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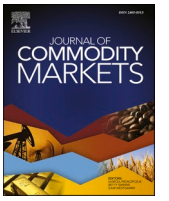

Does commodity price uncertainty matter for the cost of credit? Evidence from developing and advanced economies

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ABSTRACT

In this study, we focus on the effect of commodity price uncertainty on the cost of bank credit for a broad sample of loans traced to firms operating in developing and advanced economies. Using loan-level data for the 1990–2019 period, we find novel evidence that commodity price uncertainty, as estimated by a Bayesian Dynamic Factor Model, increases the cost of bank loans particularly for commodity dependent firms operating in developing countries vis-à-vis commodity dependent firms operating in advanced economies. In a further analysis, when examining the effect of group specific commodity price uncertainty on cost of borrowing, we find that agricultural price uncertainty significantly increases the cost of credit of commodity dependent firms operating in developing economies. We also find that commodity price uncertainty rises the cost of bank credit more for loans traced to firms locating in bank-based countries as compared to loans granted to firms operating in market-based economies, suggesting that the financial structure of a country could play an important role in passing through the borrowing costs to firms. Lastly, we also find that the effect of commodity price uncertainty is more pronounced for smaller firms operating in developing countries as opposed to smaller firms operating in developed countries. All in all, the above evidence provides useful policy implications, particularly, for the longevity of corporate sector operating in developing countries whereby the local financial structure poses serious threats to firms' future earnings.

1. Introduction

Early empirical work highlights the recessionary effect of rising commodity prices, such as oil prices, on the economy (Hamilton, 1983, 2003; Ravazzolo and Rothman, 2013; among others). More recently, there is an emerging literature which shows that commodity price uncertainty, as captured by the volatility of commodity prices, has long lasting dampening effects on economic activity and aggregate investment (Elder and Serletis, 2010; Jo, 2014; De et al., 2015; Elder, 2018; Tran, 2021).[1] Also, in earlier empirical work, commodity price uncertainty is found to have a significant effect on inflation and interest rates (Karali and Power, 2013; Hayo et al., 2012; Triantafyllou and Dotsis, 2017), whereas another stand of literature shows that commodity price uncertainty reduces firm

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[1] In this study we use the two terms, i.e., commodity price uncertainty and commodity price volatility, interchangeably.

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investment and productivity (Henriques and Sadorsky, 2011; Alaali, 2020). However, the research that explores the effect of commodity price uncertainty on the banking sector is rarer. Only recently Eberhardt and Presbitero (2021) find that commodity price volatility increases the probability of a bank crisis. However, to the best of our knowledge, no study to this date links commodity price uncertainty with the cost of bank borrowing. In this study, we aim to fill this gap by examining the effect of commodity price uncertainty on the cost of bank loans for a sample of firms operating in developing/emerging and advanced economies.

We focus on the cost of bank loans as it represents one of the most dominant sources of debt financing for firms operating in both developing and developed countries (Bharath et al., 2008; De Fiore and Uhlig, 2011; Hasan et al., 2014; Ghosh, 2016). Bank financing plays an important role for firms' growth and the economy and provides grounds on the growing research that examines the drivers of the cost of bank credit. Hence, from a managerial and policy perspective it is useful to examine the role that commodity price uncertainty plays on the cost of bank loans. In addition, we focus on the commodity price uncertainty as a potential determinant of bank cost of loans due to the sharp increase of commodity price uncertainty in global commodity markets (Headey and Fan, 2010; FAO et al., 2011; Prakash, 2011b). Also, rising uncertainty for the prices of basic agricultural products, such as wheat and soybeans, has raised concerns of basic nutrition needs of least developed economies. The food insecurity issue could have serious negative implications on earnings of firms as the demand of their produced goods depends upon the price uncertainty of commodity products.

The existing literature offers theoretical grounds of a positive relationship between commodity price uncertainty and the cost of bank loans through mainly two channels. Firstly, in the early work by Bernanke (1993), it is documented that oil price uncertainty increases the option value of waiting to invest which is further reinforced by Bloom's (2009) study, whereby the author finds that rising uncertainty leads to reduction of investment for firms. This postponement of investments may lead to reduction of profitable projects which may lead to lower revenues for firms during periods of higher uncertainty. Reduction of investment might lead to the decrease of demand of loans for investment purposes, but firms would continue to borrow for reasons excluding investment such as adjusting their leverage ratios (Modigliani and Miller, 1958) or distributing dividends to their shareholders (Wruck, 1994). Hence, under higher commodity price uncertainty firms might experience a drop in their revenues collection due to the loss of profitable investments which would negatively affect their loan repayment capability. Thus, banks would increase the cost of lending to compensate for the higher risk they carry. The second channel through which commodity price uncertainty could affect cost of bank loans is through its effect on financial sector. To the extent that high commodity price uncertainty leads to the reduction of investment and profits for firms, this may also suggest reduction of tax contributions and revenues for the government (Eberhardt and Presbitero, 2021). This in turn would decrease loan repayment capacity of the public sector, which would increase the risk of default of banks. Consequently, banks would be less willing to extent credit and would impose more stringent lending terms to borrowing firms when commodity price uncertainty is high. Therefore, our fist hypothesis (H1) is that commodity price uncertainty positively affects the cost of bank loans.

We also investigate whether the effect of commodity price uncertainty on the cost of bank credit is more pronounced for firms operating in developing/emerging vis-à-vis firms operating in advanced countries. Developing/emerging countries are highly dependent in terms of revenues on commodity exports, as commodities account for 60% of their total export production and 30% of their imports are commodity based (UNCTAD, 2019). Hence, firms in developing countries would be more exposed to commodity price uncertainty compared to firms in developed countries in terms of their revenues collection. Also, hedging strategies of firms/banks locating in developing countries are weaker in comparison with the hedging strategies of firms/banks locating in developed countries due to the underdeveloped nature of financial markets in the former economies. Price uncertainty reduces productivity growth in the absence of effective hedging practices (Ceballos et al., 2017). Consequently, the above factors render both firms and financial institutions more vulnerable to rising commodity price uncertainties, which push banks to charge higher costs to loans traced to firms locating in developing/emerging countries compared to loans traced to firms locating in developed countries. Therefore, our second hypothesis (***H2***) is that commodity price uncertainty has a more pronounced positive effect on the cost of bank loans for firms operating in developing/emerging economies vis-à-vis for firms operating in advanced countries.

To study the effect of commodity price uncertainty on the cost of bank loans, we obtain loan data from Dealscan database and build a sample of 4255 syndicated loans granted to 951 borrowing firms from 74 developing and developed countries over the 1990–2019 period. We calculate the cost of bank credit as the natural logarithm of loan spreads, which is the sum of the loan interest rate in basis points above LIBOR and annual fees for a loan facility that is traced to a firm. To measure commodity price uncertainty, we follow a novel methodological approach developed by Ferrara et al. (2022). We estimate a Bayesian Dynamic Factor Model capturing comovement in the uncertainty series of major agricultural, energy and metals commodity markets. We construct a common uncertainty index capturing uncertainty comovement in major global commodity markets. This is of major importance for the policy perspective of this study since a common (single) index that captures uncertainty comovement in major commodity markets, could be more easily tracked and targeted by the central bank as compared with the individual uncertainty series for major agricultural, energy and metals commodity markets. For instance, while it is practically impossible for a central bank to target simultaneously the reduction of uncertainty in major agricultural, energy and metals markets such as crude oil, gold, silver, wheat and soybeans, it is feasible for the monetary authority to effectively target and reduce uncertainty using a single index capturing the common variation in uncertainty of all the aforementioned commodity markets. Moreover, in previous studies (Elder and Serletis, 2010; Jo, 2014; De et al., 2015; Elder, 2018; Tran, 2021), commodity price uncertainty is estimated either by the volatility of the price of West Texas Intermediate (WTI) crude oil, or a broad commodity price index, which might be driven significantly by fluctuations in oil prices. We overcome this issue by estimating a global commodity price uncertainty index which captures the dynamics that are common to all major commodity markets. Also, given the high heterogeneity on commodity asset classes our methodological approach enables to disentangle commodity group-specific uncertainty, i.e., agricultural, energy and metals price uncertainty, from global commodity price uncertainty. This allows us to observe the effect of each commodity price uncertainty group on the cost of bank loans, thereby providing detailed empirical evidence as to which specific group of commodity price uncertainty affects the cost of borrowing most.

After accounting for numerous borrowing firm-level, loan-level, and country-level characteristics, we find that commodity price uncertainty exerts a positive and significant effect on the cost of bank loans. This finding lends support to our H1 hypothesis that higher commodity price uncertainty increases the cost of bank credit. We also observe that the positive effect of commodity price uncertainty on the cost of credit is stronger for firms operating in developing/emerging countries. This result provides empirical evidence to our ***H2*** hypothesis. Next, we decompose the commodity price uncertainty variable into three components, which include agricultural price uncertainty, energy price uncertainty and metals price uncertainty. Our findings show that agricultural price uncertainty increases cost of credit more significantly for firms operating in developing countries, highlighting the important role of uncertainty of agricultural prices for borrowing firms operating in these countries. To uncover whether hedging plays a significant role in the relationship between commodity price uncertainty and the cost of bank loans, we split our sample of loans traced to firms locating in market-based economies and loans granted to firms locating in bank-based economies. We find that for loans granted to firms in bank-based countries the cost is significantly higher than for loans credited to firms in market-oriented countries.

In a further analysis, we run estimations where we divide borrowing firms into commodity dependent and non-commodity dependent firms based on their industry classification. Results show that commodity price uncertainty increases the cost of bank loans more for commodity dependent firms as opposed to non-commodity dependent firms. Moreover, this effect is stronger for loans traced to commodity dependent firms operating in developing/emerging countries. Also, our component analysis shows that agricultural price uncertainty exerts the most significant impact on the cost of bank loans, and this effect is significant for commodity dependent firms operating in developing/emerging countries Finally, we also observe if the relationship between commodity price uncertainty and the cost of bank loans, varies based on different borrowing firm's size classes. This analysis reveals that the positive effect of commodity price uncertainty on the cost of credit is enhanced for smaller firms as opposed to larger firms.

In addition, the positive relationship of commodity price uncertainty and cost of bank loans is robust to further tests. These include additional control variables that could be related to commodity price uncertainty, such as the level of commodity prices, geopolitical uncertainty, and economic policy uncertainty. In the component analysis, we control for the level of agricultural prices, energy prices and metal prices in models where we test for the effect of agricultural price uncertainty, energy price uncertainty, and metals price uncertainty respectively. As robustness test, we also run estimation with additional fixed effects and alternative ways of clustering standard errors (firm-level and country-level clustering).

The study contributes to the literature in several ways. The paper belongs to the emerging literature that focuses on the effects of unexpected changes of commodity prices on bank outcomes (Agarwal et al., 2020; Eberhardt and Presbitero, 2021). We are the first to examine the role of commodity price uncertainty on the cost of bank loans. We add to this literature by suggesting that commodity price uncertainty increases the cost of bank loans.

Secondly, we contribute to the literature that examines the effect of commodity price fluctuations in developing and advanced economies (Fernández et al., 2018; Ferrara et al., 2022). We complement this literature by suggesting that commodity price uncertainty increases the cost of bank credit more significantly for borrowing firms operating in developing/emerging countries.

Finally, we contribute to the literature that highlights the important role of agricultural price fluctuations in food security and growth of developing/emerging economies (Sarris et al., 2011; Amolegbe et al., 2021). We add to this literature by finding that agricultural price uncertainty significantly increases the cost of borrowing for commodity dependent firms operating in these countries.

The remainder of this paper proceeds as follows. Section 2 provides an overview of the literature. Section 3 presents the dataset along with the descriptive statistics, model specification and proposed methodology. Section 4 summarises the empirical results. Finally, section 5 concludes, offering policy recommendations considering the empirical findings.

2. Literature review and hypotheses development

Commodity price uncertainty could affect the cost of credit through two main channels. The first mechanism of transmission of the effect of commodity price uncertainty on the cost of bank loans could be through the firm-level channel. In early work, Bernanke (1983) finds that rising rate of oil price uncertainty increases the option value of waiting to invest and decreases investment incentive for firms, thereby reducing profitable opportunities. In similar vein, Bloom (2009) aligns with this finding by estimating the effects of uncertainty and establishing that higher uncertainty raises the real-option value of waiting, forcing firms to scale back their investment plans. Postponement of investment which might lead to loss of growth opportunities may also suggest decreased demand of loans for investment purposes. However, firms may continue borrowing for reasons other than investment, such as for adjusting corporate debt levels (Modigliani and Miller, 1958) or paying dividends to shareholders (Wruck, 1994). Since firms experience a drop in their earnings because of loss of profitable investments during periods of higher commodity price uncertainty, banks would charge higher loan spreads for granting loans to compensate for the higher risk of non-loan repayment.

The second channel through which commodity price uncertainty could affect the cost of bank loans could be through its effect on bank stability. As discussed above, increased uncertainty of commodity prices would lead to postponement of investment for firms due to the unpredictability for future movements of commodity prices and the fear of high losses. This postponement might lead to less profits for firms resulting into lower tax contributions and thus reduced government revenues. This, in turn, suggests that public sector would have a lower capability in serving loan payments to banking institutions deteriorating in that way banks' position (Eberhardt and Presbitero, 2021). Additionally, public sector may be unable to pay supplier services which may initiate once again negative impacts on banks' stability (Eberhardt and Presbitero, 2021). Also decrease in public earnings would trigger the need of government to raise public debt, increasing in that way banks holdings of government debt and the likelihood of a banking crisis (Balteanu and Erce, 2018; Sosa-Padilla, 2018). Consequently, the deterioration of the banking stability due to higher commodity price uncertainty would

prone banks to impose more stringent terms to their borrowers raising the loan spreads.

Based on the above discussion, we formulate our first, H1., hypothesis:

H1. Ceteris paribus, commodity price uncertainty increases the cost of borrowing.

Based on the extant literature, commodity price uncertainty would have a stronger positive effect on the cost of borrowing of firms located in developing/emerging countries as opposed to loans traced to firms operating in advanced countries. Firms in emerging and developing countries are more commodity-dependent, and in turn we expect that commodity price uncertainty would raise their cost of credit more as compared to firms in developed countries. Firms in commodity-dependent countries operate primarily in agriculture and extractive industries, producing commodity-dependent products, such as corn and wheat products (Andrén-Sandberg, 2017). Hence, firms' revenues in developing countries rely heavily on the predictability of commodity prices. Varangis and Larson (1996) argue that commodity price uncertainty has implications for the cost of credit of firms that invest on commodity-related projects, as banks are reluctant to finance firms because the loan repayment would be dependent on the uncertainty of commodity prices. Higher uncertainty of commodity prices renders commodity-dependent firms' revenues locating in developing countries less certain. Also, it is well-documented in the literature that firms use hedging strategies as it increases their corporate value, through a reduction of volatility in firm value and the estimated costs of financial losses (Smith and Stulz, 1985). Moreover, Chen and King (2014) find that hedging reduces firms' cost of debt due to lower bankruptcy costs (Smith and Stulz, 1985; Graham and Rogers, 2002), reduced underinvestment (Froot et al., 1993), less risk-shifting, (Campbell and Kracaw, 1990), and lower information asymmetry issues (DeMarzo and Duffie, 1991; DaDalt et al., 2002). However, firms in developing countries may use financial derivatives at a lower extent to hedge their risk due to the underdeveloped nature of financial markets. Consequently, they might be more exposed to the uncertainty of commodity prices compared to firms operating in developed countries. Price uncertainty is found to reduce investment and productivity growth in the absence of effective hedging practices (Ceballos et al., 2017). Therefore, the higher reliance of firms' revenues on commodity price uncertainty coupled with the lower use of effective corporate hedging practices render banks less willing in extending credit to firms locating in developing countries, forcing borrowers to pay additional costs to access banking lending by increasing borrowing cost. Hence, commodity price uncertainty would have a stronger negative effect on the cost of bank loan for firms locating in developing countries than firms operating in developed countries.

The stronger effect of commodity price uncertainty on the cost of bank loans for firms locating in developing/emerging countries as opposed to loans traced to firms operating in developed countries, could be also justified by the more pronounced negative effect that the uncertainty of commodity prices would have on banks' stability in developing countries. As discussed above, financial markets in developing countries are rather underdeveloped and hence banks might be hesitant in using financial derivatives to hedge their risk under tentative periods (Apanga et al., 2016). Recent international regulatory reforms, i.e., Basel II and III, encourage banks in developing countries to enhance their risk management strategies. However, the local environment that banks operate poses serious challenges against the effectiveness of these practices. For the development of suitable risk assessment techniques, banks in developing countries lack the sufficient resources, such as the infrastructure to trade a futures contract , access and quality risk data, that are required to conduct appropriate risk management practices. Hence, these frictions that banks in developing countries face, render the efficacy of bank hedging difficult (Stephanou and Mendoza, 2005). Consequently, banks in developing countries would have higher concentration risk as they could not transfer some or all of the risk to other parties through the use of financial derivatives, as opposed to banks in developed countries that may have easier access to financial instruments and thus could apply more effective risk management practices and reduce their concentration risk. There is empirical evidence to verify the negative effect of commodity price uncertainties on the stability of banks operating in developing/emerging countries. Eberhardt and Presbitero (2021) find that commodity price uncertainty increases the probability of banking crises and weakens balance sheets of banks locating in emerging countries. Hence, the above discussion shows that the banking sector in developing/emerging economies is more vulnerable to uncertainties of commodity prices compared to the banking sector of developed countries. This might push banks in developing economies to deteriorate lending terms more compared to banks in developed countries, thereby increasing more the cost of borrowing for borrowing firms.

Based on this, we formulate our second, ***H2***, hypothesis:

H2. *commodity price uncertainty raises firms' cost of borrowing in developing countries more than in developed countries.*

3. Data, descriptive statistics, and model specification

Our main econometric specification takes the following form:

$$Ln\ Spread_{\kappa\rho\varepsilon\tau} = a' + a_1 Commodity\ Price\ Uncertainty_{\tau} + a_2 Loan - level\ Controls_{\iota\tau} + a_3 Firm - level\ Controls_{\rho\tau} + a_4 Country - level\ Controls_{\varepsilon\tau} + u_{\kappa\rho\varepsilon\tau} \quad (1)$$

In Eq. (1), *Ln Spread* stands for the cost of a bank loan which is the natural logarithm of the spread over LIBOR plus the facility fee. The loan ι is granted to firm ρ by the lead bank κ in a given country ε and year τ. *Commodity Price Uncertainty* is the commodity price uncertainty measure that exhibits annual variation. We predict that the coefficient a_1 would be positive, denoting that increase of

Table 1
Definitions of variables and measurement details.

Variable	Definition	Source
Dependent variable		
Ln spread	Natural logarithm of the spread over LIBOR plus the facility fee.	DealScan
Main independent variable		
Commodity Price uncertainty	Annual commodity price uncertainty as estimated by following a DFM	Ferrara et al. (2022) study
Agricultural Price uncertainty	Annual agricultural price uncertainty as estimated by following a DFM	idem
Metals Price uncertainty	Annual metals price uncertainty as estimated by following a DFM	idem
Energy Price uncertainty	Annual energy price uncertainty as estimated by following a DFM	idem
Firm-level Characteristics		
Firm leverage	The ratio of total debt to total assets (multiplied by 100).	Compustat
Firm tangibility	The ratio of tangible assets to total assets (multiplied by 100).	idem
Firm profitability	The ratio of earnings before interest to sales	idem
Firm size	Log of total firm assets.	idem
Firm liquidity	Ratio of current assets to current liabilities.	idem
Loan-level Characteristics		
Loan maturity	Log of loan duration in months.	DealScan
Covenant	Dummy variable equal to one if the firm uses general covenants in its loan deals and zero otherwise	idem
Secured	Dummy variables equal to one if the loan has collateral and zero otherwise	idem
Loan size	Log of loan amount in millions	idem
Country-level Characteristics		
GDP growth	Annual GDP growth rate.	IMF
Population	Counts all residents regardless of legal status or citizenship.	idem

Notes: the table provides the list, definitions and sources of all the variables used in our baseline analysis.

Table 2
List of countries.

Advanced Countries		Developing/Emerging Countries		
Australia	Iceland	Argentina	Nigeria	Virgin Islands (British)
Austria	Ireland	Bangladesh	Oman	Zambia
Belgium	Israel	Cayman Islands	Panama	
Canada	Italy	Chile	Peru	
Croatia	Japan	China	Philippines	
Cyprus	Kuwait	Egypt	Qatar	
Czech Republic	Lithuania	Georgia	Russian Federation	
Slovenia	Luxembourg	Ghana	Saudi Arabia	
South Korea	Malta	Hong Kong	South Africa	
Denmark	Netherlands	India	St. Lucia	
Finland	United Kingdom	Indonesia	Thailand	
France	New Zealand	Jordan	Trinidad and Tobago	
Germany	Norway	Kazakhstan	Tunisia	
Spain	Poland	Laos	Turkey	
Sweden	Portugal	Liberia	Ukraine	
Switzerland	Romania	Macao	United Arab Emirates	
Greece	Singapore	Malaysia	Venezuela	
Hungary	Slovakia	Mexico	Vietnam	

Notes: the table shows the list of countries in our dataset and classifies them into advanced countries and developing/emerging countries using the United Nations Conference on Trade and Development (UNCTDA) classification.

Commodity Price Uncertainty increases the cost of bank loans. *Loan − level Controls*, *Firm − level Controls*, and *Country − level Controls* are loan, borrowing firm, and country control variables that may influence the *Ln Spread*. In turn, a' stands for a vector of fixed effects including firm, regional, country, loan purpose and loan type fixed effects.[2] Lastly, u stands for the error.

We source data on loans from DealScan, which is the most complete database of loan deals on the global lending markets. All loan deals are in US dollars. We exclude all loans for which there is no spread. Our final dataset includes 4255 syndicated loans, 951 borrowing firms and 74 countries, comprised by 36 advanced countries and 38 developing/emerging countries. We group countries into developed and developing/emerging economies following United Nations Conference on Trade and Development (UNCTDA) classification.[3]

We match loan-level data with firm-level data from Compustat using the GVKEY firm identifier. This matching process is critical for

[2] Regional fixed effects include the following list of regions: i) Asia Pacific, ii) Latin America/Caribbean, iii) Western Europe, iv) Africa, v) Eastern Europe/Russia, vi) Middle East.

[3] In robustness tests, we classify countries following World Bank classification. Results are similar and available upon request.

Table 3
Summary statistics.

	N	Mean	p25	Median	p75
Ln spread	4255	4.96	4.382	5.075	5.617
Commodity Price Uncertainty	4255	.007	−.008	−.001	.013
Agricultural Price Uncertainty	4255	.007	−.008	−.002	.02
Energy Price Uncertainty	4255	−.007	−.016	−.005	.002
Metals Price Uncertainty	4255	.003	−.012	−.005	.013
Firm leverage	4255	.12	.011	.068	.186
Firm tangibility	4255	.432	.138	.362	.649
Firm profitability	4255	.167	.069	.138	.267
Firm size	4255	6.275	4.684	6.081	7.731
Firm liquidity	4255	.322	.018	.064	.233
Loan maturity	4255	3.848	3.547	4.094	4.43
Covenant	4255	.06	0	0	0
Secured	4255	.286	0	0	1
Loan size	4255	6.492	5.193	6.301	7.623
GDP growth	4255	2.234	0	3.328	4.838
Population	4255	16.719	15.628	16.922	17.895

Notes: the table shows the summary statistics of the main variables used in the empirical analysis, showing the number of observations, mean, 25th percentile, median and 75th percentile. Our dataset covers the period 1990–2019.

determining the financial variables of firms that may impact the cost of bank loans. We next match the dataset to country-level macroeconomic variables from the International Monetary Fund (IMF) database. Table 1 presents the list of countries included in our dataset. Table 2 presents definitions of variables and measurement details. Table 3 presents summary statistics and Table 4 shows correlations for the variables included in our baseline regressions.

3.1. Measuring commodity price uncertainty

We follow the standard approach in the literature by using the nearest maturity commodity futures, which are sound proxies for the underlying commodity spot prices. In particular, we obtain daily data for the GSCI nearby commodity futures prices for major agricultural (corn, cotton, soybeans, wheat), metals (copper, gold, silver, platinum) and energy (crude oil, heating oil, petroleum, gasoline). Our commodity futures dataset spans the period from January 1, 1990 to December 31, 2019. Following the approach commonly used in the uncertainty literature (Bloom, 2009; Elder and Serletis, 2010; Jo, 2014), we proxy for uncertainty in major agricultural, metals and energy markets as the volatility of the daily price returns of the respective commodity futures markets. We estimate commodity price uncertainty for any commodity i, for $i = 1, \ldots, n$, as the quarterly realized variance of the daily returns of the commodity prices according to equation (2) for a given quarter t:

$$COMRV_{i,t} = \frac{1}{T}\sum_{d=1}^{T}\left(r_{t,d} - r\right)^2 \times 252 \tag{2}$$

where $r_{t,d}$ are the daily log-returns of any commodity i within the quarter t and r is the average commodity price return within the quarter. The realized variances $RV_{i,t}$ are multiplied by 252 in order to be annualized. Note also that we reject the hypothesis of a unit root for all the commodity RV series.[4]

3.1.1. Dynamic factor model

For the estimation of global, agricultural, metals and energy price uncertainty we follow the approach of Ferrara et al. (2022) who estimate a Bayesian Dynamic Factor Model (DFM henceforth) capturing co-movement in commodity price uncertainty series. Our latent factor approach is extensively used in the literature for the estimation of latent (unobservable) factors capturing comovement between macroeconomic or financial time series (Kose et al., 2003; Jurado et al., 2015; Karadimitropoulou, and León-Ledesma, 2013; Delle Chiaie et al., 2022; Ferrara et al., 2022). Our objective is to extract a common component from the set of COMRV series, while accounting for commodity group-specific uncertainty, namely the agricultural (corn, cotton, soybeans, wheat), metals (copper, gold, silver, platinum) and energy (crude oil, heating oil, petroleum, gasoline) price uncertainty.[5] This model is able to extract latent factors capturing (i) the global co-movement in commodity price uncertainty and (ii) the specific co-movements in the Realized Variance (COMRV) of agricultural, energy and metals commodity price returns, respectively. The estimation of the DFM is carried out from 1990Q1 to 2019Q4.

Our dataset consists of a panel of n = 12 demeaned COMRV series ($COMRV_{i,t}$) for $i = 1, \ldots, n$. Our series can be described by the following DFM with commodity-specific groups:

[4] The descriptive statistics along with the ADF unit root tests for the quarterly realized variances of agricultural, metals and energy commodity futures can be available upon request.

[5] This DFM with groups has been put forward by Kose et al., 2003 with an application in international business cycle synchronisation.

Table 4
Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Ln spread	1.000															
(2) Commodity Price Uncertainty	0.040	1.000														
(3) Agricultural Price Uncertainty	0.048	0.773	1.000													
(4) Energy Price Uncertainty	−0.033	−0.588	−0.463	1.000												
(5) Metals Price Uncertainty	0.015	0.767	0.310	−0.736	1.000											
(6) Firm leverage	0.003	0.041	0.023	−0.019	0.041	1.000										
(7) Firm tangibility	−0.002	−0.049	−0.008	−0.008	−0.040	−0.320	1.000									
(8) Firm profitability	−0.022	−0.010	−0.014	−0.026	0.015	0.136	0.073	1.000								
(9) Firm size	−0.058	−0.043	−0.027	0.019	−0.025	−0.309	0.182	0.148	1.000							
(10) Firm liquidity	−0.019	−0.020	−0.018	0.046	−0.043	−0.136	−0.015	−0.096	0.007	1.000						
(11) Loan maturity	−0.017	−0.003	−0.013	−0.043	0.026	0.000	0.000	0.015	0.039	0.019	1.000					
(12) Covenant	0.041	0.014	0.030	−0.003	−0.007	0.052	−0.019	−0.026	−0.021	−0.029	0.032	1.000				
(13) Secured	0.038	0.003	0.013	0.013	−0.001	−0.008	−0.018	−0.044	0.027	−0.012	0.258	0.147	1.000			
(14) Loan size	−0.014	0.084	0.103	−0.080	0.067	0.029	0.015	−0.001	0.013	−0.018	−0.107	−0.037	−0.142	1.000		
(15) GDP growth	−0.011	0.047	0.024	0.010	0.013	−0.001	0.048	−0.007	0.007	−0.022	0.007	0.009	0.050	0.017	1.000	
(16) Population	0.047	−0.039	−0.041	0.039	−0.033	0.051	−0.061	0.048	−0.033	−0.052	0.048	−0.018	0.019	−0.187	−0.063	1.000

Notes: the table shows the correlation matrix of the variables used in our main analysis.

Table 5
The effect of Commodity Price Uncertainty on the Cost of Credit.

	Full Sample				Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.296***	1.28***	1.275***	1.268***	1.503***	.53
	(3.779)	(3.638)	(3.53)	(3.724)	(2.763)	(.976)
Firm leverage		−.155	−.158	−.158	.171	−.227
		(-1.06)	(-1.075)	(-1.085)	(.578)	(-1.171)
Firm tangibility		.013	.018	.019	−.11	−.013
		(.15)	(.194)	(.211)	(-.839)	(-.097)
Firm profitability		−.197**	−.192**	−.194**	−.449**	−.231***
		(-2.755)	(-2.69)	(-2.734)	(-2.225)	(-3.22)
Firm size		−.026	−.03	−.028	−.025	−.018
		(-.963)	(-1.139)	(-1.104)	(-.62)	(-.545)
Firm liquidity		.057*	.057*	.057*	.033	.057
		(1.996)	(2.048)	(1.993)	(.689)	(1.642)
Loan maturity			−.037**	−.038**	−.087***	−.023
			(-2.566)	(-2.563)	(-4.059)	(-1.386)
Covenant			−.057	−.056	−.053	−.043
			(-.77)	(-.753)	(-.324)	(-.561)
Secured			.069**	.07**	.042	.099**
			(2.178)	(2.198)	(.616)	(2.392)
Loan size			.014*	.014*	.036**	.02
			(1.856)	(1.843)	(2.214)	(.034)
GDP growth				−.002	−.006	−.002
				(-.826)	(-.804)	(-1.16)
Population				−.066	.29	−.241
				(-.32)	(.893)	(-1.013)
Constant	4.951***	5.141***	5.2***	6.291*	.349	9.294**
	(633.014)	(27.826)	(22.107)	(1.817)	(.064)	(2.344)
Observations	4255	4255	4255	4255	1315	2864
R-squared	.784	.785	.786	.786	.797	.817
Firm FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y

Notes: the table reports the effects of commodity uncertainty on the cost of credit over the period 1990–2011 using annual loan data. The dependent variable is the Loan spread (LN Spread), The main independent variable is commodity price uncertainty. Column 1 include only the commodity price uncertainty and a different set of fixed effects, in column 2 we add firm-level control variables, column 3 we add loan-level control variables, and column 4 we add country-level control variables. Column 5 focuses on the effect of commodity price uncertainty on cost of credit operating for firms operating in developing/emerging economies, while column 6 reports estimation for loans traced to firms operating in advanced countries. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

$$COMRV_{i,t} = \beta_i^C F_t^C + \beta_i^G F_{g,t}^G + \varepsilon_{i,t} \tag{3}$$

where F^C represents the common uncertainty commodity factor and F^G is a vector of 3 group-specific uncertainty commodity factors. Hence, the estimated (latent) factor F_t^C is our measure for global commodity price uncertainty, capturing the comovement in uncertainty of 12 major global agricultural, metals and energy markets used in our sample, with our second estimated (latent) factor $F_{g,t}^G$ capturing the uncertainty comovement for each commodity group, generating the latent agricultural, metals and energy price uncertainty series. Coefficients β_i^C and β_i^G are respectively the factor loadings measuring the impact of each commodity price uncertainty series i on the common factor and commodity group-specific factor. Finally, $\varepsilon_{i,t}$ the error term is zero-mean and normally distributed allowing for autocorrelation, while assuming the absence of cross-sectional correlation at all leads and lags. The error term is supposed to follow an AR(3) process since these dynamics are sufficient to whiten residuals as shown below:

$$\varepsilon_{i,t} = \sum_{l=1}^{p} \varphi_{i,l} \varepsilon_{i,t-l} + \varepsilon_{i,t} \tag{4}$$

The error term captures the fluctuation in uncertainty which is idiosyncratic (not common to all commodity markets, neither to commodity groups). The two latent factors, F^C and F^G follow an AR(3) process with their dynamics being characterized by short-term memory, such as[6]:

[6] In order to conclude that the AR(3) process is adequate to capture the dynamics of the latent factors, we have proceeded to AR test, and have seen that the AR(3) model suffices to describe the dynamics of individual agricultural, metals and energy price uncertainty series. These results can be provided upon request.

$$F_t^C = \sum_{l=1}^{p} \varphi_l^C F_{t-1}^C + v_t^C \tag{5}$$

$$F_{g,t}^G = \sum_{l=1}^{p} \varphi_{g,l}^G F_{g,t-1}^G + v_{g,t}^G \tag{6}$$

where $v_t^C, v_{g,t}^G \sim N(0, \sigma_C^2)$ and $N(0, \sigma_{g,G}^2)$ respectively. Finally, the innovations $\varepsilon_{c,t}$, v_t^C, and $v_{g,t}^G$, are mutually orthogonal across all equations in the system.

The model described by equations (3)–(6) is estimated with the Bayesian approach using Gibbs sampling, which is a Markov Chain Monte Carlo (MCMC) method for approximating joint and marginal distributions by sampling from conditional distributions. For more details on the MCMC approach see Ferrara et al. (2022) and Kose et al., 2003.

From equations (3)–(6), we obtain the F^C, our common *Commodity Price Uncertainty* factor, and the F^G, the commodity-group specific uncertainty factors, namely the *Agricultural Price Uncertainty*, *Energy Price Uncertainty* and *Metals Price Uncertainty* factors. Those factors are then used in the econometric analysis. Since our syndicated loan dataset has yearly frequency, our measure for yearly commodity price uncertainty is the average of the quarterly commodity price uncertainty series.

3.2. Loan-level, firm-level and country-level control variables

The dependent variable in our analysis is the *Ln spread*, which is the natural logarithm of the spread over LIBOR plus the facility fee. The *Ln spread* is used as a proxy of the cost of bank loans in the vast majority of literature (Ivashina, 2009; Bharath et al., 2011; Hasan et al., 2014; Lin et al., 2018). We anticipate several loan-level characteristics that could affect the cost of bank loans following other studies (see e.g. Bharath et al., 2011). Specifically, (i) we control for the duration of the loan (Loan maturity), which is the natural logarithm of loan duration in months, (ii) we include a dummy variable denoting if the loan has general covenants (Covenant), (iii) we add a dummy variable describing if the loan has collateral (Collateral), (iv) and we account for the loan size of the loan (Loan Size) which is the natural logarithm of loan size in million dollars. We also use several firm-level variables that could affect the cost of bank loans following previous studies (Graham et al., 2008; Kim et al., 2013; Hasan et al., 2014; Lian, 2018, among others). These include (i) the firm leverage, which is the ratio of total debt to total assets; (ii) the firm tangibility calculated as the ratio of tangible assets to total assets; (iii) the firm profitability, which stands for the ratio of earnings before interest to sales; (iv) firm size, which is the natural logarithm of total firm assets; and (v) the firm liquidity, calculated as current assets to current liabilities.

Also, we control for variables that proxy for current economic conditions, to minimize the probability that commodity price uncertainty captures other country-specific characteristics found at the country-year level. Firstly, we use GDP growth as there is previous evidence showing that crude oil volatility is associated with lower investment, decreased GDP growth and higher likelihood of economic recession (Elder, 2018; Nguyen et al., 2021). Also, GDP growth which is a proxy for the level of economic activity in an economy (Altavilla, 2004) is found to have an impact on bank credit (Saif-Alyousfi et al., 2021). We also include population (*Population*) that is employed in earlier studies (Wolswijk, 2006; Badev et al., 2014) as an additional country-level determinant of bank financing.

4. Empirical findings

4.1. Baseline regressions (H1 and H2)

Table 5 presents the baseline estimations regarding our two main hypotheses: the effect of commodity price uncertainty on the cost of credit (H1), and the effect of commodity price uncertainty on the cost of credit of borrowing firms operating in advanced countries vis-à-vis firms operating in developing/emerging economies (***H2***). We employ ordinary least squares (OLS) with robust standard errors. We use within year clustering for our baseline estimations as our primary variable of interest, the commodity price uncertainty variable, varies across time (Smith et al., 2016). We also employ a battery of fixed effects, including country, region, borrowing firm, loan purpose and loan type fixed effects. Our regression models show a good fit with an adjusted R^2 of 78% on average. In model 1 of Table 5 we include in the estimation only the *Commodity Price Uncertainty* variable, in model 2 we add the firm-level control variables, in model 3 we augment the estimation by including the loan-level characteristics and in model 4, we employ the full specification by including the country-level control variables as well. The coefficients of the *Commodity Price Uncertainty* variable are positive (1.296, 1.28, 1.275, 1.268) and significant at the 1% level in models 1–4 of Table 5. These findings lend support to our H1 hypothesis that borrowing firms' cost of borrowing increases when *Commodity Price Uncertainty* increases. This finding might be due to the dampening effects of rising uncertainty of commodity prices on firms' investment (Bernanke, 1983; Bloom, 2009). Borrowing firms might postpone profitable investments under periods of rising commodity price uncertainty due to the increase in the real-option value of waiting (Bernanke, 1983), which in turn may reduce their profits and their loan repayment capacity. Reduction in investment might lead to a decrease in the demand for loans for investment purposes, but firms may continue to lever due to other reasons such as adjusting their debt ratio or paying dividends to their shareholders (Modigliani and Miller, 1958; Wruck, 1994). Given that increasing commodity price uncertainty might reduce firms' revenues due to a decrease of undertaking profitable investments, banks would be less reluctant to lend and hence they would charge higher borrowing costs to compensate for the higher risk of extending credit to firms with lower loan repayment capability.

In the next two models of Table 5, we run baseline estimations to observe the impact of commodity price uncertainty on the cost of borrowing for firms operating in developing/emerging economies compared to the cost of credit for firms operating in advanced countries. In model 5, we run the full specification on the effect of *Commodity Price Uncertainty* on the cost of credit for borrowing firms

Table 6
The effect of Commodity Price Uncertainty on the Cost of Credit: Component Analysis.

	Full Sample			Developing	Advanced	Developing	Advanced	Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Agricultural Price Uncertainty	1.772***			2.029***	.642				
	(3.246)			(2.765)	(.851)				
Energy Price Uncertainty		−2.298**				−2.605	−1.069		
		(-2.172)				(-1.463)	(-.765)		
Metal Price Uncertainty			.961**					1.562*	.287
			(2.324)					(1.77)	(.511)
Firm leverage	−.166	−.166	−.159	.147	−.226	.155	−.226	.157	−.223
	(-1.154)	(-1.123)	(-1.089)	(.504)	(-1.17)	(.54)	(-1.152)	(.541)	(-1.151)
Firm tangibility	.015	.008	.008	−.124	−.015	−.129	−.016	−.114	−.018
	(.16)	(.083)	(.082)	(-.956)	(-.113)	(-.965)	(-.121)	(-.838)	(-.136)
Firm profitability	−.187**	−.21***	−.206***	−.446**	−.228***	−.431**	−.24***	−.439**	−.237***
	(-2.656)	(-2.903)	(-2.878)	(-2.208)	(-3.199)	(-2.137)	(-3.374)	(-2.18)	(-3.357)
Firm size	−.028	−.028	−.029	−.023	−.018	−.023	−.02	−.027	−.019
	(-1.099)	(-1.112)	(-1.153)	(-.59)	(-.549)	(-.58)	(-.585)	(-.658)	(-.55)
Firm liquidity	.057*	.056*	.057*	.032	.057	.035	.056	.035	.057
	(2.011)	(1.989)	(1.972)	(.677)	(1.641)	(.738)	(1.634)	(.733)	(1.631)
Loan maturity	−.037**	−.038**	−.038**	−.085***	−.023	−.089***	−.023	−.089***	−.023
	(-2.516)	(-2.528)	(-2.498)	(-3.9)	(-1.385)	(-4.024)	(-1.381)	(-4.075)	(-1.373)
Covenant	−.057	−.051	−.05	−.052	−.043	−.06	−.04	−.052	−.04
	(-.77)	(-.705)	(-.694)	(-.319)	(-.563)	(-.369)	(-.533)	(-.327)	(-.54)
Secured	.068**	.073**	.071**	.039	.099**	.038	.101**	.043	.1**
	(2.152)	(2.3)	(2.266)	(.589)	(2.387)	(.553)	(2.444)	(.616)	(2.415)
Loan size	.015*	.015*	.015**	.035**	.001	.038**	.002	.037**	.001
	(1.971)	(1.977)	(2.055)	(2.186)	(.079)	(2.352)	(.043)	(2.323)	(.077)
GDP growth	−.002	−.002	−.002	−.006	−.002	−.006	−.002	−.006	−.002
	(-.779)	(-.712)	(-.757)	(-.771)	(-1.146)	(-.776)	(-1.043)	(-.778)	(-1.111)
Population	−.088	−.108	−.109	.273	−.26	.257	−.261	.267	−.273
	(-.434)	(-.516)	(-.51)	(.841)	(-1.112)	(.798)	(-1.032)	(.82)	(-1.096)
Constant	6.648*	6.999*	7.019*	.614	9.594**	.876	9.626**	.738	9.82**
	(1.943)	(1.977)	(1.952)	(.113)	(2.458)	(.163)	(2.291)	(.135)	(2.374)
Observations	4255	4255	4255	1315	2864	1315	2864	1315	2864
R-squared	.786	.786	.786	.796	.816	.796	.816	.796	.816
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of the three components of commodity price uncertainty, i.e., agricultural, energy and metals, price uncertainty, on the cost of credit. Models 1–3 report estimations including the full sample, Models 4,6,8 include estimations for firms operating in developing/emerging economies, and Models 5,7,9 present results for loans traced to firms operating in advanced economies. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

operating in the developing/emerging countries. We find that the effect is positive and significant at the 1% level. In model 6, we repeat the same estimation for firms operating in advanced countries. We observe a positive effect of *Commodity Price Uncertainty* on the cost of credit of firms that operate in advanced economies, albeit the result is statistically weaker. Based on the coefficient of the commodity price uncertainty of model 5 of Table 5 (1.5), our results show, from an economical point of view, that one standard deviation (0.4) increase in the commodity price uncertainty results to a 1.79 basis points increase in bank loan spreads ($1.79 = e^{1.5}*0.4$). An alternative way to understand economically the importance of these findings is by calculating the interest rate costs based on the average size of the loan in our sample ($659 million) and the average loan maturity time (3.85 years). According to our estimates, a one standard deviation increase in commodity price uncertainty suggests around $0.45 million in interest rate costs ($0.45 = 659*0.000179*3.85$). The above findings provide support to the ***H2*** hypothesis, which posits that the effect of commodity price uncertainty is stronger for firms operating in developing/emerging as opposed for firms operating in advanced economies. This could be justified by the stronger negative effect that commodity price uncertainty has on the banking sector stability in developing/emerging countries compared to the effect it has on banks locating in advanced countries. Banks in developing/emerging countries have lower access to financial derivatives due to the underdeveloped nature of financial markets which in turn suggests that they have less effective hedging strategies (Apanga et al., 2016). Also, banks in these countries lack appropriate risk management techniques due to inefficient resources, i.e., risk management expertise and access to high quality risk data (Stephanou and Mendoza, 2005). All in all, these frictions render banks in developing countries to have higher concentration risk and be more vulnerable to commodity price uncertainties compared to banks in developed countries. Hence, the former would impose more stringent lending terms to borrowing firms, charging higher loan spreads. In addition, our findings regarding the firm-level and loan-level control variables are in line with previous studies (Graham et al., 2008; Bharath et al., 2011).

Table 7
The effect of Commodity Price Uncertainty on the Cost of Credit: Bank-based vis a vis Market based economies.

	Bank-based	Market-based	Bank- based/Developing				Bank-based/Advanced			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.55***	.735	1.403**				.996			
	(3.489)	(1.3)	(2.463)				(.863)			
Agricultural Price Uncertainty				2.029**				.936		
				(2.665)				(.638)		
Energy Price Uncertainty					−2.605				−1.331	
					(-1.463)				(-.533)	
Metals Price Uncertainty						1.462				.436
						(1.67)				(.411)
Firm leverage	.045	−.082	.171	.147	.155	.157	.146	.128	.146	.154
	(.317)	(-.301)	(.578)	(.504)	(.54)	(.541)	(.52)	(.447)	(.522)	(.555)
Firm tangibility	.024	.148	−.11	−.124	−.129	−.114	−.011	−.016	−.002	−.011
	(.226)	(1.28)	(-.839)	(-.956)	(-.965)	(-.838)	(-.064)	(-.09)	(-.012)	(-.064)
Firm profitability	−.249**	−.113	−.449**	−.446**	−.431**	−.439**	−.227**	−.217**	−.235**	−.231**
	(-2.709)	(-.778)	(-2.225)	(-2.208)	(-2.137)	(-2.18)	(-2.602)	(-2.506)	(-2.516)	(-2.599)
Firm size	−.048	.018	−.025	−.023	−.023	−.027	−.045	−.047	−.049	−.049
	(-1.379)	(.547)	(-.62)	(-.59)	(-.58)	(-.658)	(-.568)	(-.597)	(-.64)	(-.636)
Firm liquidity	.051	.074	.033	.032	.035	.035	.061	.062	.059	.06
	(1.462)	(1.526)	(.689)	(.677)	(.738)	(.733)	(1.066)	(1.055)	(1.014)	(1.035)
Loan maturity	−.036*	−.033	−.087***	−.085***	−.089***	−.089***	.002	.003	.004	.004
	(-1.989)	(-1.429)	(-4.059)	(-3.9)	(-4.024)	(-4.075)	(.071)	(.092)	(.114)	(.128)
Covenant	−.111	−.002	−.053	−.052	−.06	−.052	−.129	−.13	−.127	−.125
	(-1.111)	(-.017)	(-.324)	(-.319)	(-.369)	(-.327)	(-1.194)	(-1.195)	(-1.184)	(-1.166)
Secured	.115**	.02	.042	.039	.038	.043	.233***	.231***	.231***	.23***
	(2.768)	(.359)	(.616)	(.589)	(.553)	(.616)	(2.942)	(2.899)	(3.086)	(2.97)
Loan size	.017	−.001	.036**	.035**	.038**	.037**	−.012	−.01	−.011	−.011
	(1.497)	(-.166)	(2.214)	(2.186)	(2.352)	(2.323)	(-.75)	(-.678)	(-.694)	(-.697)
GDP growth	−.004	−.001	−.006	−.006	−.006	−.006	−.001	−.001	−.001	−.001
	(-.569)	(-1.109)	(-.804)	(-.771)	(-.776)	(-.778)	(-.132)	(-.159)	(-.101)	(-.111)
Population	−.022	−.197	.29	.273	.257	.267	−.135	−.183	−.18	−.192
	(-.075)	(-.647)	(.893)	(.841)	(.798)	(.82)	(-.328)	(-.458)	(-.425)	(-.456)
Constant	5.571	8.307	.349	.614	.876	.738	7.552	8.368	8.329	8.533
	(1.121)	(1.672)	(.064)	(.113)	(.163)	(.135)	(1.062)	(1.209)	(1.138)	(1.177)
Observations	2716	1417	1315	1315	1315	1315	1358	1358	1358	1358
R-squared	.788	.862	.797	.796	.796	.796	.812	.812	.812	.812
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of commodity price uncertainty on the cost of credit for commodity dependent firms, split between bank-based and market-based economies. Models 1,2 report estimations including the full sample, Models 3–6 include estimations for firms operating in developing/emerging bank-based economies, and Models 7–10 present results for loans traced to firms operating in advanced bank-based economies. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

4.2. Component analysis

In this section, we run estimations whereby we employ the three components of commodity price uncertainty and observe the effect of each component on the cost of credit. The three components of commodity price uncertainty variable are: i) the agricultural commodity price uncertainty, ii) the energy commodity price uncertainty and iii) the metals commodity price uncertainty component. We do this test to comprehend in more detail the individual effect of each of the components of the commodity price uncertainty index. This will enrich our understanding in terms of the association of each commodity price uncertainty component with the cost of credit. Models 1–3 of Table 6 report the findings of these estimations. We run OLS regressions with fixed effects as in our baseline estimations. In model 1 of Table 6, we observe the effect of *Agricultural Price Uncertainty* on the cost of borrowing. We find that the effect is positive and significant at the 1% level. In model 2 of Table 6, we report findings of the effect of *Energy Price Uncertainty* on the cost of credit. We see that energy price uncertainty exerts a negative and significant at the 5% level effect on loan spreads. In model 3 of Table 6, we show that the *Metals Price Uncertainty* exerts a positive and significant at the 5% level effect on the cost of borrowing. Altogether, from a component analysis point of view the above findings show that increases of both agricultural and metal price uncertainty results to increase of the cost of credit. These findings are in line with our previous estimations and further enrich our understanding that the positive effect of commodity price uncertainty on the cost of credit is driven primarily by the uncertainties on the agricultural and metal prices. On the other hand, we observe that energy price uncertainty reduces the cost of credit. The reduction of cost of credit

followed by rising energy price uncertainty is in line with the literature showing the positive short-run effects of energy price uncertainty via the 'growth option' channel (Bloom, 2009). Rising energy price uncertainty may increase earnings of firms through new investment opportunities that are undertaken today due to the fear of further increases in energy prices in the future. Punzi (2019) provides empirical evidence verifying the above theoretical argument, by showing that energy price uncertainty has an expansionary short-run effect on the GDP growth of major Asian economies, thereby suggesting increased firm earnings in the short-run. Hence, banks may charge lower loan spreads to firms that might increase their profitability under periods of higher energy price uncertainty.

Next, we repeat these estimations based upon the development status of countries, whereby borrowing firms operate. These estimations are available in models 4–9 of Table 6. In model 4 of Table 6, we examine the effect of *Agricultural Price Uncertainty* on the cost of credit for firms operating in developing countries. We find that the effect is positive and significant at the 1% level. In model 5 of Table 6, we repeat the estimation for the firms operating advanced countries. We still observe that the effect is positive but is not statistically robust. In models 6–7 of Table 6, we present the findings from the effect of *Energy Price Uncertainty* on the cost of borrowing for firms operating in developing countries and firms operating in developed countries respectively. In both models, we find that *Energy Price Uncertainty* exerts a negative impact on loan spreads, albeit the results are not statistically strong. In models 8–9 of Table 6, we run estimations whereby we employ *Metals Price Uncertainty*, and we observe its effect on cost of borrowing for both samples, i.e., loans traced to firms operating in developing/emerging economies, and loans granted to firms operating in advanced countries. In model 8 of Table 6, we find that the *Metals Price Uncertainty* exerts a positive and significant effect at the 10% level on the cost of borrowing for firms operating in developing countries. In model 9 of Table 6, we repeat the same estimation using corporate loans for firms operating in developed countries and we find similar results, but they are not statistically strong. Overall, the above sub-sample analysis shows that agricultural price uncertainty increases the cost of credit more significantly for the sample of firms operating in developing countries compared to firms operating in developed countries. This might be justified since firms operating in developing/emerging countries rely heavily in terms of revenues on agriculture price uncertainties. Gilbert and Morgan (2010) find that uncertainty of grain prices affects more developing countries as opposed to developed economies. In developing countries uncertainty of agricultural product prices poses serious threats to smallholder farmer producers who are concerned about their revenues falling below the production cost and hence they limit their production (Rezitis and Stavropoulos, 2010). Thus, firms in developing countries are more exposed to agricultural price uncertainty compared to firms operating in advanced countries, and hence the former might experience a sharper decrease in their revenues as compared to the latter firms. Moreover, firms and banks locating in developing economies might use at a lower-level financial derivatives to hedge the risk from rising agricultural price uncertainty due to the underdeveloped nature of financial markets. Consequently, banks charge higher loans spreads to loans traced to firms operating in developing/emerging countries compared to loans granted to firms operating in advanced countries during periods of higher agricultural price uncertainty.

4.3. Bank-based financial structures vis-à-vis market-based financial structures

In our baseline estimations we find that commodity price uncertainty increases the cost of bank loans more significantly for firms in developing countries as opposed for firms locating in developed countries. As discussed in the hypothesis section, there are important differences in the use and effectiveness of hedging for firms and banks locating in developing/emerging countries as opposed to firms and financial institutions operating in developed countries. To further examine whether hedging play an important role in our study, we split our sample between market-based and bank-oriented economies. Market-based economies have well-developed financial stock markets that firms and banks could use to ease risk management and hedging effectiveness *-market based view-* (Levine, 1991; Obstfeld, 1994). On the contrary, bank-oriented structures offer to a large extent traditional deposit-taking operations, while financial markets play a less prominent role in the economy limiting the ability of firms and banks to hedge the risk induced from uncertainties in commodity prices. Hence, we expect that firms/banks locating in countries with a market-based structure would benefit more from the facilitation of hedging practices during periods of high commodity price uncertainty as compared to firms/banks locating in bank-based financial systems. This, in turn, would be translated into lower borrowing costs for the former borrowing firms. To this end, we proceed with estimations whereby we split our sample into loans granted to firms operating in bank-based financial systems vis-à-vis loans granted to firms operating in market-based financial systems. Table 7 presents results from this analysis.

Following previous studies (Beck and Levine, 2002; Tan et al., 2015), we classify our sample of countries into market-based and bank-based economies using the ratio of market capitalisation over the loans to the private sector. We split our sample based on the median value of the financial structure measure, denoting countries above the median as market-based economies and the countries with values below the median as bank-based countries. In model 1 of Table 7, we report findings of the effect of commodity price uncertainty (*Commodity Price Uncertainty*) on the cost of credit for loans traced to firms that locate in countries that have a bank-oriented financial structure. The results show that commodity price uncertainty (*Commodity Price Uncertainty*) exerts a positive and significant at the 1% effect on the cost of bank loans. In model 2 of Table 7, we repeat the estimation using only the sample of loans traced to firms that operate in countries that have a market-based financial system. The findings show that commodity price uncertainty (*Commodity Price Uncertainty*) exerts a positive effect on cost of borrowing, but the results are not statistically significant. These findings lend support to our conjecture and further highlight the importance of hedging for corporations and financial institutions in withstanding the negative effects of commodity price uncertainties. Next, we use the bank-based financial structure subsample and split it in loans traced to firms operating in developing as opposed to loans granted to firms operating in developed countries (Model 3 and 7 respectively). In model 3 of Table 7, we find that commodity price uncertainty (*Commodity Price Uncertainty*) has a positive and significant at the 1% level effect on the cost of borrowing for firms that operate in developing bank-oriented economies. In model 7 of Table 7, the effect of commodity price uncertainty (*Commodity Price Uncertainty*) on cost of bank loans is positive, albeit not statistically important. The results imply that the exposure of firms is higher in bank-based developing/emerging economies compared to

Table 8
The effect of Commodity Price Uncertainty on the Cost of Credit of commodity dependent firms.

	Full Sample	Developing	Advanced
	(1)	(2)	(3)
	Ln spread	Ln spread	Ln spread
Commodity Dependence	.023	.072	.023
	(.586)	(.822)	(.468)
*Commodity Price Uncertainty*Commodity Dependence*	1.957***	3.634***	.234
	(3.107)	(3.036)	(.219)
Firm leverage	−.195	.055	−.236
	(-1.39)	(.21)	(-1.212)
Firm tangibility	−.011	−.149	−.016
	(-.118)	(-.971)	(-.11)
Firm profitability	−.22**	−.465**	−.258***
	(-2.762)	(-2.071)	(-3.092)
Firm size	−.037	−.046	−.039
	(-.963)	(-.758)	(-.722)
Firm liquidity	.065**	.045	.058
	(2.247)	(.955)	(1.669)
Loan maturity	−.035**	−.079**	−.026
	(-2.619)	(-2.747)	(-1.555)
Covenant	−.072	.003	−.051
	(-.85)	(.019)	(-.597)
Secured	.066*	.044	.101**
	(1.825)	(.613)	(2.238)
Loan size	.012	.031*	−.005
	(1.428)	(1.972)	(-.463)
GDP growth	−.001	−.007	.002
	(-.322)	(-.64)	(.131)
Population	−.45*	−.496	−.457
	(-1.829)	(-1.449)	(-1.151)
Constant	12.78***	13.614**	13.046*
	(2.993)	(2.336)	(1.956)
Observations	4109	1283	2743
R-squared	.792	.807	.822
Firm FE	Y	Y	Y
Country FE	Y	Y	Y
Region FE	Y	Y	Y
Loan purpose & type FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: the table presents findings from the interaction between commodity price uncertainty and the level of commodity dependence of firms that receive loans over the 1990–2019 period. Model 1 reports estimates for the full sample, Model 2 presents findings including loans traced to firms operating in developing/emerging countries, and Model 3 reports estimations including loans traced to firm operating in advanced countries. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

bank-based advanced economies under increased commodity price uncertainties. In models 4–6 and 8–10 of Table 7, we perform the component analysis for the two subsamples, i.e., loans traced to firms operating in bank-based developing/emerging economies vis-à-vis loans granted to firms operating in bank-based advanced economies. We find that agricultural price uncertainty (*Agricultural Price Uncertainty)* has a positive and significant effect at the 5% level on the cost of borrowing for firms operating in bank-based developing/emerging countries (model 4 of Table 7). In model 8 of Table 7, where we repeat the estimation for loans traced to firms that operate in bank-based advanced countries, the results show a positive effect of agricultural price uncertainty on the cost of credit, but the findings are not statistically strong. Altogether the above results suggest that firms operating in bank-based developing countries would face increased borrowing costs compared to firms operating in bank-based developed countries during periods of high commodity price uncertainty. While in both loan subsamples the banking sector plays a prominent role in terms of financing, the well-developed nature of financial markets in the developed countries enhance the use and effectiveness of risk management practices offsetting in that way the losses of firms and banks from rising commodity price uncertainty.

4.4. Commodity dependent firms

Our previous estimations show that commodity price uncertainty increases the cost of bank lending. However, these results may vary with firm heterogeneity stemming from the level of firms' dependence in terms of production on commodity price uncertainty. Firms from specific industries, such as farm companies and oil and gas extraction companies, are expected to be more dependent on rising commodity pricing uncertainties and hence we conjecture that the effect of commodity price uncertainty on their cost of credit would be pronounced. For this test, we run OLS estimations that include the interaction term between a dummy variable that takes the value of one for firms that belong to industries that are more exposed to commodity price uncertainties, i.e., commodity dependent

Table 9
The effect of Commodity Price Uncertainty on the Cost of Credit of commodity dependent firms: Component Analysis.

	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Dependence	.018	.054	.025	.019	.078	.005	.031	.091	.022
	(.437)	(.635)	(.504)	(.399)	(.925)	(.101)	(.778)	(1.064)	(.48)
Agricultural Price Uncertainty Commodity Dependence*	2.938**	6.659***	−.331						
	(2.477)	(5.03)	(-.256)						
Energy Price Uncertainty Commodity Dependence*				−2.487	−3.358	−3.299			
				(-1.055)	(-.907)	(-1.111)			
Metals Price Uncertainty Commodity Dependence*							1.763*	2.728	.901
							(1.916)	(1.062)	(.742)
Firm leverage	−.193	.02	−.24	−.212	.079	−.254	−.204	.08	−.24
	(-1.392)	(.076)	(-1.241)	(-1.455)	(.306)	(-1.246)	(-1.436)	(.311)	(-1.216)
Firm tangibility	−.013	−.193	−.017	−.01	−.133	−.015	−.009	−.121	−.016
	(-.137)	(-1.221)	(-.12)	(-.106)	(-.832)	(-.108)	(-.09)	(-.755)	(-.111)
Firm profitability	−.22***	−.477**	−.257***	−.21**	−.424*	−.249***	−.214**	−.427*	−.257***
	(-2.776)	(-2.16)	(-3.1)	(-2.627)	(-1.833)	(-2.898)	(-2.673)	(-1.872)	(-3.084)
Firm size	−.037	−.048	−.038	−.039	−.053	−.042	−.038	−.051	−.04
	(-.969)	(-.782)	(-.714)	(-.992)	(-.901)	(-.769)	(-.987)	(-.868)	(-.734)
Firm liquidity	.066**	.046	.058	.066**	.05	.059*	.065**	.048	.058
	(2.285)	(.997)	(1.678)	(2.29)	(1.035)	(1.722)	(2.263)	(1.011)	(1.679)
Loan maturity	−.036**	−.08***	−.026	−.038**	−.089***	−.024	−.037**	−.085***	−.025
	(-2.692)	(-2.837)	(-1.584)	(-2.693)	(-3.283)	(-1.52)	(-2.623)	(-3.037)	(-1.552)
Covenant	−.073	.005	−.051	−.073	.001	−.052	−.072	.001	−.051
	(-.853)	(.029)	(-.594)	(-.858)	(.007)	(-.616)	(-.843)	(.009)	(-.598)
Secured	.065*	.04	.101**	.067*	.046	.104**	.067*	.044	.102**
	(1.773)	(.567)	(2.233)	(1.87)	(.66)	(2.299)	(1.863)	(.627)	(2.264)
Loan size	.012	.03*	−.005	.013	.032**	−.005	.012	.032*	−.005
	(1.449)	(2.01)	(-.445)	(1.548)	(2.089)	(-.481)	(1.504)	(2.044)	(-.481)
GDP growth	−.001	−.007	.001	−.001	−.007	.001	−.001	−.007	.001
	(-.293)	(-.619)	(.126)	(-.32)	(-.633)	(.148)	(-.342)	(-.656)	(.114)
Population	−.451*	−.507	−.452	−.436*	−.473	−.456	−.442*	−.481	−.464
	(-1.81)	(-1.441)	(-1.151)	(-1.787)	(-1.339)	(-1.172)	(-1.818)	(-1.392)	(-1.175)
Constant	12.803***	13.835**	12.968*	12.568***	13.289**	13.042*	12.663***	13.389**	13.17*
	(2.961)	(2.314)	(1.966)	(2.966)	(2.208)	(1.995)	(3)	(2.272)	(1.986)
Observations	4109	1283	2743	4109	1283	2743	4109	1283	2743
R-squared	.792	.808	.822	.792	.806	.823	.792	.806	.822
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of the three components of commodity price uncertainty, i.e., agricultural, energy and metals, price uncertainty, on the cost of credit for commodity dependent firms. Models 1,4,7 report estimations including the full sample, Models 2,5,8 include estimations for firms operating in developing/emerging economies, and Models 3,6,9 present results for loans traced to firms operating in advanced economies. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

firms, and zero otherwise, as a proxy for commodity dependent firms[7] and the commodity price uncertainty variable. This identification strategy allows the inclusion of time fixed effects in our estimations. In our baseline estimations, we do not include time fixed effects as the commodity price uncertainty variable is time variant and hence the inclusion of time fixed effects would cause the drop of the commodity price uncertainty factor from our specifications. However, the interaction term between a time variant variable (*Commodity Price Uncertainty*) and a firm-level time variant characteristic (*Commodity Dependence)* enables us also to include year fixed effects in our estimations to control for all the time variant macroeconomic conditions. Table 8 presents the findings from this analysis.

In model 1 of Table 8, the results show that the interaction between commodity price uncertainty (*Commodity Price Uncertainty*) and the commodity dependence dummy (*Commodity Dependence*) has a positive and significant effect at the 1% level on the cost of bank loans. In model 2 of Table 8, we run similar estimation for the sample of loans that are traced to firms operating in developing countries. We observe that the interaction is still positive and significant at the 1% level. Further, in model 3 of Table 8, we repeat the

[7] In our sample we classify as commodity dependent firms, these firms that belong to the following industries: Oil & Gas Extraction, Special Trade Contractors, General Farms, Primarily Crop, Food & Kindred Products, Paper & Allied Products, Chemical & Allied Products, Petroleum & Coal Products, Fabricated Metal Products, Instruments & Related Products, Miscellaneous Manufacturing Industries, Building Materials & Gardening Supplies, General Merchandise Stores, Food Stores, Hotels & Other Lodging Places, Personal Services, Engineering & Management Services.

Table 10
The effect of Commodity Price Uncertainty on the Cost of Credit: Firm Size Analysis.

	Above median	Below median	Above 75th percentile	Below 75th percentile	Above 95th percentile	Below 95th percentile
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.438**	.893**	.749	.955***	−1.424	1.38***
	(2.408)	(2.124)	(.821)	(3.732)	(-.385)	(4.383)
Firm leverage	−.215	−.129	−1.525**	−.139	2.146	−.167
	(-.736)	(-.739)	(-2.507)	(-.772)	(.857)	(-1.111)
Firm tangibility	.017	−.025	.263	−.157	−.319	.039
	(.121)	(-.166)	(1.274)	(-1.259)	(-.976)	(.375)
Firm profitability	−.211*	−.105	−.11	−.143	−2.176*	−.184**
	(-1.755)	(-1.334)	(-.533)	(-1.524)	(-2.028)	(-2.608)
Firm size	−.041	−.012	−.017	−.1**	.432	−.019
	(-.837)	(-.148)	(-.193)	(-2.246)	(1.156)	(-.529)
Firm liquidity	.081	.047	.053	.062**	−.577***	.062**
	(1.546)	(1.677)	(.627)	(2.225)	(-4.718)	(2.111)
Loan maturity	−.016	−.051**	.015	−.044**	.057	−.034*
	(-.694)	(-2.228)	(.482)	(-2.396)	(.631)	(-2.043)
Covenant	−.101	.051	−.076	−.058	−.088	−.068
	(-1.174)	(.489)	(-.499)	(-.888)	(-.238)	(-.894)
Secured	.131**	.022	.001	.072*	.218	.064*
	(2.483)	(.702)	(.021)	(1.967)	(1.15)	(1.797)
Loan size	.019	.014	.004	.022**	−.017	.017**
	(1.396)	(1.235)	(.316)	(2.496)	(-.233)	(2.3)
GDP growth	−.001	−.003	−.005	−.002	−.014	−.003
	(-.279)	(-1.38)	(-.618)	(-.677)	(-.729)	(-1.095)
Population	.008	−.167	−.077	−.029	−3.345	.021
	(.023)	(-.816)	(-.171)	(-.187)	(-1.527)	(.102)
Constant	5.006	8.024**	6.284	6.078**	57.627	4.747
	(.882)	(2.372)	(.863)	(2.313)	(1.685)	(1.397)
Observations	2097	2099	1039	3163	192	4031
R-squared	.766	.848	.774	.818	.846	.792
Firm FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of commodity price uncertainty on the cost of credit based on different borrowing firms' size classes. We split the sample of loans using the median value (Models 1 and 2), the 75th percentile threshold (Models 3 and 4) and the 95th threshold value (Models 5 and 6). Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

estimation for the sample of loans granted to firms operating in advanced countries. The interaction is positive but not statistically significant. Those findings confirm our conjecture that commodity price uncertainty increases the cost of credit more for firms that are commodity dependent compared to firms whose production is not associated closely with commodity price fluctuations. This finding lends support to our speculation that the effect of commodity price uncertainty on the cost of bank loans would be more pronounced for firms whose production is commodity based.

Models 1, 4, and 7 of Table 9 present findings that include interactions between the commodity dependent dummy variable and the three individual components of the commodity price uncertainty index - agricultural, energy and metals commodity price uncertainty. In model 1 of Table 9, we find that the interaction between agricultural price uncertainty (*Agricultural Price Uncertainty*) and the dummy that captures the level of commodity dependence (*Commodity Dependence)* is positive and significant at the 5% level. Also, in model 7 of Table 9, we show that the interaction between metal price uncertainty (*Metals Price Uncertainty*) and the commodity dependence dummy (*Commodity Dependence*) enters the regression positive and significant at the 10% level. Next, we repeat this exercise by splitting the sample into loans granted to firms operating in developing vis-à-vis loans traced to firms operating in developed countries (models 2,3,5,6, 8 & 9 of Table 9). Overall, results from this analysis show that commodity dependent firms operating in developing countries suffer more significantly in terms of costs of bank credit compared to commodity dependent firms operating in developed countries under increased levels of agricultural price uncertainty. This finding further corroborates our previous results, suggesting that the commodity dependent borrowing firms operating in developing/emerging countries carry increased costs of bank borrowing due to their high dependence on the demand of agricultural products as opposed to firms operating in advanced economies.

4.5. Firm size analysis

The previous section (section 4.4) shows that firm heterogeneity plays an important role in the association between commodity price uncertainty and the cost of bank loans. In this section we proceed with a detailed examination of another firm specific

Table 11
The effect of Commodity Price Uncertainty on the Cost of Credit of small firms.

	Developing	Advanced	Developing	Advanced	Developing	Advanced
	Below median	Below median	Below 75th percentile	Below 75th percentile	Below 95th percentile	Below 95th percentile
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.015	.486	1.223**	.06	1.577***	.53
	(.943)	(.807)	(2.226)	(.148)	(2.936)	(.968)
Firm leverage	−.022	.008	.164	−.073	.229	−.253
	(-.061)	(.057)	(.483)	(-.382)	(.702)	(-1.346)
Firm tangibility	−.037	.124	−.255	−.052	−.083	−.027
	(-.117)	(1.149)	(-1.173)	(-.339)	(-.513)	(-.182)
Firm profitability	−.17	−.103*	−.309	−.171**	−.446**	−.209***
	(-.73)	(-2.037)	(-1.246)	(-2.282)	(-2.176)	(-2.97)
Firm size	.223	−.058	−.087	−.092*	−.033	−.002
	(1.272)	(-.606)	(-1.033)	(-1.757)	(-.442)	(-.062)
Firm liquidity	.059	−.006	.022	.048	.036	.06
	(1.412)	(-.287)	(.501)	(1.22)	(.705)	(1.66)
Loan maturity	−.065	−.041*	−.088***	−.027	−.083***	−.02
	(-1.274)	(-1.752)	(-2.774)	(-1.57)	(-4.362)	(-1.14)
Covenant	.175	.066	−.063	−.038	−.113	−.045
	(.554)	(.73)	(-.447)	(-.553)	(-.745)	(-.56)
Secured	.045	−.021	.134	.07	.056	.093*
	(.602)	(-.553)	(1.534)	(1.529)	(.842)	(1.979)
Loan size	.02	.009	.025	.012	.031*	.003
	(.461)	(.791)	(1.438)	(1.248)	(2.022)	(.349)
GDP growth	−.011	−.003	−.005	−.002	−.008	−.003
	(-1.397)	(-1.555)	(-.63)	(-.919)	(-.936)	(-1.29)
Population	−.298	−.218	.225	−.107	.361	−.226
	(-.988)	(-.608)	(.75)	(-.464)	(1.113)	(-.869)
Constant	9.142*	9.052	1.786	7.35*	−.803	8.921*
	(1.72)	(1.547)	(.351)	(1.908)	(-.15)	(2.048)
Observations	620	1443	954	2155	1235	2727
R-squared	.856	.869	.832	.839	.8	.819
Firm FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of commodity price uncertainty on the cost of credit of small firms locating in developing and advanced countries. We use the sample of loans for firms that have a firm size below the median value (Models 1 and 2), below the 75th percentile threshold (Models 3 and 4) and below the 95th threshold value (Models 5 and 6). Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

characteristic, i.e., the size of the firm. Previous studies show that smaller firms face higher barriers to access credit as compared to larger firms (Levy, 1993; Beck et al., 2006; Beck et al., 2008; Karlsson, 2021). Small firms are less informationally transparent, and lenders are less willing to extend credit, while large firms have lower information asymmetry and thus, they have higher bargaining power which push banks granting more credit at favorable pricing terms. There is also evidence to suggest that larger firms have better access to financing compared to smaller firms during periods of increased financial constraints (Beck et al., 2005). Given that commodity price uncertainty could induce a credit rationing mechanism, we expect that this would be more severe for smaller borrowing firms as opposed to larger borrowers. Hence, we expect that smaller firms would face increased borrowing costs compared to larger firms during periods of higher commodity price uncertainty. To test this conjecture, in this section, we proceed with estimations based on the size of the borrowing firm and test for the effect of commodity price uncertainty on different borrowing firm's size classes. Results from this test are available in Table 10.

Firstly, we split the sample of loans based on the median value of firm size and run our baseline estimation. Model 1 of Table 10 includes the subsample of loans traced to firms that have size values above the median, while model 2 includes the subsample of loans granted to firms that have a firm size below the median. The results show that in both samples the effect of commodity price uncertainty (*Commodity Price Uncertainty*) on cost of credit is positive and significant at the 5% level. Next, we split the sample of loans based on the 75th percentile of firm size. Model 3 of Table 10 includes the subsample of loans traced to firms that have a firm value above the 75th percentile, and model 4 includes the subsample of loans traced to firms that have a firm value below this threshold. We find that commodity price uncertainty (*Commodity Price Uncertainty*) exerts a positive and significant effect at the 1% level on the cost of credit for smaller banks (model 4 of Table 10). In Model 5 and 6 we split the sample based on the 95th percentile of the firm size variable. We observe that commodity price uncertainty (*Commodity Price Uncertainty*) has a positive and significant effect at the 1% level on the cost of borrowing for firms belonging to the subsample below the 95th percentile cut-off point (model 6 of Table 10). Overall, the results confirm our conjecture that larger firms have easier access to financing, suggesting that they have greater

Table 12
Control for additional variables.

	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.248***	1.278*	.701	1.162***	1.255**	.517	1.265***	1.396**	.511
	(3.527)	(2.043)	(1.311)	(4.156)	(2.126)	(1.051)	(3.583)	(2.364)	(.898)
Commodity Prices	.004	.024	−.034						
	(.12)	(.271)	(-.641)						
Geopolitical Uncertainty				.001	.001	.001			
				(-.607)	(-.546)	(-.054)			
Economic Policy Uncertainty							.001	.001	.001
							(.414)	(.252)	(.733)
Firm leverage	−.158	.167	−.225	−.152	.188	−.226	−.159	.166	−.228
	(-1.087)	(.576)	(-1.16)	(-1.06)	(.639)	(-1.188)	(-1.092)	(.552)	(-1.189)
Firm tangibility	.02	−.114	−.017	.019	−.111	−.013	.022	−.108	−.006
	(.213)	(-.878)	(-.136)	(.208)	(-.847)	(-.097)	(.234)	(-.842)	(-.048)
Firm profitability	−.194**	−.447**	−.227***	−.195**	−.446**	−.231***	−.192**	−.453**	−.225***
	(-2.707)	(-2.209)	(-3.224)	(-2.73)	(-2.21)	(-3.21)	(-2.68)	(-2.215)	(-3.189)
Firm size	−.028	−.022	−.017	−.026	−.022	−.018	−.032	−.03	−.023
	(-1.083)	(-.558)	(-.514)	(-.959)	(-.553)	(-.517)	(-1.12)	(-.704)	(-.661)
Firm liquidity	.057*	.034	.057	.057*	.036	.057	.057*	.032	.057
	(1.99)	(.704)	(1.644)	(2.005)	(.744)	(1.646)	(1.965)	(.666)	(1.627)
Loan maturity	−.038**	−.087***	−.023	−.039**	−.088***	−.023	−.038**	−.087***	−.022
	(-2.566)	(-4.083)	(-1.359)	(-2.648)	(-4.195)	(-1.415)	(-2.553)	(-4.037)	(-1.313)
Covenant	−.056	−.054	−.042	−.056	−.059	−.042	−.056	−.054	−.042
	(-.754)	(-.331)	(-.556)	(-.751)	(-.36)	(-.561)	(-.746)	(-.336)	(-.555)
Secured	.07**	.042	.099**	.07**	.042	.1**	.069**	.039	.1**
	(2.182)	(.616)	(2.347)	(2.211)	(.619)	(2.384)	(2.133)	(.565)	(2.373)
Loan size	.014*	.036**	.001	.014*	.036**	.001	.014*	.036**	.001
	(1.842)	(2.208)	(.039)	(1.847)	(2.209)	(.037)	(1.82)	(2.21)	(-.022)
GDP growth	−.002	−.007	−.002	−.002	−.006	−.002	−.002	−.006	−.002
	(-.833)	(-.807)	(-1.159)	(-.751)	(-.74)	(-1.099)	(-.814)	(-.786)	(-1.143)
Population	−.06	.316	−.32	−.041	.322	−.238	−.122	.243	−.403
	(-.275)	(.935)	(-1.193)	(-.196)	(.994)	(-1.04)	(-.521)	(.606)	(-1.47)
Constant	6.166	−.255	10.815**	5.883	−.17	9.235**	7.224*	1.133	11.968**
	(1.638)	(-.044)	(2.342)	(1.67)	(-.031)	(2.42)	(1.829)	(.169)	(2.643)
Observations	4255	1315	2864	4255	1315	2864	4255	1315	2864
R-squared	.786	.797	.817	.786	.797	.817	.786	.797	.817
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: the table reports the effects of commodity uncertainty on the cost of credit while controlling for additional variables. These include commodity prices, geopolitical uncertainty, and economic policy uncertainty. Models 1,4,7 report estimations including the full sample, Models 2,5,8 include estimations for firms operating in developing/emerging economies, and Models 3,6,9 present results for loans traced to firms operating in advanced economies. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

bargaining power compared to smaller firms under periods of rising commodity price uncertainty.

In Table 11, we run the analysis using the subsamples of smaller borrowing firms and we split between loans granted to firms operating in developing/emerging vis-à-vis loans granted to firms operating in advanced countries (models 1,3, & 5 vis-à-vis models 2,4 & 5). Altogether, the findings show that commodity price uncertainty significantly increases the cost of the loans traced to smaller firms operating in developing countries, while this effect is not statistically important for loans granted to smaller firms operating in developed countries. This result could be explained by the notion that while small firms in developing/emerging countries rely more heavily in terms of their production and revenues on commodity markets they could benefit from the use of effective hedging strategies. On the contrary, smaller borrowing firms in developed countries have lower income dependence on commodity production and could apply better hedging strategies due to the well-developed nature of financial markets. Consequently, the effect of rising commodity price uncertainties on cost of borrowing would be more pronounced to small firms in developing countries compared to smaller firms in developed economies.

4.6. Omitted variable issue

In our study, we employ several firm-level, loan level, and country level variables. We also use several fixed effects, including country, region, firm, loan purpose and loan type fixed effects. However, it is possible that our results may be driven by an omitted variable, causing bias in our estimations. As our main variable of interest is the commodity price uncertainty, we recognise that our

Table 13
Control for additional variables: component analysis.

	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Agricultural Price Uncertainty	1.823***	2.155**	.828						
	(3.518)	(2.688)	(1.173)						
Agricultural Prices	−.015	−.035	−.059						
	(-.26)	(-.334)	(-.737)						
Energy Price Uncertainty				−2.352**	−1.791	−2.07			
				(-2.066)	(-.799)	(-1.323)			
Energy Prices				−.002	.031	−.042			
				(-.081)	(.408)	(-1.027)			
Metals Price Uncertainty							.779*	1.368	.095
							(1.91)	(1.45)	(.168)
Metals Prices							.052	.028	.053
							(1.296)	(.348)	(1.094)
Firm leverage	−.167	.144	−.233	−.166	.145	−.223	−.152	.161	−.216
	(-1.167)	(.492)	(-1.233)	(-1.125)	(.504)	(-1.13)	(-1.033)	(.551)	(-1.11)
Firm tangibility	.017	−.124	−.005	.007	−.133	−.027	.008	−.113	−.019
	(.178)	(-.965)	(-.037)	(.079)	(-1.001)	(-.209)	(.09)	(-.838)	(-.147)
Firm profitability	−.185**	−.448**	−.218***	−.21***	−.434**	−.242***	−.204***	−.438**	−.234***
	(-2.532)	(-2.196)	(-3.006)	(-2.903)	(-2.176)	(-3.429)	(-2.861)	(-2.179)	(-3.356)
Firm size	−.03	−.026	−.027	−.028	−.019	−.017	−.034	−.029	−.024
	(-1.029)	(-.659)	(-.735)	(-1.108)	(-.481)	(-.522)	(-1.304)	(-.753)	(-.714)
Firm liquidity	.057*	.032	.058	.056*	.035	.056	.059**	.037	.057
	(2.03)	(.68)	(1.659)	(1.981)	(.74)	(1.638)	(2.078)	(.769)	(1.667)
Loan maturity	−.037**	−.085***	−.023	−.038**	−.088***	−.022	−.039**	−.09***	−.024
	(-2.524)	(-3.914)	(-1.375)	(-2.525)	(-4.003)	(-1.347)	(-2.559)	(-4.105)	(-1.406)
Covenant	−.057	−.048	−.043	−.051	−.056	−.037	−.048	−.057	−.037
	(-.764)	(-.287)	(-.57)	(-.698)	(-.35)	(-.493)	(-.657)	(-.369)	(-.482)
Secured	.068**	.039	.098**	.073**	.041	.102**	.071**	.04	.101**
	(2.139)	(.595)	(2.366)	(2.288)	(.588)	(2.45)	(2.244)	(.577)	(2.44)
Loan size	.015*	.035**	.001	.015*	.038**	.001	.015*	.037**	.001
	(1.949)	(2.183)	(-.045)	(1.977)	(2.34)	(.052)	(1.9)	(2.304)	(.002)
GDP growth	−.002	−.006	−.002	−.002	−.006	−.002	−.002	−.006	−.002
	(-.774)	(-.801)	(-1.148)	(-.713)	(-.79)	(-.989)	(-.613)	(-.752)	(-.927)
Population	−.118	.211	−.4	−.113	.297	−.388	−.239	.215	−.442
	(-.494)	(.548)	(-1.62)	(-.526)	(.856)	(-1.534)	(-.971)	(.549)	(-1.575)
Constant	7.235*	1.825	12.241***	7.085*	.023	11.977***	8.976**	1.496	12.431**
	(1.707)	(.273)	(2.829)	(1.932)	(.004)	(2.807)	(2.196)	(.236)	(2.71)
Observations	4255	1315	2864	4255	1315	2864	4255	1315	2864
R-squared	.786	.796	.817	.786	.796	.817	.786	.796	.817
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: the table reports findings on the effect of the three components of commodity price uncertainty, i.e., agricultural, energy and metals, price uncertainty, on the cost of credit while including additional control variables. These are agricultural, energy and metals prices. Models 1,4,7 report estimations including the full sample, Models 2,5,8 include estimations for firms operating in developing/emerging economies, and Models 3,6,9 present results for loans traced to firms operating in advanced economies. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

findings may be affected by the level of commodity prices. There is evidence suggesting that access to credit could be determined by increases/decreases of commodity prices (Agarwal et al., 2020). Also, there is abundant of empirical evidence showing that lending terms and cost of credit increases due to rises of geopolitical uncertainty and economic policy uncertainty (Waisman et al., 2015; Procasky and Ujah, 2016; Ashraf and Shen, 2019; Tran, 2021; Khoo, 2021). Hence, we perform additional estimations where we control for commodity prices, geopolitical uncertainty, and economic policy uncertainty.[8] The results from these estimations are available in Table 12. We observe that the effect of commodity price uncertainty on the cost of credit is positive and significant at the 1% level (models 1, 4, 7 of Table 12), and the effect is pronounced for the cost of borrowing of firms operating in developing countries

[8] We source daily series for the agricultural, metals and energy GSCI nearby commodity futures from Datastream prices to estimate commodity price uncertainty. For our analysis, we use the yearly average of these series. We also use the data on geopolitical uncertainty index as developed by Caldara and Iacoviello (2018) (https://www.matteoiacoviello.com/gpr.htm). Lastly, we employ the economic policy uncertainty index of Baker et al. (2016) (https://www.policyuncertainty.com).

Table 14
Additional fixed effects.

	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced	Full Sample	Developing	Advanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.121***	.013	.801						
	(3.268)	(.017)	(1.415)						
Commodity Dependence				.071	−.073	.121	.307***	.331***	.331***
				(1.208)	(-.332)	(1.358)	(3.087)	(3.612)	(3.612)
Commodity Price Uncertainty Commodity Dependence*				5.372***	4.85***	.592	6.008***	5.614**	.368
				(4.929)	(3.753)	(.963)	(5.15)	(4.546)	(.776)
Firm leverage	−.021	.147	−.078	−.222	−.861	−.147			
	(-.169)	(.502)	(-.446)	(-1.053)	(-.476)	(-.415)			
Firm tangibility	.015	−.118	−.016	−.314	−2.912**	−.13			
	(.128)	(-.625)	(-.119)	(-1.621)	(-2.359)	(-.63)			
Firm profitability	−.1	−.127	−.158**	−.011	−.555	−.115			
	(-1.298)	(-.395)	(-2.188)	(-.097)	(-.706)	(-.631)			
Firm size	−.027	−.013	−.025	−.04	−1.109	−.013			
	(-1.063)	(-.267)	(-.782)	(-.551)	(-1.459)	(-.135)			
Firm liquidity	.056**	.039	.048	.069	−1.147***	.034			
	(2.062)	(.756)	(1.484)	(1.654)	(-3.104)	(.603)			
Loan maturity	−.024	−.055*	−.023	−.031	.017	−.029	−.04	.023	−.049
	(-1.68)	(-1.933)	(-1.283)	(-1.557)	(.285)	(-1.148)	(-1.45)	(.375)	(-1.411)
Covenant	−.067	−.037	−.056	.007	−.596	−.027	.055	.001	.089
	(-1.066)	(-.226)	(-.898)	(.089)	(-.98)	(-.24)	(.229)	(.113)	(.342)
Secured	.071**	.029	.101***	.073	−.146	.062*	.024	−.154	.047
	(2.128)	(.429)	(2.946)	(1.387)	(-1.126)	(1.755)	(.263)	(-1.084)	(.644)
Loan size	.009	.024	−.006	−.004	.005	−.009	−.003	−.006	.001
	(1.222)	(1.351)	(-.714)	(-.309)	(.102)	(-.768)	(-.162)	(-.095)	(.022)
GDP growth	−.002	−.012	.001	−.003	−.056*	.006			
	(-.794)	(-1.565)	(-.1)	(-.625)	(-2.045)	(1.529)			
Population	−.183	−.028	−.147	−.012	2.858	.182			
	(-1.006)	(-.098)	(-.582)	(-.024)	(1.651)	(.176)			
Constant	8.187**	5.483	7.782*	5.641	−33.528	2.28	5.023***	4.729***	5.118***
	(2.68)	(1.131)	(1.827)	(.678)	(-1.161)	(.132)	(37.58)	(8.09)	(33.413)
Observations	3971	1150	2693	2749	600	1847	1929	463	1345
R-squared	.843	.859	.868	.916	.952	.927	.946	.941	.943
Firm FE	Y	Y	Y	Y	Y	Y	N	N	N
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Lead bank FE	Y	Y	Y	N	N	N	Y	Y	Y
Year FE	N	N	N	N	N	N	N	N	N
Lead bank-Year FE	N	N	N	Y	Y	Y	N	N	N
Firm-Year FE	N	N	N	N	N	N	Y	Y	Y

Notes: the table reports the findings on the effect of commodity price uncertainty on the cost of credit including additional fixed effects. In Models 1–3 we include lead bank fixed effects, in Models 4–6 we add lead bank-year fixed effects, and in Models 7–9 we add borrowing firm-year fixed effects. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

vis-à-vis firms operating in advanced economies (models 2, 5 & 8 vis-à-vis 3, 6, 9, of Table 12). Overall, these findings corroborate our baseline results and lend further support to our H1 and ***H2*** hypotheses.

Similarly, we control for agricultural prices, metal prices and energy prices, when we run estimations testing for the effect of the individual component of commodity price uncertainty, i.e., agricultural price uncertainty, metals price uncertainty, and energy price uncertainty respectively, on the cost of credit. Table 13 presents the findings from this test. Overall, the results also provide supporting evidence to our previous estimations, whereby agricultural price and metals price uncertainty increases the cost of credit, while energy price uncertainty reduces the borrowing cost.

To further ease concerns regarding omitted variable issues, we introduce in our estimations additional fixed effects as in several earlier studies (Ivashina, 2009; Bharath et al., 2011; Kim et al., 2013; Hasan et al., 2014; Bermpei et al., 2019). The results from these tests are available in Table 14. In models 1–3 of Table 14, we include lead bank fixed effects. These fixed effects aim to control for all the unobserved time invariant characteristics of the lead lender (Gropp and Heider, 2010). In models 4–6, we include lead bank-year fixed effects. To include lead bank-year fixed effects we use the interaction specification presented in section 4.4 as it allows us to include in the estimation the time variant fixed effects. Lead bank-year fixed effects control for all time variant bank characteristics, such as the concentration risk of the bank and its level of income diversification. For our study, capturing these effects is very important as banks' exposure to commodity price uncertainties could play a critical element in setting pricing terms. In brief, banks that use effective hedging strategies and have increased income diversification could reduce their concentration risk related to rising

Table 15
Alternative clustering of standard errors.

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread	Ln spread
Commodity Price Uncertainty	1.268***	1.403*	.53	1.268**	1.403	.53
	(2.637)	(1.749)	(.895)	(2.584)	(1.642)	(.779)
Firm leverage	−.158	.171	−.227	−.158	.171	−.227
	(-1.109)	(.623)	(-1.333)	(-1.126)	(.681)	(-1.497)
Firm tangibility	.019	−.11	−.013	.019	−.11	−.013
	(.187)	(-.62)	(-.113)	(.15)	(-.471)	(-.12)
Firm profitability	−.194***	−.449**	−.231***	−.194***	−.449	−.231***
	(-2.609)	(-2.153)	(-2.901)	(-3.376)	(-1.658)	(-3.816)
Firm size	−.028	−.025	−.018	−.028	−.025	−.018
	(-.944)	(-.645)	(-.552)	(-1.301)	(-.915)	(-.784)
Firm liquidity	.057**	.033	.057**	.057***	.033	.057**
	(2.358)	(.868)	(2.137)	(2.712)	(1.067)	(2.469)
Loan maturity	−.038**	−.087***	−.023	−.038*	−.087*	−.023
	(-2.056)	(-2.615)	(-1.136)	(-1.816)	(-1.962)	(-1.107)
Covenant	−.056	−.053	−.043	−.056	−.053	−.043
	(-.773)	(-.332)	(-.507)	(-.658)	(-.272)	(-.416)
Secured	.07**	.042	.099**	.07**	.042	.099**
	(2.061)	(.772)	(2.34)	(2.128)	(.708)	(2.339)
Loan size	.014	.036*	.001	.014	.036	.001
	(1.536)	(1.722)	(.032)	(.92)	(.964)	(.022)
GDP growth	−.002	−.006	−.002	−.002	−.006	−.002
	(-1.003)	(-1.449)	(-1.026)	(-.868)	(-1.306)	(-.875)
Population	−.066	.29	−.241	−.066	.29*	−.241
	(-.301)	(.952)	(-.916)	(-.411)	(1.692)	(-1.224)
Constant	6.291*	.349	9.294**	6.291**	.349	9.294***
	(1.739)	(.069)	(2.108)	(2.345)	(.123)	(2.81)
Observations	4255	1315	2864	4255	1315	2864
R-squared	.786	.797	.817	.786	.797	.817
Firm FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Loan purpose & type FE	Y	Y	Y	Y	Y	Y

Notes: the table reports the effects of commodity uncertainty on the cost of credit over the period 1990–2019 using annual loan data and alternative ways of clustering standard errors. Models 1–3 include estimations where we cluster standard errors at the firm-level, while Models 4–6 include specifications where we cluster standard errors at the country-level. vis-à-vis. Significance at the 10%, 5% and 1% levels is represented by *, **, and ***, respectively.

uncertainty of commodity prices. Lower concentration risk would render banks more willing to impose favorable loan terms. The use of lead bank-year fixed effects would control to a certain extent for these effects. Next, in models 7–9 of Table 14, we include firm-year fixed effects which capture the unobserved time variant firm heterogeneity. While we include numerous firm-level characteristics in our baseline regressions, the inclusion of firm-year fixed effects aims to account for all the time variant firm-level factors that could affect the relationship between commodity price uncertainty and the cost of credit. For example, as discussed in section 4.3 of the study, risk management practices of borrowing firms could significantly affect firms' revenues and consequently the extent to which commodity price uncertainty could affect their cost of borrowing. Hence, we use the specification employed in section 4.4 and include the firm-year fixed effects. The results are similar to our baseline estimations and confirm H1 and ***H2*** hypotheses.

4.7. Alternative clustering of standard errors

In our previous estimation, we cluster standard errors at the year level as we consider that commodity price uncertainty displays yearly variation. In this section, we also run estimations where we cluster standard errors both at the firm-level and the country-level. The results from these estimations are available in Table 15. The findings from these specifications confirm our H1 and ***H2*** hypotheses and are similar to the results of the main estimations.

5. Conclusion

In this paper we show that the comovement in price uncertainty of major global commodity markets has a positive effect on the cost of credit for firms and this effect is particularly strong for commodity dependent firms operating in developing/emerging economies. When decomposing the commodity price uncertainty comovement into agricultural, metals and energy price uncertainty, we show that agricultural price uncertainty exerts the most significant positive effect on the cost of credit of commodity dependent firms operating in developing/emerging countries. Also, we observe that firms locating in bank-based countries face increased bank borrowing costs as compared with firms locating in market-based countries. These results are further pronounced for loans traced to

firms operating in bank-based developing countries vis-à-vis loans traced to firms operating in bank-based developed countries.

There are important policy implications that stem out from our research. Firstly, we employ a common (single) commodity price uncertainty that central banks could aim to reduce to limit the negative effects that rising commodity price uncertainties have on the cost of borrowing of firms operating particularly in countries that are well known for their growth dependence on the uncertainty of commodity prices, i.e., developing/emerging economies. Secondly, our study shows that during periods of high agricultural price uncertainty firms in developing countries have higher cost of borrowing, and this might be explained by the fact that they reduce their production under the fear of wide losses decreasing in that way their revenues. Given the wide interest of central banks on the economic future of developing/emerging countries, our findings suggest that policy makers may need to place particular emphasis on reducing the levels of agricultural price uncertainty. Finally, our results suggest that more thought should be placed in improving the development of financial markets and encouraging the use of financial instruments in developing/emerging economies to hedge the risk from rising commodity price uncertainties. In the banking sector, regulators should also prompt financial institutions to increase enforcement of the current regulatory framework (BASEL III) and the adoption of risk management mandates. This would allow for easier implementation of effective risk management rendering banks in developing/emerging countries less vulnerable to rising commodity price uncertainties.

Credit author statement

Theodora Bermpei: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Software, Validation, Investigation, Formal analysis, Data Curation. **Aikaterini Karadimitropoulou:** Methodology, Software, Validation, Investigation, Formal analysis, Data Curation. **Athanasios Triantafyllou:** Methodology, Writing - original draft, Writing - review & editing, Software, Validation, Investigation, Formal analysis, Data Curation. **Jebreel Alshalahi:** Methodology, Validation, Investigation, Formal analysis, Data Curation.

Financial disclosure statement

There is no financial/personal interest or belief that could affect our objectivity.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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