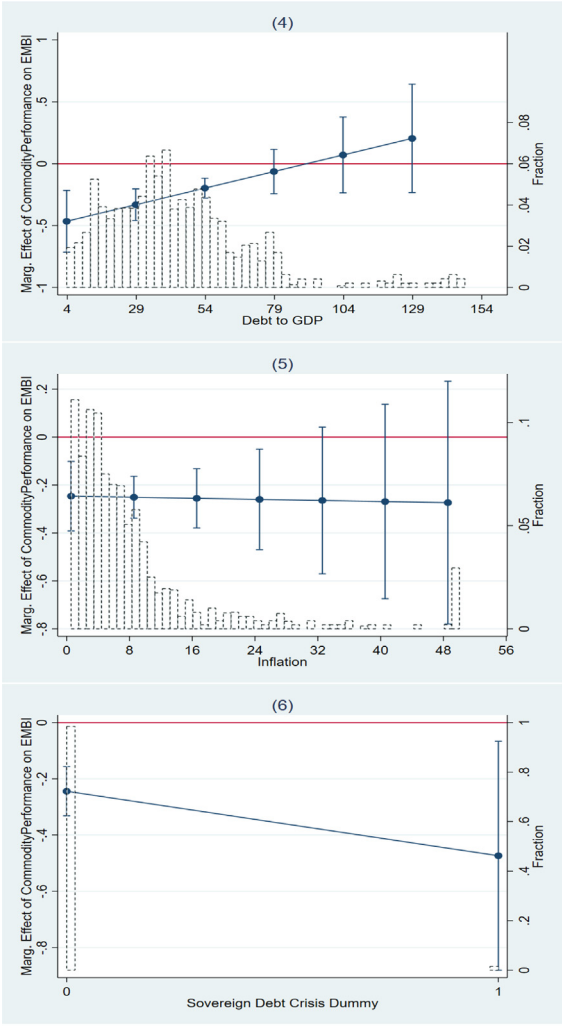

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Fig. 2 (*continued*)

eign repayment history without any restructuring events, but also find similar effects for a value of 50. The continuous variable enters negatively and statistically significantly at the 10% level in interaction with commodity price changes (column (7)). The margin plot in Fig. 2 furthermore confirms the hypothesis that a country with a distant or no sovereign debt restructuring history is hit significantly less by price shocks of its commodity exports compared to a country with only recent cases of bond renegotiations. This result could imply that financial markets pay closer attention to the commodity price performance of countries with a less stable debt repayment history in recent years as suggested by Reinhart et al. (2003), so that, for instance, negative price shocks of key commodities also have a more forceful impact on the riskiness of the respective country's debt.

Next, we test if the level of economic development matters for commodity-related spillovers. To this end, we build an interaction term between commodity performance and GDP per capita of each country. The resulting interaction term has a negative sign but is small and statistically insignificant (column (8)). This result could indicate that with regard to the within variation of economic development that we are capturing, commodity dependence is sticky for emerging market economies even if a country grows in terms of GDP. It could also be due to the fact that the countries in our sample are somewhat more developed since they report EMBI and stock market data which leaves out poorer countries e.g. in Sub-Sahara-Africa. Nevertheless, this analysis gives us some confirmation that our remaining results are not driven by any biases between richer and poorer countries, e.g. when it comes to institutional characteristics that could be a function of economic development.

Lastly, we want to analyze the effect of U.S. monetary policy on commodity dependence of emerging markets. Interest rates set by the Federal Reserve are determined with regard to the U.S. economy and likely only partially driven by economic

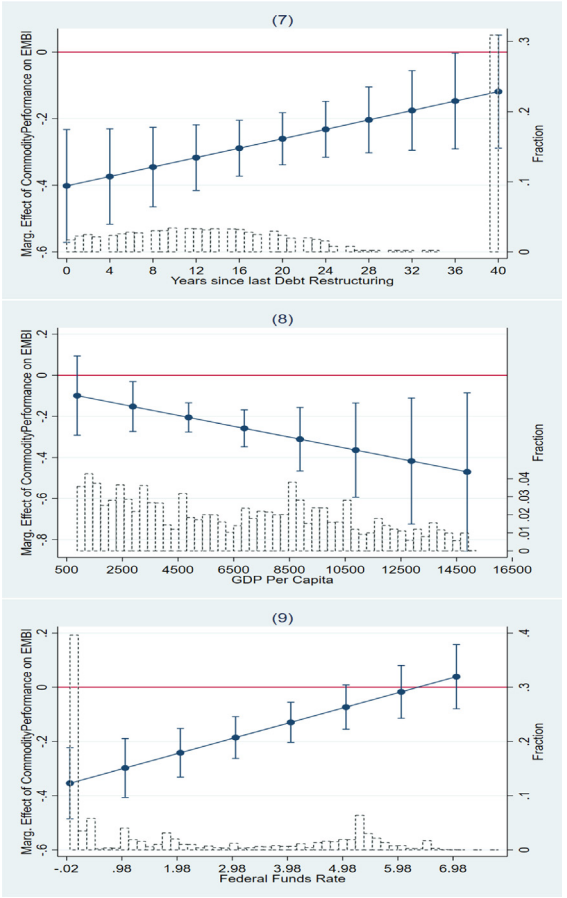

Fig. 2 (*continued*)

developments of emerging markets or commodity prices. However, as shown by Bräuning and Ivashina (2019), monetary policy decisions in the U.S. have powerful effects on onemerging markets in that expansionary measures by the Federal Reserve increase international capital flows and borrowing behavior by foreign firms. Furthermore, Frankel (2006) argues that U.S. monetary policy affects the decision for commodity exporters when to extract raw materials, to hold inventories or for investors to go into emerging markets rather than U.S. treasury bills. We therefore hold the hypothesis that more expansionary monetary policy is associated with increasing commodity dependence. Our interaction coefficient in column (9) that shows the effect of commodity performance depending on the U.S. federal funds rate is in line with this hypothesis and the literature. We find a positive and highly statistically significant coefficient at the 1% level and a margin plot in Fig. 2 which suggests that commodity dependence increases significantly at a federal funds rate lower than 5%. This effect of more expansionary U.S. monetary policy spinning the commodity cycle remains if we replace the federal funds rate by the 3-month U.S. treasury rate or the shadow rate by Wu and Xia (2016) (unreported).

4.3. Policy measures against commodity dependence

In order to inform the policy debate, we want to analyze what our model suggests to be promising ways to lower commodity dependence. We focus on policy measures that are to some degree more under the control of governments than the broader macroeconomic or international variables tested above.

First, we want to investigate if countries with higher institutional quality are less commodity-dependent. To this end, we draw yearly data from the World Bank Governance Indicators which conduct extensive surveys to approximate different forms of institutional quality on a basis of ranks ranging from 0 to 100 whereby higher indicator values imply improving institutional quality. We draw three indicators which we hypothesize to be related to the spillover of commodity prices on sovereign risk: control of corruption, rule of law and political stability (and absence of violence), which are all available from 1996 onwards.[9]

[9] There are some gaps in the data for the early years which we close by linearly interpolating the series. All our results also hold when using unadjusted data.

When interacting separately with the lagged yearly values of the three measures for institutional quality, we find clear results: all respective interaction terms are positive and strongly statistically significant, with control of corruption and rule of law at the 1% level and political stability at the 5% level (Table 8, columns (1)-(3)). The margin plots depicted in Fig. 3 support the hypothesis that with better institutional quality, commodity price shocks are less effective in impacting sovereign risk. This result implies that countries are more commodity-dependent if institutional quality is worse, for instance when ownership or legal frameworks in the production process of raw materials are less clearly structured. These findings could indicate that with improving control of corruption and a stronger rule of law, countries can mitigate rent extraction behavior in the production and selling of raw materials, reinvest gains from commodity exports more effectively, or smooth negative commodity price shocks thanks to clearer ownership structures. Our results are in line with Mehlum et al. (2006) who suggest that institutional quality is the decisive criterion for commodities to be a curse or a source of wealth.

One could be concerned that institutional quality is more difficult to improve for commodity-exporting countries as suggested by Arezki and Brückner (2011a). While our daily data structure in which institutional quality can be considered as given alleviates this concern somewhat, we also test if our results hold if we repeat the analysis for more heavy commodity exporters, defined as having a commodity export share of more than 10% on total exports. We find that the statistical significance of our result remains, except for the political stability interaction (unreported). However, we still obtain a margin plot that clearly suggests that commodity dependence can be significantly lowered with improving political stability. Therefore, even among stronger commodity exporters, those with effective institutions seem to fare better in terms of reducing commodity dependence.

We test the differentiating impact of commodity prices on sovereign creditworthiness on a further variable that approximates institutional quality namely the progressiveness of the tax system. We draw yearly data on the Gini coefficient of emerging markets from the database by Solt (2019).[10] We build an interaction term with commodity performance and the amount of tax redistribution, i.e. the difference between the pre- and post-tax Gini indices. The interaction term enters positive as shown in column (4) but is marginally insignificant before the 10% level. However, the margin plot in Fig. 3 additionally suggests that more progressive tax systems are associated with less commodity dependence.

Next, we test three interactions which might alleviate emerging markets' commodity dependence. In a direct way, building a stronger manufacturing sector should lead to less dependence on global price fluctuations of exported commodities. In a more indirect manner, attracting FDI inflows can lead to technological spillovers which could also improve the economic structure of a country beyond pure commodity exporting. Lastly, increasing gross-fixed capital formation (GFCF) i.e. investments in plant, machinery, schools and infrastructure could also diversify the economic structure of a country.

We therefore interact, separately, with the yearly-lagged manufacturing value-added, net FDI inflows and GFCF investments, all as a share of GDP. All interaction coefficients (columns (5), (6) (7)) are positive, with manufacturing and FDI statistically significant at the 5% level but GFCF being statistically insignificant. Still, all margin plots in Fig. 3 strongly support the conclusion, speaking more broadly, that fostering downstream production, investing in infrastructure and technology and diversifying economic structures can be promising ways to reduce commodity dependence.

In recent years, several countries have started to build up foreign-exchange reserves as a buffer e.g. for balance of payment crises. We find evidence that countries with higher monthly foreign exchange reserves (relative to their GDP), are also significantly less commodity-dependent as suggested by the positive and statistically significant coefficient (1%) in column (1) in Table 9 and the margin plot in Fig. 4. Higher foreign exchange reserves may reduce the dependence on foreign exchange inflows via exporting commodities and serve as a buffer for commodity-induced terms of trade shocks as suggested by Aizenman et al. (2012), thus mitigating the emergence of sovereign distress caused by balance of payments problems.

Furthermore, we investigate the effect of capital controls and trade openness in association with commodity price changes on sovereign creditworthiness. We first use the yearly KOF globalization index by Gygli et al. (2018). This index measures along several dimensions how open a country is towards trade and international financial flows. Our evidence suggests that more open countries are significantly less dependent on the price performance of their exported commodities, as shown by a significant (10% level, column (2)) and positive interaction term coefficient and the margin plot in Fig. 4. Disentangling the KOF index into the de facto and de-jure version shows that the de facto variation matters more for this effect, which enters positive and statistically significant at the 5% level (not reported). This result is in line with the findings of Aizenman et al. (2016) who find trade openness to be one of the key factors in determining sovereign risk.

When using the Chinn-Ito-Index from Chinn and Ito (2006) as a measure for current and capital account openness instead of the KOF index, we find largely similar if somewhat weaker results. Though the interaction effect is positive but statistically insignificant, the marginal effect depicted in Fig. 4 lends support to the hypothesis that more closed-off economies have a stronger dependency on their commodities for their sovereign risk, as the marginal effect of such spillovers decreases and eventually turns insignificant the more open capital accounts are. This result could suggest

[10] We aware that data on inequality of emerging markets is imperfect, even though the data quality by Solt (2019) is considered to be standardized as best as possible. See Lang and Tavares (2018) for a discussion.

Table 8
Drivers of commodity-sovereign risk dependence: policy measures (1).

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI	(5) ΔEMBI	(6) ΔEMBI	(7) ΔEMBI
ΔCommodityPerformance	−0.573***	−0.684***	−0.441***	−0.297***	−0.685***	−0.391***	−0.493**
	(0.143)	(0.137)	(0.104)	(0.0619)	(0.194)	(0.0735)	(0.190)
ControlOfCorruption	−0.000899						
	(0.00408)						
ΔCommodityPerformance × ControlOfCorruption	−0.000979***						
	(0.00285)						
RuleOfLaw		0.000388					
		(0.00346)					
ΔCommodityPerformance × RuleOfLaw		0.0108***					
		(0.00264)					
PoliticalStability			−0.000528				
			(0.00504)				
ΔCommodityPerformance × PoliticalStability			0.00594**				
			(0.00272)				
GiniRedistribution				−0.106			
				(0.113)			
ΔCommodityPerformance × GiniRedistribution				0.0109			
				(0.00738)			
ManufacturingShare					0.0197		
					(0.0180)		
ΔCommodityPerformance × ManufacturingShare					0.0258**		
					(0.00997)		
FDI-Inflows						0.00345	
						(0.0102)	
ΔCommodityPerformance × FDI-Inflows						0.0392**	
						(0.0175)	
GFCF							0.0198***
							(0.00644)
ΔCommodityPerformance × GFCF							0.0109
							(0.00811)
Observations	124,720	124,720	124,720	127,769	125,061	129,316	129,057
R-squared	0.240	0.240	0.239	0.216	0.225	0.217	0.218
Number of Countries	34	34	34	34	34	34	34
Time & Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Interaction terms of ΔCommodityPerformance with ControlOfCorruption ((1), World Bank control of corruption rank), RuleOfLaw ((2), World Bank rule of law rank), Political Stability ((3), World Bank political stability rank), GiniMarket ((4), difference in post- and pre-tax Gini index), ManufacturingShare ((5), share of manufacturing value added on GDP), FDI-Inflows ((6), net FDI inflows to GDP), and GFCF ((7), gross-fixed capital formation to GDP) are estimated. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

that more open economies could be able to better fend off a negative shock to their commodity performance because of deeper financial markets and a broader set of financing choices. The stronger effects of the de facto KOF could suggest that attracting trade flows and financial investment can be a further means in diversifying economic structures away from pure commodity extraction.

Lastly, we want to investigate the effects of development assistance measures on commodity dependence. We interact commodity performance, first, with a country's yearly exposure of loans to the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA) scaled to GDP. Both institutions are the main World Bank entities that extend loans to spur economic activity and to fight poverty (see Dreher et al., 2019 for a paper on the political economy of IBRD). Second, we interact with the yearly amount of net development assistance received scaled to GNI. Though both measures are not directly implemented to fight commodity dependence, they could still be associated with diversifying economic activities or investing in infrastructure projects which we showed previously as effective ways to reduce commodity dependence. However, we find only weak confirmation that development assistance or World Bank loans are promising ways to reduce raw material reliance of emerging markets. For both interactions, the coefficient has the expected positive sign, i.e. more assistance tends to decrease commodity dependence (columns (4) and (5)). But both coefficients are statistically insignificant and the slopes of the interaction effects, depicted in Fig. 4, are small. If anything, we find stronger effects for IBRD loans, in that a country is more commodity-dependent if it has none or only small loan exposure compared to countries that have at least some IBRD loan exposure. Therefore, we conclude that development assistance can potentially impact commodity dependence, however, the more promising results were

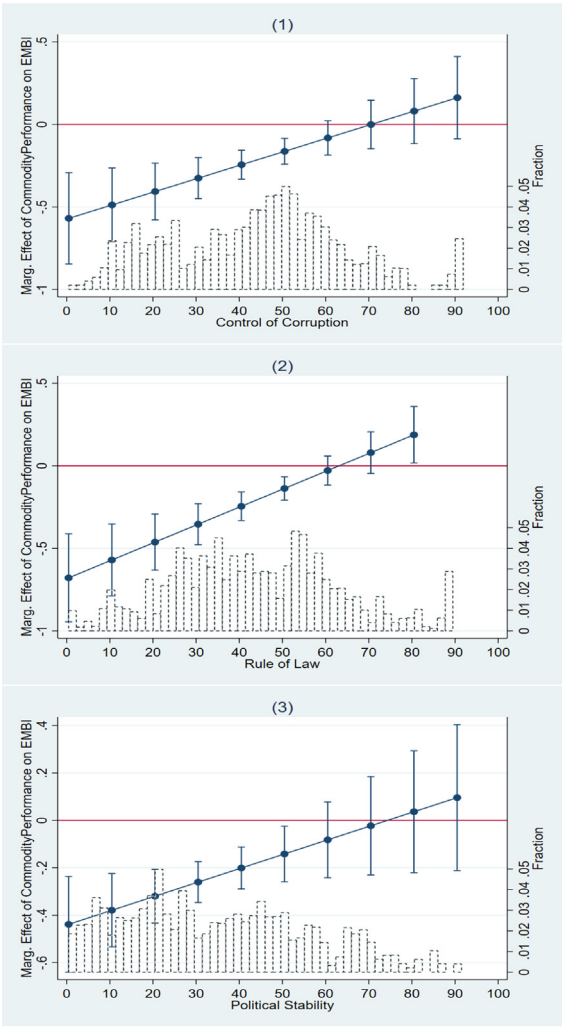

Fig. 3. Marginal effects of commodity performance on EMBI spread returns interacted with policy measures against commodity dependence (1). Bars indicate 95% confidence intervals. Distribution of interaction variable is shown. The results of the corresponding regressions are in Table 8.

with regard to improving institutional quality, broadening economic structures, building up reserves and opening trade and financial accounts.

5. Robustness checks

5.1. Dropping countries with liquidity issues

We perform a range of sensitivity analyses to demonstrate the robustness of our results. First, we want to make sure that our results are not driven by liquidity issues some emerging markets might have in their EMBI or stock market data. To do so, we first drop all countries from the sample if their EMBI index turned temporarily illiquid during our estimation period, which we define formally as a constant EMBI spread for at least seven consecutive trading days. So far, we handled these periods by setting the affected EMBI changes to missing for the respective countries. Dropping the eight affected countries and repeating our benchmark estimation (1) shows that the coefficient of export-weighted commodity price shocks is of similar size and statistical significance as in our main specification (Table 10, column (1)).

We then exclude the five countries whose stock market data has temporarily been varying only on a weekly instead of the daily level, which we previously handled the same way as with the EMBI returns. Results in column (2) report a commodity performance coefficient that is statistically significant at the 1% level, comparable to our main results.

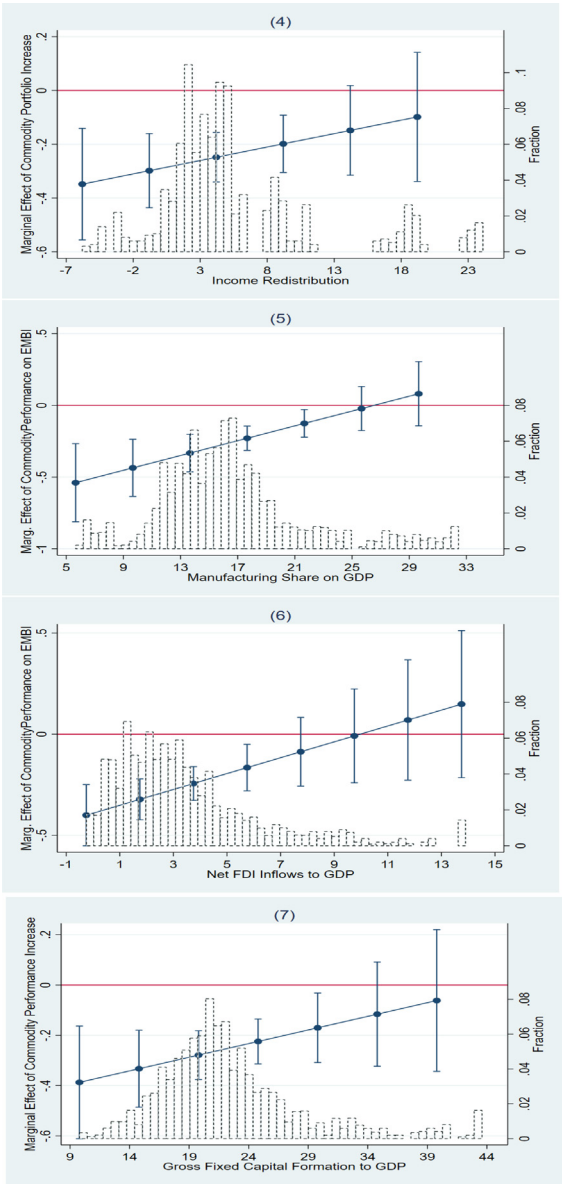

Fig. 3 (*continued*)

Lastly, we drop all countries from the baseline estimation if they have less than 3000 business days of both stock market and EMBI return data which is somewhat over twelve years of data. This criterion affects 13 countries. Results for this specification in column (3) yield a commodity performance coefficient that is extremely close to our main specification and statistically significant at the 1% level. These robustness checks indicate that our way of handling periods of lower liquidity in EMBI or stock data, by setting the respective data to missing if zero returns occur for at least two business days, was already a thorough method to deal with this issue and that any biases from low liquidity periods are limited in importance.

5.2. Alternative specifications for EMBI and commodity performance

Next, we want to further alleviate concerns that our main results only hold because of the way we measured our variable of interest, i.e. export-weighted commodity price changes. We propose an alternative specification to capture price changes of key commodities of an emerging market that is similar to the procedure we used to take commodity imports into account in Section 3.2. We multiply price changes of a commodity with the absolute export value (in U.S.

Table 9
Drivers of commodity-sovereign risk dependence: policy measures (2).

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI	(5) ΔEMBI
ΔCommodityPerformance	−0.444***	−1.059**	−0.257***	−0.335***	−0.271***
	(0.0935)	(0.434)	(0.0458)	(0.0989)	(0.0664)
ReservesToGDP	−0.285				
	(0.567)				
ΔCommodityPerformance × ReservesToGDP	1.095***				
	(0.399)				
KOF		0.0188			
		(0.0251)			
ΔCommodityPerformance × KOF		0.0126*			
		(0.00651)			
ChinnIto			0.0400		
			(0.0256)		
ΔCommodityPerformance × ChinnIto			0.0420		
			(0.0477)		
IBRDLoans				10.05*	
				(5.585)	
ΔCommodityPerformance × IBRDLoans				3.917	
				(2.855)	
NetAidGNI					−0.0772**
					(0.0316)
ΔCommodityPerformance × NetAidGNI					0.0438
					(0.0589)
Observations	129,316	129,316	127,087	124,170	117,413
R-squared	0.217	0.217	0.215	0.213	0.210
Number of Countries	34	34	33	34	34
Time & Country FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Interaction terms of ΔCommodityPerformance with ReservesToGDP ((1), official reserve assets in U.S. Dollar to GDP in U.S. Dollar), KOF ((2), KOF globalization index by Gygli et al. (2018)), ChinnIto ((3), Chinn-Ito capital account openness index by Chinn and Ito (2006)), IBRDLoans ((4), outstanding International Bank for Reconstruction and Development and International Development Association loans to GDP) and NetAidGNI ((5), net official development assistance to GNI) are estimated. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

dollars) of the specific commodity for every country. We aggregate these value-weighted returns and then divide them by the GDP of each country. In this way, we take the importance of commodity exports on the share of a country's total economy into account, similarly as with the interaction model for the share of commodity exports on total exports. Our results are robust with respect to our previous findings, in that we report a coefficient of GDP-weighted commodity export returns that is statistically significant in affecting sovereign creditworthiness at the 1% level (Table 11, column (1)).

Though they are not part of the main GSCI index, there are additional GSCI spot price series for orange juice, palladium, platinum, bio-fuel, soybean oil and tin. We match these price series with the respective export volume of our sample countries and extend our commodity performance measure by these extra raw materials (except for orange juice which has no clear export match). Reassuringly, we find a slightly stronger commodity performance coefficient that is reported in column (2). However, the difference to the main specification is small, likely because these extra commodities otherwise would have been in the main index.

We already made sure that commodity prices cannot influence contemporaneous commodity weights by lagging all weights by one year. We take an additional step to make sure that export weights are unaffected by the price movement of the corresponding commodity by fixing each weight at its first observed value. For most countries, this first observation is in 1994. We hold this value constant for all periods thereafter. Our result is in line with our baseline coefficient, and also statistically significant at the 1% level (column (3)), reassuring that most variation comes from commodity prices, whereas the weights are largely sticky.

In another robustness check we use sovereign credit default swap (CDS) premiums instead of EMBI spreads to measure sovereign creditworthiness. We draw CDS data from Thomson Reuters which is, however, only available since 2008 and only for 29 of our 34 sample countries. Comparable to our main specification, we take the first difference of the CDS spread as a new dependent variable. Even despite the data limitations, our commodity performance measure continues to have the expected negative sign and is statistically significant at the 1% level (column 4).

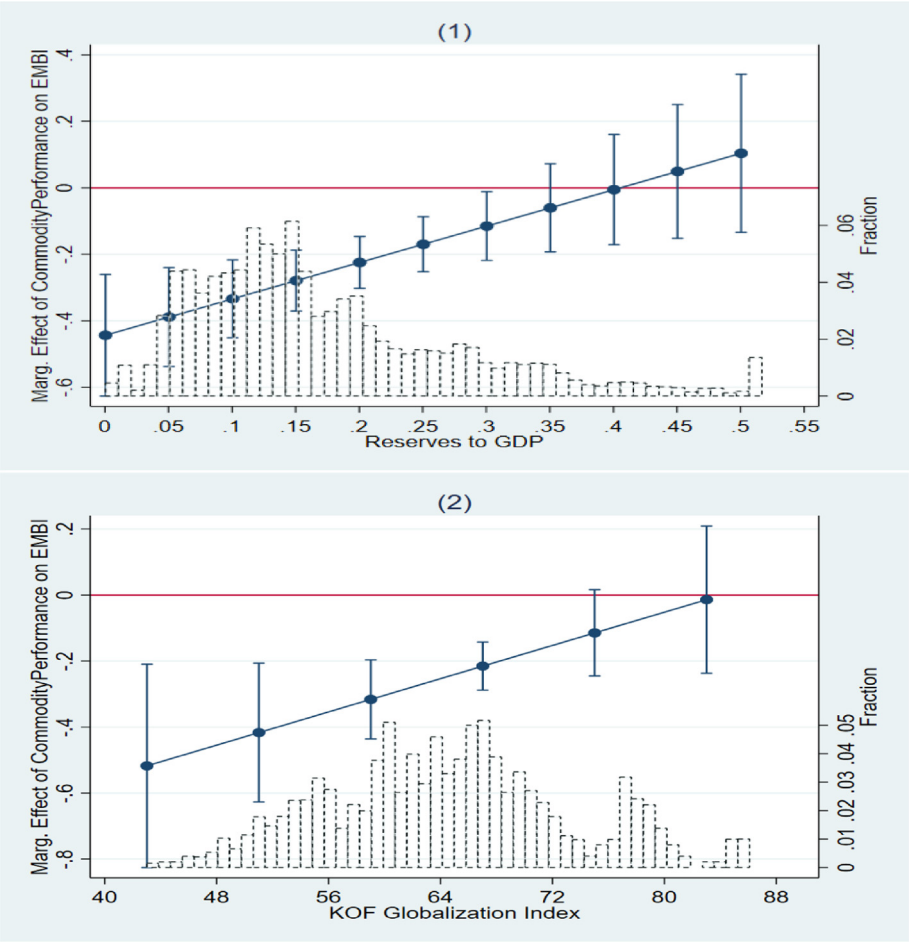

Fig. 4. Marginal effects of commodity performance on EMBI spread returns interacted with policy measures against commodity dependence (2). Bars indicate 95% confidence intervals. Distribution of interaction variable is shown. The results of the corresponding regressions are in Table 9.

5.3. Alternative control variables

We further check that we have sufficiently controlled for any influences that could impact the relationship between commodity prices and sovereign risk. To this end, we introduce some new control variables into our main specification. One further variation we might want to control for comes from credit risk in the U.S. interbank market that could spill over to emerging markets and which can be approximated by the TED spread. Though the TED spread enters with a positive sign and statistical significance when added to our main estimation, it does not change the significance level of our commodity performance measure which remains at the 1% level (Table 12, column (1)).

So far, we have not controlled for the economic performance of the U.S. Therefore, another potential variable worth including could be U.S. stock market returns, as they might affect both commodity prices and sovereign creditworthiness of emerging markets. However, adding the daily natural log returns of the S&P 500 to our main specification leaves coefficient size and significance of the commodity performance almost unchanged (column (2)).

We also split up the term spread we included in our main specification and add changes in the 3-month U.S. treasury bill rate as an additional control variable. Our main results are not affected (column (3)).

5.4. Alternative fixed effects, frequency and clustering

In order to account for market-wide changes at a higher frequency, we replace the month fixed effects in our baseline estimation with week fixed effects. The commodity performance coefficient becomes just slightly smaller in size due to this procedure but remains statistically significant at the 1% level (Table 13, column (1)).

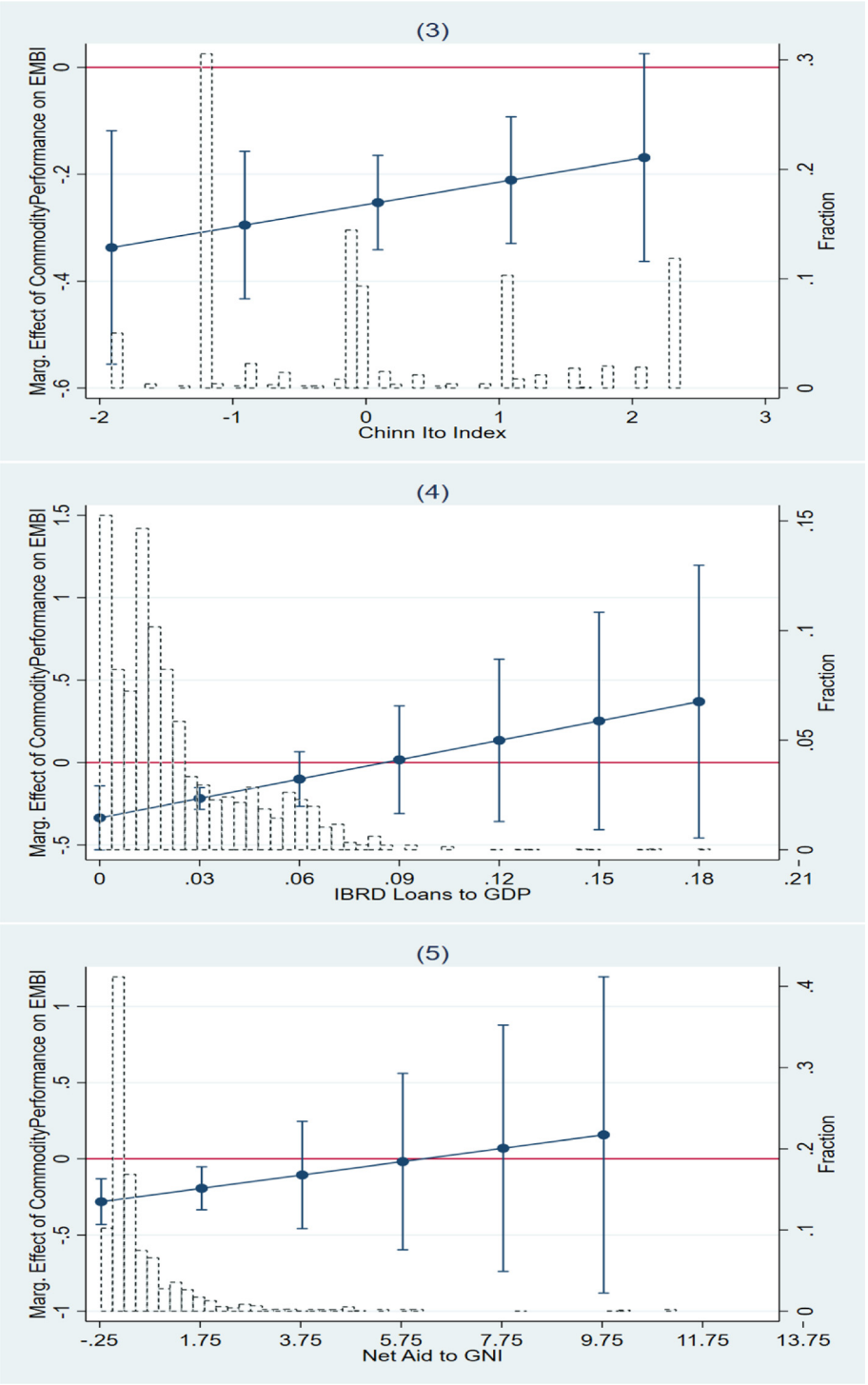

Fig. 4 (*continued*)

Table 10
Robustness: dropping countries with liquidity issues.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI
ΔCommodityPerformance	−0.269***	−0.243***	−0.268***
	(0.0488)	(0.0462)	(0.0519)
Observations	108,062	116,645	100,043
R-squared	0.222	0.218	0.199
Number of Countries	26	29	21
Time & Country FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily differences of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Robustness checks repeat baseline equation and include: (1): drop all countries for which EMBI data turned, at some point, temporarily illiquid. (2): drop all countries for which stock market data turned, at some point, temporarily illiquid. (3): drop countries for which there are less than 3000 business days (roughly 12 years) of common EMBI and stock market data. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 11
Robustness: alternative specifications for EMBI and commodity performance.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔCDS Spread
ΔCommodityPerformance: GDP-weighted	−2.422***			
	(0.562)			
ΔCommodityPerformance: additional commodities		−0.259***		
		(0.0434)		
ΔCommodityPerformance: constant weights			−0.250***	
			(0.0384)	
ΔCommodityPerformance				−0.455***
				(0.0644)
Observations	127,357	129,901	129,901	54,982
R-squared	0.217	0.216	0.216	0.165
Number of Countries	34	34	34	29
Time & Country FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily difference of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Robustness checks repeat baseline equation and include: (1): scaling CommodityPerformance to GDP. (2): include additional GSCI commidites in CommodityPerformance. (3): Holding the first observed commodity export weight constant. (4): use CDS spreads (first difference) as a dependent variable. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

One further concern we want to alleviate is that the daily frequency in our data could be too noisy for a robust inference. We therefore collapse our data to the monthly frequency and repeat our baseline estimation. We obtain a somewhat higher coefficient of export-weighted commodity price shocks that is statistically significant at the 5% level (column (2)).

Furthermore, we cluster standard errors of our baseline both on the country and the week level, to also allow for the correlation of errors within weeks. Our results remain statistically significant at the 1% level with this procedure (column (3)).

Next, we include day-of-the-week fixed effects to make sure our results are not driven by trading anomalies on certain business days, e.g. Fridays. Our main results are not affected by this approach (column (4)). We therefore conclude that the daily data structure is unlikely to be too noisy or biased with respect to our research design, but rather captures the maximum variation and information in the data.

Finally, we use time series regressions for each country to check for country-specific differences in the commodity-sovereign risk-dependence (results available upon request). Overall, 26 out of the 34 sample countries have the expected negative sign of commodity performance in explaining sovereign risk. The coefficients are strongest for Argentina, Brazil, Ivory Coast, Kazakhstan, Peru, Philippines and Venezuela, which is reasonable, as these countries are in general large commodity exporters. Positive coefficients, though they are never statistically significant, are obtained e.g. for Poland or Hungary, which rely to lesser extends on commodity exports.

Table 12
Robustness: alternative control variables.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI
ΔCommodityPerformance	−0.278***	−0.233***	−0.249***
	(0.0467)	(0.0415)	(0.0437)
ΔTED-Spread	11.51***		
	(1.970)		
ΔS&P-500		−0.676***	
		(0.172)	
Δ3-Month-TBill-Yield			−0.0574
			(0.890)
Observations	115,634	129,316	129,316
R-squared	0.218	0.219	0.217
Number of Countries	34	34	34
Time & Country FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

This table shows results from OLS-panel regressions of the daily differences of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Robustness checks repeat baseline equation and include: (1): include TED-Spread as additional control variable. (2): include S&P-500 return as additional control variable. (3): include 3-month-TBill-yield instead of TermSpread as additional control variable. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 13
Robustness: alternative fixed effects, frequency and clustering.

	(1) ΔEMBI	(2) ΔEMBI	(3) ΔEMBI	(4) ΔEMBI
ΔCommodityPerformance	−0.209***	−0.433***	−0.249***	−0.249***
	(0.0421)	(0.205)	(0.0541)	(0.0441)
Observations	129,316	6,264	129,316	129,316
R-squared	0.256	0.285	0.217	0.217
Number of Countries	34	34	34	34
Week Time & Country FE	Yes	No	No	No
Month Time & Country FE	No	No	Yes	Yes
Year Time & Country FE	No	Yes	No	No
DayOfWeek FE	No	No	No	Yes
Controls	Yes	Yes	Yes	Yes
Cluster	Country	Country	Country & Week	Country

This table shows results from OLS-panel regressions of the daily differences of a country's Emerging Market Bond Index Spread (ΔEMBI) on the daily returns on the weighted price index of a country's exported commodities (ΔCommodityPerformance) and controls. Robustness checks repeat baseline equation and include: (1): apply weekly instead of monthly fixed effects. (2): collapse data at monthly frequency. (3): cluster on country- and week-level. (4): include day-of-the-week fixed effects. Estimation period is from 01/01/1994 to 12/31/2016. Variable definitions are provided in Table 14. Control variables include a country's stock index and exchange rate (to U.S. Dollar) returns, changes in the VIX, U.S. term spread, U.S. corporate spread, 10-year U.S. treasury yield and global government bond index. Estimations include country and time fixed effects on the monthly level. Standard errors (in parentheses) are clustered at the country level, ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

6. Conclusion

This paper investigates the economic importance of commodity dependence on emerging markets' sovereign creditworthiness and derives macroeconomic and policy conditions that could propagate or curb this dependence. Using daily data for 34 emerging market economies from January 1, 1994 to December 31, 2016, we measure dependence as the impact of country-specific, export-weighted commodity price changes on EMBI sovereign bond yield spreads relative to U.S. Treasuries (controlling for a large set of major national and international financial indicators, country and time fixed effects). We obtain a statistically robust and economically meaningful commodity-sovereign risk dependence channel.

For the full set of countries, a one standard deviation increase in commodity price returns is associated on average with a 33.2 bps decrease in the EMBI spread differences. For heavy exporters (with a commodity export share on total exports equal or above the 90th percentile), the standardized effect yields a 47.5 bps decrease in EMBI spread differences which corresponds to 5% of the EMBI's standard deviation, and compares to around 40% of the standardized effects of the VIX and the corporate risk spread. Thus, particularly for commodity-dependent countries, commodity price fluctuations are a major determinant of sovereign creditworthiness. This average effect can be further differentiated along the characteristics of a

Table 14
Description and sources of variables.

Variable	Description	Source
Variables in Baseline Regression (Section 3.1) (all variables winsorized at 1st and 99th percentile, unless otherwise stated)		
ΔEMBI	Daily difference in Emerging Market Bond Index Spread (Global) (winsorized at 5th and 95th percentile)	J.P. Morgan
ΔCommodity Performance	Lagged-export-share weighted commodity price changes as described in Section 2.2	UN Comtrade, ITC Trade Map, S&P
ΔStock Returns	Daily change in natural logarithm of a country's general stock market index in U.S. Dollar	Datastream, MSCI, S&P For Ecuador, we merge local Quito Stock Exchange (in $) and S&P data to receive maximum coverage.
ΔExchange Rate Returns	Daily percentage change of a country's local currency exchange rate towards the U.S. Dollar	Thomson Reuters
ΔVIX	Daily change in VIX volatility index	CBOE
ΔCorporate Spread	Daily change in spread between the S&P U.S. high yield corporate bond index and the corresponding investment grade index	S&P
Δ10-Year Treasury Yield	Daily change in the yield of the 10-year U.S. Treasury bond	Datastream
ΔTerm Spread	Daily change in spread between 10-year U.S. Treasury yield and 3-month U.S. T-Bill yield	Datastream, Federal Reserve
ΔGlobal Government Bond Index	Daily change in natural logarithm of Bank Of America Merrill Lynch Global Government Index	Merrill Lynch
Variables in Alternative Specification Regressions (Section 3.2)		
ΔCommodity Performance: Excluding world-market-relevant exporters	CommodityPerformance excluding a commodity if country had at any time world-export share of more than 10%	
ΔCommodity Performance: Adjusting for imports	CommodityPerformance using net commodity exports (see Section 3.2)	
ΔCommodity Performance: Net Shock Indicator	CommodityPerformance using dummies for relevant commodities and extreme price events (see Section 3.2)	
Variables in Interaction Regressions (Section 4) (all variables winsorized at 1st and 99th percentile, except indices)		
Commodity Export Share	Share of commodity exports on total exports	UN Comtrade, ITC Trade Map
Commodity Standard Deviation	Rolling standard deviation of CommodityPerformance over past 23 business days (one month)	
Commodity HHI	Hirschman-Herfindahl-index (HHI), i.e. sum of squared export weights within CommodityPerformance	
Specialization: Agriculture, Energy, Industrial Metals, Precious Metals	1 if respective subgroup has share on total exports of at least 10%, 0 otherwise.	
GDP in local currency	GDP in constant prices, seasonally adjusted and local currency	Oxford Economics
GDP in U.S. Dollar	GDP in current prices and U.S. Dollar	World Bank
GDP Growth	Quarterly natural log growth rate of local currency GDP	
Tax Revenues to GDP	Government tax revenue (% of GDP, linearly interpolated)	World Bank
Corporate Profits to GDP	Corporate sector profits (% of GDP)	Oxford Economics
Debt to GDP	General gross government debt (% of GDP)	Oxford Economics
Inflation	Annual consumer price increase (winsorized at 5th and 95th percentiles to rule out hyperinflation periods)	World Bank
Sovereign Debt Crisis	Yearly dummy for sovereign debt crisis	Laeven and Valencia (2018)
Years since last Sovereign Debt Restructuring	Number of years since last sovereign debt restructuring. Value of 40 if no sovereign debt restructuring took place	Laeven and Valencia (2018)
GDP per Capita	Gross domestic product per capita in constant prices and U.S. Dollar	World Bank
Federal Funds Rate	U.S. federal funds effective rate	Federal Reserve
Shadow Rate	Federal funds shadow rate	Wu and Xia (2016)
Control of Corruption	Control of corruption rank (The extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests; linearly interpolated)	World Bank
Rule of Law	Rule of law rank (The extend of which agents have confidence in and abide by the rules of society; linearly interpolated)	World Bank
Political Stability	Political stability rank (The likelihood that the government will be destabilized by unconstitutional or violent means, including terrorism; linearly interpolated)	World Bank
Gini Redistribution	Absolute income redistribution (market-income inequality minus net-income inequality)	Solt (2019)
Manufacturing Share	Manufacturing value added (% of GDP)	World Bank
FDI-Inflows	Net foreign direct investment inflows (% of GDP)	World Bank
GFCF	Gross Fixed Capital Formation (% of GDP)	World Bank
Reserves to GDP	Total reserve assets (% of GDP)	IMF

Table 14 (*continued*)

Variable	Description	Source
KOF	KOF Globalisation Index (composite index measuring globalization along several criteria such as trade and financial flows and regulation)	Gygli et al. (2018)
Chinn-Ito	KAOPEN index of Chinn and Ito (2006) (index measuring regulatory controls over current or capital account transactions and exchange rate regimes)	Chinn and Ito (2006)
IBRD Loans	Outstanding loans from International Bank for Reconstruction and Development and International Development Association (% of GDP)	World Bank
Aid to GNI	Net official development assistance received (% of GNI; for Hungary, Bulgaria, Poland and Russia: % of GDP)	World Bank
Variables in Robustness Regressions (Section 5) (all variables winsorized at 1st and 99th percentile)		
ΔCDS Spread	Daily difference CDS spread (winsorized at 5th and 95 h percentile)	Thomson Reuters
ΔTED Spread	Spread between 3-Month LIBOR based on U.S. dollars and 3-Month Treasury Bill	Fed St. Louis
ΔS&P 500	Daily change in natural log of Standard and Poor's 500 Composite	S&P
Δ3-Month T-Bill Yield	U.S. treasury bill 3-month yield	Federal Reserve

country's commodity portfolio, national and international macroeconomic conditions and set of policy measures that affect commodity extraction.

We find, first, that commodity dependence increases with a larger share of commodity exports on total exportations. Exporting predominantly energy is associated with tighter commodity sensitivity, while the export of industrial metals with lower commodity dependence. Diversification within the commodity portfolio, i.e. being less concentrated on a single commodity, or exporting less price volatile commodities, however, does not seem to be associated with lower commodity dependence. As our later results show, a country can likely do more to tackle commodity dependence if it diversifies its economic structure towards downstream production and manufacturing sectors, instead of an additional commodity.

Second, we present evidence that commodity dependence increases in times of recession and lower public and private revenue streams. We do not find evidence that the outbreak of sovereign debt crises affects commodity dependence. Still, financial markets seem to pay attention to more recent incidents of sovereign defaults, which are associated with stronger commodity dependence the lower the number of years they date back. We also obtain strong evidence that more expansionary U.S. monetary policy spins the commodity cycle and increases commodity dependence significantly.

Third, we show consistent evidence that improving institutional quality can be a promising way to mitigate commodity dependence. All of our interactions variables, i.e. control of corruption, rule of law, political stability but also the progressiveness of a country's tax system, indicate that institutional quality is a decisive factor to tackle the dependence of a country's creditworthiness on raw material prices. We argue that better institutions likely increase transparency, provide clear ownership rights and limit corruption in the extraction process. The result also holds when focusing only on heavy commodity-exporting countries.

We also present results indicating that attracting more FDI flows, having larger manufacturing sectors and investing more in physical capital like machinery or infrastructure can be fruitful ways to reduce commodity dependence by fostering downstream production technologies. In contrast, having a low stock of foreign exchange reserves is associated with increasing commodity dependence. We also uncover that more open trade and financial accounts are associated with a weaker reliance on raw material prices. Lastly, development assistance measures such as received aid or World Bank loans show only a small effect on reducing commodity dependence.

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.

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