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Corporate commodity exposure: A multi-country longitudinal study

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A B S T R A C T

This paper conducts a large-scale multi-country longitudinal study and examines the extent that firms are exposed to commodity price risk in 23 OECD countries. An industry analysis reveals that all industries are significantly exposed to commodity price movements ranging between 8 and 10% except for the energy sector where 38% of firms being significantly exposed. Investigating the determinants of commodity price exposure, we report that firm size is negatively associated with commodity exposure, while the fraction of R&D expenses, leverage, country GDP, and sophistication of the financial derivatives markets are positively related to commodity price exposure.

1. Introduction

Minimizing earnings volatility is a key policy focus of financial managers operating multinational firms. While risk management efforts are usually directed towards minimizing interest rate exposure and foreign exchange translation, transaction and operating exposures arising from international investment and trade, little attention is paid to the contributory effect of changes in commodity price movements on stock prices. Bartram (2005) highlights that commodity prices are a substantial business risk but to date, no multi-country longitudinal studies have been conducted to examine the impact of commodity price fluctuations on firm value. Our paper addresses this question by examining the extent and determinants of corporate commodity price exposure in 23 OECD countries.

Our paper significantly contributes to the literature in several important ways. To the best of our knowledge, we are the first to conduct a large multi-country longitudinal study investigating the extent of firm-level commodity price risk exposure. We discover that commodity price exposure significantly impacts all 23 OECD countries, with Canada (New Zealand and Turkey) experiencing the highest (lowest) level of exposure. Consistent with prior research the industry analysis reveals that 38% of firms in the energy sector are significantly exposed to commodity price movements but interestingly we report that all other sectors experience exposure ranging from 8 to 11%. Furthermore, we show the extent of firm-level exposure changes over time which the highest levels occurring during the global financial crisis (GFC) period. We employ a multivariate panel analysis to examine the determinants of commodity price exposure and find that large firms are associated with lower commodity exposure. In contrast, firms with high leverage and R&D expenses experience greater levels of exposure. Our analysis also shows that more developed countries and countries with

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sophisticated financial derivatives markets experience greater levels of commodity exposure. In addition, we show the determinants of commodity exposure across industries. Finally, sub-period analysis confirms the robustness of our results.

The remainder of this paper is structured as follows. Section 2 presents a literature review on commodity exposure across industries. Section 3 describes the data and methodology. Section 4 discusses the empirical results and section 5 concludes.

2. Literature review

Over the past three decades, there has been an increase in both the volatility of commodities and the spread of volatility between various commodities. Furthermore, commodity prices have exhibited higher levels of volatility compared to stock market indices, interest rates, and exchange rates (Bartram, 2005; Schalck and Chenavaz, 2015; Tang, 2015). A significant volume of work has been produced on the extent and determinants of firm exposure to interest rate risk (Choi and Elyasiani, 1997; Oertmann et al., 2000; Prasad and Rajan, 1995) and foreign exchange risk (Allayannis and Ofek, 2001; Bodnar and Gentry, 1993; Bodnar and Wong, 2003; Hutson and Laing, 2014; Hutson and Stevenson, 2010). Literature in commodity risk management is burgeoning but there is a relative dearth of research examining firm-level commodity price exposure. Examples to date include Carter et al. (2006) on the airline industry's use of fuel hedging, Dionne and Garand (2003) on the use of gold hedges by gold industry participants, and Jin and Jorion (2006) on the oil and gas hedging activities by relative industry producers.

2.1. Extent of commodity exposure

In recent decades, financial reforms and the financialization of commodities have increased the trading volume of commodity derivatives, leading to a growing body of literature on commodity price exposure (Boons et al., 2012; Adams and Glück, 2015). However, prior research has mostly focused on specific countries or regions or limited the study to a particular industry or type of commodity exposure, leaving gaps in our understanding of the overall extent of commodity price exposure. Carter et al. (2017) provides a comprehensive review of research that has been conducted in the context of jet fuel, oil and gas, and gold price exposures classified by commodity producer and user. Prior studies have mainly examined the sensitivity of markets and sectoral indices to major commodities such as gold, oil or metals. Fang et al. (2007) finds that firm stock price sensitivity to gold price shocks tends to change drastically when gold prices fluctuate substantially. Carter et al. (2006) and Berghöfer and Lucey (2014) show dramatic volatility in monthly jet fuel spot prices and crude oil prices resulting from a series of natural disasters and geopolitical events. More specifically, Treanor et al. (2014) show that the volatility of jet fuel prices is roughly four times greater than that of the foreign currencies exchange rates. Kumar and Rabinovitch (2013) also illustrate a high degree of crude oil and natural gas prices volatility.

On the commodity production side, Tufano's (1998) examining 48 firms gold mining firms in the U.S. and Canada from 1990 to 1993 show that over 50% of the firms are significantly exposed to gold price movements. Fang et al. (2007) study the exposure of gold mining firms in Australia from 1995 to 2000 and find that the magnitude of gold beta is greater than 1, indicating that gold mining firm stock price increases more than one unit from each unit increase in gold price change. Similarly, Baur (2014) concludes that the average gold beta is approximately 1 in Australian gold mining sector from 1980 to 2010. From the perspective of energy production, Strong's (1991) utilizing a sample of 25 U.S. oil firms highlights that 52% are significantly exposed to the risk of oil price movements. Prior studies have achieved consistent results that oil price changes have a significant positive impact on firm stock return for listed companies in the U.K. from 1986 to 1988 (Manning, 1991; El-Sharif et al., 2005), public companies traded on the New York Stock Exchange (Al-Mudhaf and Goodwin, 1993) and Canadian listed firms (Sadorsky, 2001). Furthermore, oil and gas price movements are also found to be significantly positively correlated with stock return in the Canadian market based on the five common factors with quarterly stock return data from 1995 to 2002 (Boyer and Filion, 2007). Jin and Jorion (2006) report that U.S. firms over the 1998–2001 period have greater positive exposure to natural gas price movements compared to oil price movements. Similarly, Mohanty and Nandha (2011) also find positive oil price risk factors at the 1% significance level. In comparison, Kilian (2008) provides evidence of an adverse impact of oil price shocks on the retail and tourism-related industries such as restaurants and lodging sectors.

On the commodity user side, Carter et al. (2006) estimates the coefficient of the jet fuel price exposure of the U.S. airline firms as −0.11 (statistically significant at the 5% level). Kilian (2008) also find negative effects of energy price fluctuations on the airlines. In contrast, Treanor et al. (2014) conclude a positive relationship between airline jet fuel price exposure and jet fuel price movements. Berghöfer and Lucey (2014) examine operational and fuel hedging in the U.S, European and Asian airline industry. They report less significant negative exposure coefficients amongst U.S. airlines and attribute the finding to reduced jet fuel price volatility over the sample period examined. In a related stream of literature, Shaeri et al. (2016) examine the U.S. firm stock sensitivity to oil price exposure fluctuations for both financial and non-financial industries at the subsector level from 1983 to 2005 and find that the non-financial subsectors of airlines and oil equipment services are most greatly negatively and positively exposed to oil price risk, respectively. Bartram (2005) examines exposure to commodity prices from 1987 to 1995 for 490 non-financial German firms classified by industry but finds that overall commodity price exposure is not more significant when compared to interest rate and foreign exchange rate exposures. The findings in Bartram (2005) are attributed to commodity price movements affecting only a few cash flows and/or firms implementing effective financial hedging strategies.

To date, prior studies have not conducted an extensive study that examines the impact of commodity price movements on firm value across countries and industries. This paper addresses this issue utilizing a multi-country longitudinal study.

2.2. Determinants of commodity exposure

Studies have examined the determinants of exposure including the association between corporate hedging and commodity price exposure. Tufano (1998) reports that gold mining firms are negatively exposed to the volatility of gold price returns, while firms with more diversified operations and more hedging activities have lower gold price exposure. Similarly, Treanor (1998) finds that operational and financial hedging are inversely related to the fuel price exposure of airline companies. Petersen and Thiagarajan (2000) studied two American gold mining companies and investigated the influence of financial hedging, operational hedging and leverage degree on the firm exposure to gold price changes. Fang et al. (2007) also report evidence that corporate hedging activities affect relevant gold price risk factors. Jin and Jorion (2006) discover that oil and gas hedging is negatively associated with the commodity price risk exposure, while oil and gas reserves are significantly positively related to the commodity exposure, consistent with the same evidence of a positive relationship between proven oil reserves and oil price exposure provided by Clinch and Magliolo (1992).

As discussed above, prior studies have investigated the data construction for the hedging valuation of various commodity derivative instruments. However, there is limited analysis on commodity exposure risk management in a broad non-financial setting. Two exceptions are Guay and Kothari (2003) and Nelson et al. (2005). Nelson et al. (2005) finds that less than 5% of their U.S. sample firms disclose the use of commodity derivatives and that their use is most prevalent in extractive industries, versus over 15% of the sample firms utilizing interest rate and currency derivatives. Guay and Kothari (2003) find that over 60% of the U.S. sample companies are involved in hedging activities with interest rate and foreign currency derivatives, while only 15% of them use commodity derivatives. The larger percentages found in this study for commodity derivative use reflect the fact that the sample consisted of very large firms while that of Nelson et al. (2005) was more heterogeneous. Studies to date have not examined the impact of derivatives on commodity price exposure using a large multi-country study.

Examining firm-level characteristics, Mohanty and Nandha (2011) show that the book-to-market value, size, and momentum characteristics of stocks and oil prices significantly impact oil price risk exposure in the U.S. oil and gas industry. Tufano (1998) also provides empirical evidence that the fraction of production hedged with derivative instruments is positively related to financial leverage. In terms of determinants of commodity price exposure, a lack of a holistic perspective in previous research motivates our research topic in this paper to establish the firm characteristics across industries over time.

In this paper, we address three research questions. Firstly, *to what extent are firms in 23 OECD countries exposed to commodity price movements?* Secondly, *does commodity price exposure differ across industries?* Thirdly, *what are the determinants of corporate commodity price risk exposure?*

3. Data and methodology

3.1. Data

We examine non-financial publicly listed firms over the period 1998–2018. Consistent with Hutson and Stevenson (2010), we also

Table 1
Control variable definitions.

Variable	Definition	Source
EXPOSURE	The square root of absolute commodity price exposure coefficient ($\sqrt{\lvert\alpha_3^i\rvert}$) of firm i at year j, as estimated in equation [1].	Refinitiv[a]
SIZE	Total asset in USD of firm i in year j	Refinitiv
QUICK	Quick ratio of firm i in year j	Refinitiv
MTBV	Market-to-book value of firm i in year j	Refinitiv
R&D	R&D expense out of the revenue of firm i in year j	Refinitiv
DA	Debt to asset ratio of firm i in year j	Refinitiv
GDP	Gross Domestic Product Per Capita, in U.S. dollars.	The World Bank
DERIV	Total derivatives turnover divided by the Gross Domestic Product. Derivatives turnover data were collected from the BIS triennial survey data https://stats.bis.org/statx/toc/DER.html GDP was collected from the World Bank database. https://data.worldbank.org/	BIS triennial survey data. The World Bank.
INDUSTRY DUMMIES	Industry sectors are based on the Refinitiv (formerly Thomson Reuters) Business Classifications Codes. 1. Basic materials include Chemicals, Mineral resources (incl. metals, mining, and construction materials), and applied resources. 2. Consumer cyclical goods and services include automobiles and auto parts, cyclical consumer products, cyclical consumer services, and retailers. 3. Non-cyclical consumer goods and services include food and beverages, personal and household products and services, and food and drug retailing. 4. Energy sector includes coal, oil, and gas, oil and gas-related and equipment, renewable energy. 5. Healthcare sector includes healthcare services, pharmaceuticals, and medical research. 6. The industrial sector includes industrial goods, services, conglomerates, and transportation. 7. Technology sector includes technology equipment, software and IT services. 8. Telecommunications includes integrated and wireless telecommunications services. 9. Utilities include electric, natural gas, water, multiline and other utilities.	Refinitiv

Notes: This table presents the control variable definitions and data sources. Due to skewness, the natural logarithm is taken for the following control variables: *SIZE, QUICK, MTBV, R&D* and *GDP*. All control variables are winsorized at the 1 and 99 percent levels.

[a] Refinitiv was formerly Thomson Reuters.

select the 23 OECD countries which have open and developed economies in this study. We collect the commodity exposure and firm-level characteristic control variable data from Thomson Reuters. Country-level control variable data was collected from the WorldBank. We examine a total of 6425 firms (90,513 firm-year observations). We employ the following two-stage analysis. In the first stage, we estimate the commodity exposure coefficients as detailed in section 3.2 below. In the second stage, we employ fixed-effects regression analysis.

3.2. Commodity price exposure estimates

We build on an extensive body of work that has examined the relation between exchange exposure and firm value, which has mostly been operationalized via Jorion's (1990) technique of measuring the sensitivity of equity returns to exchange rate changes while controlling for market movements:

$$r_t^{ij} = a_0^i + a_1^i R_i^j + a_2^i s_t^j + a_3^i K_t^j + e_t^i \quad [1]$$

where, $r_t^{i,j}$ is the log difference return on stock i in country j; R_t^j is the return on country j's benchmark stock index for time period t. S_t^j is the log difference change in the U.S. dollar trade-weighted exchange rate index over the same time period, and K_t^j is the return on the commodity index under investigation. We conduct fixed-effects panel estimation with the dependent variable of the exposure coefficient estimated in equation [1] to investigate the factors influencing commodity price exposure. As the coefficient captures both positive and negative commodity exposure, we take the absolute value of the commodity exposure coefficient, $|\alpha_3^i|$, to obtain an overall estimate of exposure. To reduce the negative influence of truncation bias, we transform the absolute commodity exposure coefficient by taking into the square root, $\sqrt{|\alpha_3^i|}$ (Dominguez and Tesar, 2006; Hutson and Laing, 2014; Hutson and Stevenson, 2010; Laing et al., 2020).

The following firm-specific characteristics have been examined in prior studies as the determinants of foreign exchange rate or commodity price risk exposure. Table 1 presents detailed variable definitions and data sources.

Size. Firm size, proxied by firm total asset value *(SIZE)*, is negatively correlated with risk exposure since larger firms are assumed to implement superior financial hedging strategies which reduce risk exposure as a result (Carter et al., 2006; Chow et al., 1997; Haushalter, 2000; Laing et al., 2020). Laing et al. (2020) have explored the role that firm size plays in commodity risk management and report a negative relation between firm size and risk exposure during the post-GFC period.

Liquidity. Laing et al. (2020) suggest that hedging firms hold liquid reserves to absorb unexpected price shocks from commodities markets. Likewise, Purnanandam (2008) finds a complementary relation between commodity hedging and firm liquidity, indicating that more liquid hedging firms are exposed to less commodity exposure. However, Nance et al. (1993) illustrate that firms are more likely to encounter financial distress by holding more liquid assets. Thus, firms may use highly liquid assets to substitute financial hedging - which may result in greater exposure to commodity price movements. Following prior studies (Purnanandam, 2008; Hutson and Laing, 2014; Laing et al., 2020), we employ the quick ratio *(QUICK)* to measure corporate liquidity.

Growth opportunity. Previous research summarizes that firms with a high price-to-book value of equity tend to adopt derivative instruments (Froot et al., 1993) – which may result in lower commodity price exposure. Kumar and Rabinovitch (2013) also highlight a positive association between financial hedging policies and growth opportunities as under-investment problems are mitigated. We utilize market-to-book value *(MTBV)* and research and development expenses *(R&D)* as proxies for corporate growth opportunities (Géczy et al., 1997; Hutson and Laing, 2014; Nance et al., 1993).

Leverage. Nance et al. (1993) highlight the importance of financial hedging for levered firms as the debt repayments are a fixed claim against the organization's cash flows. He and Ng (1998) find that highly levered firms exhibit higher levels of financial hedging resulting in lower exchange rate exposure. In contrast, Hunter (2005) and Hutson and Stevenson (2010) reveal a positive relation between leverage and exchange rate exposure. The results suggest that highly leveraged firms experience greater levels of financial distress when they do not utilize financial hedging. Similarly, Laing et al. (2020) report that leverage is significantly associated with risk exposure to the commodity price movements at the 5% level or above for the U.S. oil and gas sectors. We utilize the debt-to-asset ratio *(DA)* to proxy for financial leverage.

Gross Domestic Product (GDP). We utilize the Gross Domestic Product (GDP) per capita to control for county-level domestic production and economic progress.

Financial Hedging. As discussed in section 2.2 above, prior studies have established an association between financial hedging and exposure to movements in gold prices (Tufano, 1998; Petersen and Thiagarajan, 2000; Fang et al., 2007), fuel prices (Treanor, 1998) and oil and gas prices (Jin and Jorion, 2006) but studies to date hand-collected financial hedging data small firm samples. For example, Tufano (1998), Petersen and Thiagarajan (2000) and Fang et al. (2007) examine a sample of 48, 2 and 49 gold mining companies. Jin and Jorion (2006) and Treanor (1998) examine 119 oil and gas firms and 29 airlines, respectively. Due to the large sample of 6425 firms (90,513 firm-year observations) examined in this paper, it was not feasible to hand-collect financial hedging derivative information. Accordingly, we utilize a country-level measure of financial hedging proxied by total derivatives turnover *(DERIV)*.

4. Results and analysis

4.1. Summary statistics

Fig. 1 presents the S&P GSCI commodity price index volatility measured as the standard deviation over the 1998 to 2018 period. There are several periods with increased volatility during 1999–2001, 2003–2005, 2007–2009, and 2013–2016. During the Global Financial Crisis period (2007–2009), the commodity index volatility reached a peak that was almost four times greater than at any other time during the 1998–2018 period. The fluctuating commodity price index is potentially related to geopolitical events as well as economic uncertainties, which can impact firm-level corporate commodity exposure. Fig. 2 shows the absolute mean commodity price exposure coefficients estimated by equation [1] *(detailed in section 3.2)*, as well as the proportion of firms significantly exposed to commodity price fluctuations. In line with commodity price volatility displayed in Fig. 1, the proportion of firms with significant commodity price exposure presented in Fig. 2, increases dramatically from 2007 to 2008.

Table 2, columns (2) and (3) present the mean and median values of the absolute risk coefficients of commodity exposure, for the full sample and each country in panels A and B, respectively. The table also reports the number and the percentage of firms with significant commodity price exposure at the 5% level or above. 10% of firms in the total sample are exposed to commodity price risk at the 5% significant level or better with the mean coefficient value of 0.238. In terms of corporate commodity exposure classified by country, the absolute mean risk coefficient is highest in Norway (0.373), Canada (0.353), and Australia (0.335) and the lowest in Mexico, Austria, and Japan, which are 0.179, 0.192, and 0.194, respectively. Companies in North America have the largest proportion of significant exposure, 18% in Canada and 15% in the U.S. In contrast, the smallest proportion of significantly exposed firms equalled 7% in New Zealand and Turkey. In the full sample, 48% and 52% of firms are negatively and positively exposed to commodity price movements in the 23 OECD countries, respectively.

Table 3, columns (2) and (3) summarise the mean values and median values of the absolute risk coefficients of commodity exposure classified by industry along with the numbers of firms positively, negatively, and significantly exposed to commodity price movements which are in columns (4), (5) and (6), respectively. Column (7) shows the percentage of firms with significant commodity exposure in each industry at the 5% level or better. Firms operating in the energy industry experience the largest levels of the mean (0.496) and median (0.359) absolute commodity price exposure. In contrast, utilities exhibit the lowest mean (0.168) and median (0.121) exposure. Interestingly all industries are significantly exposed to commodity price movements at the 5% level. In general, 8%–11% of firms in each industry have significant commodity price exposure, except for the energy industry of which 38% of the firms experience significant commodity price exposure. Firms in energy sectors are most exposed to commodity price risk, as the price changes of energy commodities, especially for jet fuel, crude oil and natural gas, fluctuate drastically. Our findings complement several studies that exhibit dramatic volatility in jet fuel prices (Carter et al., 2006; Treanor et al., 2014; Berghöfer and Lucey, 2014) or discuss the great volatilities in the price changes of energy commodities including crude oil and natural gas (Kumar and Rabinovitch, 2013; Berghöfer and Lucey, 2014).

The proportion of firms with positive commodity exposure is roughly the same as the proportion of firms with negative exposure, but two exceptions are basic materials and energy industries with 58% and 80% of the sample being positively exposed to commodity price movements. Our results are consistent with prior research which focuses on the energy oil and gas sector and shows that firms are positively exposed to oil price movements in the UK (El-Sharif et al., 2005; Manning, 1991), the U.S. (Al-Mudhaf and Goodwin, 1993) and Canada (Sadorsky, 2001). Consistent with our results, Shaeri et al. (2016) also report a significantly positive weighted average exposure to oil price risk for oil and gas subsectors.

Table 4, panels A–C present the descriptive statistics for variables used in the multivariate panel analysis (section 4.2) for the full sample, each country, and industry, respectively. There is considerable variation in the average size of firms between countries with the largest firms based in Italy (US$14,300 million), Spain (US$11,800 million) and the UK (US$10,800 million), while the smallest are in Turkey, New Zealand, and Norway (respectively US$ 551,708, and US$ 1360 million). Note that relative to GDP, the depth of the derivatives market (DERIV) varied considerably with the greatest depth in the UK (1.01), Chile (0.37), and Denmark (0.33) and the lowest depth is 0.02 in Greece, Portugal, Mexico, and Turkey. The mean financial leverage degree for firms is 0.14 with firms in Portugal (Turkey) exhibiting the highest (lowest) leverage levels of 0.24 (0.08). In terms of R&D expense, the mean values vary substantially between countries. The mean value of R&D expense over total revenue is highest in Australia, Belgium, and Sweden (6.16, 5.18, and 5.17, respectively) and the lowest in Greece (0.52), Mexico (0.06) & Portugal (0.00). While the variation of the quick ratio and market-to-book mean values across countries is smaller as the standard deviation of the quick ratio (2.44) and market-to-book value (2.93) is much lower than that of R&D expenses (9.74). In contrast, the standard deviation of the debt/asset ratio is 0.14, which can explain why the leverage mean values vary slightly across countries. Panel C reports the summary statistics by industry. The largest and smallest firms are operating in the telecommunications and technology industries, respectively. Similarly, the telecommunications and technology industries have the highest and lowest leverage levels at 0.25 and 0.07, respectively. The healthcare sector exhibits the highest levels of liquidity (3.07), growth as proxied by *MTBV* (3.93), and *R&D* (15.39). In contrast, the utility sector displays the lowest levels of liquidity (1.21), growth (1.80), and *R&D* (0.08).

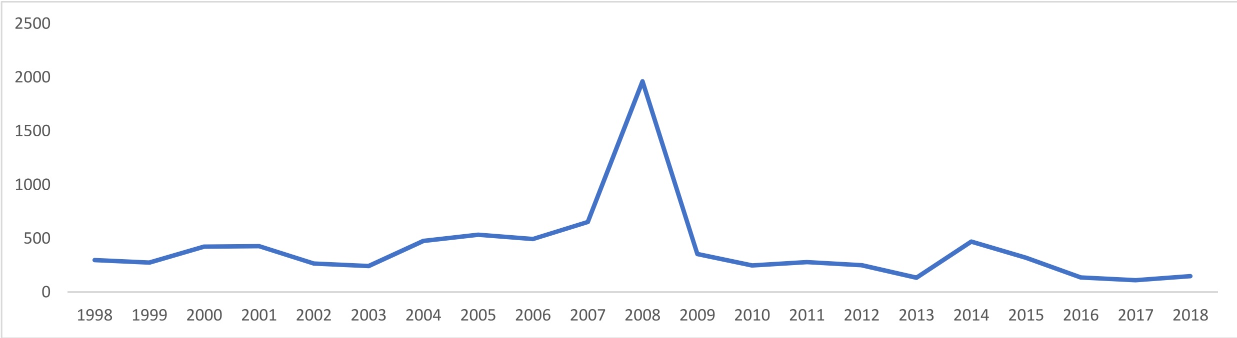

Fig. 1. S&P GSCI index volatility over time.
Notes: Fig. 1 presents S&P GSCI index volatility measured by the standard deviation for the 1998-2018 period.

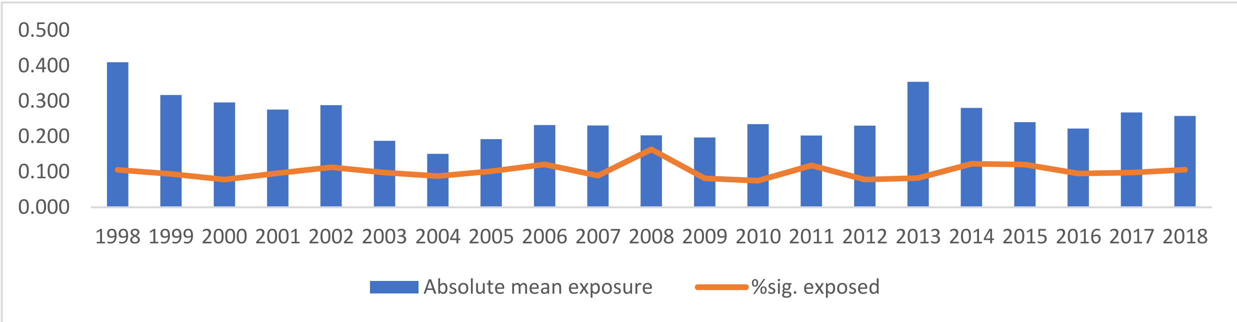

Fig. 2. Commodity price exposure over time.
Notes: Fig. 2 presents the absolute mean commodity price exposure estimates via equation [1] and the proportion of significantly exposed firms at the 5% level of better for the 1998–2018 period.

4.2. Multivariate results and robustness tests

Table 5 presents the estimates for the determinants of corporate commodity exposure using the industry-year fixed effects regression analysis.[1] Columns (1) to (4) display the results for the full sample, firms with positive exposure, negative exposure, and significant exposure at the 5% level or above, respectively. Our results show that firm size *(SIZE)* is negatively associated with corporate commodity exposure at the 1% significance level. The finding is consistent with Mohanty and Nandha (2011) who also report that size has a negative impact on corporate oil price exposure at the 5% significance level. Thus, large firms are less exposed to commodity price risk as they have a greater tendency to hedge due to economies of scale (Carter et al., 2006; Chow et al., 1997; Haushalter, 2000; Laing et al., 2020).

Columns (1) and (2) report a positive relation between market-to-book value *(MTBV)* and corporate commodity exposure for the full sample and negatively exposed firms, respectively. This finding suggests that firms with more growth opportunities experience higher levels of exposure. In contrast, column (4) exhibits a significant negative association between MTBV and corporate commodity price exposure which denotes that firms with high potential investment value tend to encounter lower levels of commodity price risk exposure. The finding aligns with Froot et al. (1993) which highlights that high-growth firms are more likely to implement financial hedges and is consistent with Mohanty and Nandha (2011) which finds a significant negative relation between the market-to-book value and oil risk exposure. Laing et al. (2020) also report a negative relation between growth opportunities proxied by price-to-book value and commodity price exposure.

In contrast to the prior findings of the positive and negative relation between R&D expenses and corporate hedging and exposure, respectively (Dolde, 1995;Géczy et al., 1997; Nance et al., 1993), we find a strong positive relation between R&D expenses and commodity price exposure. The negative relation between debt and R&D expenses is caused by underinvestment costs (Myers, 1977), so firms with more R&D expenses are associated with lower underinvestment costs, causing firms to be less motivated to hedge. Therefore, it exhibits a negative correlation between R&D expenses and hedging. Similarly, other research presents the empirical results with a negative association between R&D expenses and hedging, implying that firms with higher R&D expenses tend to have

[1] The results reported from the Hausman test suggested that fixed-effects model should be utilized in the multivariate regression analysis. For robustness Table A1 presents pooled OLS results in the appendix.

Table 2
Corporate commodity exposure by country.

Panel A:	(1) Observations	(2) Mean $\lvert\alpha_3^i\rvert$	(3) Median $\lvert\alpha_3^i\rvert$	(4) $\alpha_3^i < 0$	(5) $\alpha_3^i > 0$	(6) No. sig.	(7) % sig.
Full sample	90,513	0.238	0.158	43815	46698	9307	0.10
Panel B: By Country							
Austria	408	0.192	0.147	188	220	45	0.11
Australia	4585	0.335	0.212	1943	2642	466	0.10
Belgium	1214	0.211	0.138	538	676	115	0.09
Canada	4007	0.353	0.226	1763	2244	719	0.18
Chile	2067	0.196	0.142	829	1238	218	0.11
Germany	4533	0.257	0.166	1933	2600	387	0.09
Denmark	1312	0.222	0.163	641	671	103	0.08
Spain	1312	0.229	0.148	551	761	145	0.11
Finland	1666	0.220	0.154	786	880	140	0.08
France	5176	0.233	0.157	2424	2752	410	0.08
Great Britain	4402	0.222	0.157	2208	2194	501	0.11
Greece	732	0.225	0.157	364	368	57	0.08
Ireland	291	0.276	0.159	128	163	30	0.10
Italy	1183	0.200	0.139	549	634	129	0.11
Japan	28,731	0.194	0.136	15026	13705	2332	0.08
Mexico	579	0.179	0.129	268	311	56	0.10
Netherlands	1101	0.213	0.153	518	583	106	0.10
Norway	1677	0.373	0.235	789	888	168	0.10
New Zealand	1043	0.248	0.145	447	596	77	0.07
Portugal	521	0.265	0.174	276	245	50	0.10
Sweden	3502	0.253	0.175	1633	1869	329	0.09
Turkey	3396	0.237	0.170	1540	1856	229	0.07
United States	17,075	0.259	0.171	8473	8602	2495	0.15

Notes: Panels A and B of this table present the corporate commodity exposure for the full sample and by country, respectively. Column (1) details the total number of observations. Columns (2) and (3) present the mean and median values of the absolute risk coefficients of commodity exposure, $\lvert \alpha_3^i \rvert$, estimated via equation [1]. Columns (4) and (5) denote the sample that comprises firms that are negatively and positively exposed, respectively. Columns (6) and (7) present the number and proportion of firms that are significantly exposed at the 5% level or better.

Table 3
Corporate commodity exposure by industry.

	(1) (N)	(2) Mean $\lvert\alpha_3^i\rvert$	(3) Median $\lvert\alpha_3^i\rvert$	(4) $\alpha_3^i < 0$	(5) $\alpha_3^i > 0$	(6) No. sig.	(7) % sig.
Basic materials	11553	0.258	0.167	4879	6674	1235	0.11
Consumer cyclical	19182	0.220	0.154	9967	9215	1614	0.08
Consumer non-cyclical	8510	0.186	0.128	4561	3949	710	0.08
Energy	4607	0.496	0.359	917	3690	1764	0.38
Healthcare	7119	0.245	0.166	3939	3180	580	0.08
Industrials	23266	0.211	0.148	11296	11970	2077	0.09
Technology	12184	0.250	0.173	6153	6031	939	0.08
Telecommunications	1369	0.213	0.133	753	616	125	0.09
Utilities	2723	0.168	0.121	1323	1400	263	0.10

Notes: This table presents the corporate commodity exposure by industry. Industry sectors are classified utilizing the Thomson Reuters Industry Classification codes. Please refer to Table 1 for detailed industry classifications. Column (1) details the total number of observations (N). Columns (2) and (3) present the mean and median values of the absolute risk coefficients of commodity exposure, $\lvert\alpha_3^i\rvert$, estimated via equation [1]. Columns (4) and (5) denote the sample that consists of firms that are negatively and positively exposed, respectively. Columns (6) and (7) present the number and proportion of firms that are significantly exposed at the 5% level or better.

greater exposure (Hutson and Laing, 2014).

Moreover, we find significant evidence that the debt-to-asset ratio is positively related to commodity exposure at the 1% significance level. This result is consistent with the findings reported by Laing et al. (2020). However, it is argued that there is a negative relationship between financial leverage and corporate exposure, which is explained by the fact that firms with higher leverage tend to value hedging since it can lower the financial distress costs and prevent the underinvestment problem (Froot et al., 1993; He and Ng, 1998; Nance et al., 1993). Instead, our results can be supported by previous findings of a positive relation between foreign exchange exposure and leverage (Hunter, 2005; Hutson and Stevenson, 2010) because financial distress would increase when high-levered firms

Table 4
Control variable summary statistics.

Panel A: Full sample	(1) SIZE	(2) QUICK	(3) MTBV	(4) R&D	(5) DA	(6) GDP	(7) DERIV
Min	2.48	0.12	0.00	0.00	0.00	3119.57	0.01
Mean	5600.00	1.81	2.53	2.76	0.14	42584.80	0.13
Median	684.00	1.19	1.59	0.00	0.10	41376.39	0.09
Max	266,000.00	24.98	18.81	72.50	0.70	103059.20	1.36
St.dev.	20,300.00	2.44	2.93	9.74	0.14	13505.88	0.22
Panel B: Summary statistics by country							
Country	SIZE	QUICK	MTBV	R&D	DA	GDP	DERIV
Austria	4540.00	1.09	1.82	0.85	0.18	44,898.21	0.06
Australia	2020.00	3.09	3.57	6.16	0.13	49,544.39	0.17
Belgium	9940.00	1.53	2.34	5.18	0.15	41,373.41	0.10
Canada	3610.00	2.36	2.60	3.36	0.18	43,069.15	0.06
Chile	4550.00	2.05	2.92	3.86	0.12	70,944.75	0.37
Germany	9980.00	1.93	2.54	3.45	0.12	40,971.80	0.05
Denmark	1450.00	1.82	2.82	5.05	0.15	54,303.36	0.33
Spain	11,800.00	1.01	2.96	0.60	0.19	28,088.68	0.03
Finland	5480.00	1.36	2.28	1.40	0.15	43,734.80	0.06
France	7340.00	1.41	2.33	3.01	0.13	37,974.23	0.11
Great Britain	10,800.00	1.25	3.61	1.59	0.17	41,187.10	1.01
Greece	1640.00	1.64	1.65	0.52	0.14	22,523.49	0.02
Ireland	3140.00	2.58	2.90	1.67	0.17	59,108.30	0.06
Italy	14,300.00	1.17	2.45	0.86	0.18	33,188.30	0.03
Japan	3520.00	1.69	1.59	1.18	0.10	38,993.01	0.07
Mexico	4970.00	1.74	2.71	0.06	0.19	9217.91	0.02
Netherlands	8440.00	1.31	2.97	2.12	0.14	46,717.99	0.11
Norway	1360.00	2.12	2.40	2.93	0.22	81,197.80	0.08
New Zealand	708.00	1.87	2.84	3.38	0.16	34,951.60	0.08
Portugal	3990.00	0.88	2.31	0.00	0.24	20,476.48	0.02
Sweden	2370.00	1.75	3.12	5.17	0.13	50,451.97	0.11
Turkey	551.00	1.97	1.85	0.56	0.08	9402.37	0.02
United States	9090.00	1.95	3.55	4.63	0.18	49,960.09	0.09
Panel C: Summary statistics by industry							
	(1) SIZE	(2) QUICK	(3) MTBV	(4) R&D	(5) DA		
Basic materials	4150.00	2.13	1.87	2.10	0.14		
Consumer cyclicals	4910.00	1.36	2.46	0.52	0.14		
Consumer non-cyclicals	5570.00	1.26	2.54	0.43	0.14		
Energy	12,400.00	2.04	2.16	2.66	0.19		
Healthcare	4540.00	3.07	3.93	15.39	0.13		
Industrials	4030.00	1.60	2.26	0.80	0.13		
Technology	3170.00	2.38	3.15	5.85	0.07		
Telecomm. Services	31,400.00	1.34	3.16	0.41	0.25		
Utilities	19,200.00	1.21	1.80	0.08	0.31		

Notes: Panel A of this table presents the control variable summary statistics including the minimum, mean, median, maximum and standard deviation values for the full sample of observations (n = 90,513). Panels B and C present the control variable mean value by country and industry, respectively. Control variable definitions are detailed in Table 1. SIZE is reported in US$ million.

do not hedge and therefore unfavourable price movements would increase the corporate exposure. As Laing et al. (2020) analogize the relation between exposure and leverage from foreign exchange exposure to commodity price exposure, our results also strengthen Hunter (2005) and Hutson and Stevenson's (2010) conclusions in the context of commodity price exposure. We do not find evidence that the firm-level liquidity proxied by the quick ratio determines commodity price exposure. Similar insignificant empirical evidence for the association between liquidity and commodity exposure is also provided by Kumar and Rabinovitch (2013).

Furthermore, we provide prominent empirical evidence on a positive association between GDP and corporate commodity exposure, indicating that firms in more developed countries experience greater commodity price exposure due to the attributes of advanced commodity markets. This is also consistent with *DERIV,* which suggests a positive relation between the depth of financial markets and the ability for firms to hedge or manage risk for the full sample and significantly exposed firms in columns (1) and (4), respectively.

Overall, the determinants of corporate commodity exposure play the same role for both negatively and positively exposed firms reported in columns (2) and (3), respectively. In column (4), the magnitudes of all the determinant coefficients increase for the firms which are significantly exposed to commodity price movements. An additional robustness test is reported in column (5) and repeats the analysis excluding the global financial crisis period. Our results are robust to the sub-period analysis.

Table 6 displays the determinants of corporate commodity price exposure across industries from 1998 to 2018. We observe that

Table 5
Determinants of commodity price exposure.

	(1)	(2)	(3)	(4)	(5)
	Panel A: Full sample	Panel B: $\alpha_3^i < 0$	Panel C: $\alpha_3^i > 0$	Panel D: Sig. exposed	Panel E: Excluding GFC
SIZE	−0.021***	−0.022***	−0.021***	−0.038***	−0.023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
QUICK	−0.002	−0.003	−0.002	−0.001	−0.003
	(0.149)	(0.078)	(0.408)	(0.869)	(0.086)
MTBV	0.002**	0.006***	−0.001	−0.016***	0.001
	(0.028)	(0.000)	(0.674)	(0.001)	(0.286)
R&D	0.010***	0.010***	0.012***	0.010***	0.011***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
DA	0.092***	0.085***	0.106***	0.144***	0.095***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP	0.017***	0.016***	0.017***	0.044***	0.017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DERIV	0.008**	0.005	0.008	0.021**	0.007**
	(0.022)	(0.210)	(0.092)	(0.014)	(0.044)
Constant	0.700***	0.707***	0.719***	1.103***	0.735***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	90,513	43,788	46,725	9307	75,767
R-squared	0.105	0.097	0.129	0.177	0.112

Notes: This table presents the industry-year fixed-effects regression analysis examining the determinants of corporate commodity exposure. The dependent variable is the square root of absolute commodity price exposure coefficient ($\sqrt{|\alpha_3^i|}$), estimated via equation [1]. Columns (1) to (4) present the results for the full sample, firms with positive exposure, negative exposure, and significant exposure at the 5% level or above, respectively. Column (5) presents the results for the full sample but excludes the global financial crisis period (GFC)) of 2007–2009. Robust p-values are in the parenthesis. ***, and ** indicate significance at the 1, and 5 levels, respectively.

Table 6
Determinants of corporate commodity exposure by industry.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Basic materials	Consumer cyclical	Consumer Non-cyclical	Energy	Healthcare	Industrials	Technology	Telecomm. Services	Utilities
SIZE	−0.026***	−0.032***	−0.023***	0.003	−0.025***	−0.025***	−0.046***	−0.017	−0.012
	(0.000)	(0.000)	(0.004)	(0.753)	(0.001)	(0.000)	(0.000)	(0.250)	(0.281)
QUICK	−0.026**	−0.026***	−0.017**	0.001	−0.011	−0.012**	−0.023***	−0.014	−0.011
	(0.027)	(0.000)	(0.041)	(0.923)	(0.158)	(0.018)	(0.001)	(0.492)	(0.278)
MTBV	−0.016	0.002	0.014**	−0.027***	−0.010	−0.001	0.002	−0.020	−0.032***
	(0.058)	(0.610)	(0.023)	(0.004)	(0.249)	(0.800)	(0.692)	(0.220)	(0.003)
R&D	−0.000	0.002	−0.009	−0.008	−0.003	0.002	0.004	0.031	0.004
	(0.930)	(0.641)	(0.213)	(0.283)	(0.560)	(0.639)	(0.306)	(0.136)	(0.627)
DA	0.057	0.085***	0.078**	0.148***	0.103***	0.112***	0.103***	0.020	−0.005
	(0.091)	(0.000)	(0.023)	(0.008)	(0.002)	(0.000)	(0.001)	(0.803)	(0.941)
GDP	0.061***	0.005	−0.005	0.124***	0.028	0.010	−0.007	0.043	0.055
	(0.003)	(0.742)	(0.795)	(0.006)	(0.370)	(0.521)	(0.781)	(0.473)	(0.156)
DERIV	0.071**	0.054***	0.052	0.190**	0.097***	0.027	0.004	−0.002	0.037
	(0.013)	(0.004)	(0.061)	(0.014)	(0.001)	(0.145)	(0.916)	(0.976)	(0.384)
Constant	0.349	1.041***	0.911***	−0.692	0.698**	0.837***	1.485***	0.462	0.099
	(0.118)	(0.000)	(0.000)	(0.120)	(0.032)	(0.000)	(0.000)	(0.472)	(0.779)
Observations	11,553	19,182	8510	4607	7119	23,266	12,184	1369	2723
R-squared	0.037	0.047	0.043	0.135	0.051	0.049	0.077	0.040	0.048

Notes: This table presents the results for the fixed effects regression analysis with year controls examining the determinants of corporate commodity exposure by industry. The dependent variable is the square root of absolute commodity price exposure coefficient ($\sqrt{|\alpha_3^i|}$), estimated via equation [1]. Columns (1) to (9) present the results for the basic materials, consumer cyclical, consumer non-cyclical, energy, healthcare, industrials, technology, telecommunications services, and utility sectors, respectively. Robust p-values are in the parenthesis. *** and ** indicate significance at the 1 and 5 percent levels, respectively.

firm size has a negative impact on commodity price exposure for all industries, at the 1% significance level – except for the energy, telecommunications, and utility sector. The negative relation between firm size and exposure is consistent with prior research suggesting larger firms tend to engage in financial hedging, resulting in lower exposure. (Carter et al., 2006; Chow et al., 1997; Haushalter, 2000; Laing et al., 2020). We also report a negative relation between the quick ratio and exposure for most industries except the energy, telecommunications, healthcare, and utility sector – which suggests that firms with higher levels of liquidity are better equipped to handle unforeseen changes in commodity prices. This aligns with the idea of a complementary relation between liquidity and commodity hedging, as previously established by Purnanandam (2008), which implies that firms with higher levels of liquidity are less vulnerable to the effects of commodity price exposure when they engage in hedging.

Interestingly, the market-to-book value is positively associated with the non-cyclical consumer goods and services industry and negatively related to the energy and utility sectors. Firms with higher market-to-book value in the energy and utility sectors have greater growth opportunities, which increases the tendency to hedge and reduces risk exposure (Froot et al., 1993; Hutson and Laing, 2014; Hutson and Stevenson, 2010), but the firms in the non-cyclical industry are exposed to more commodity price risk, as the derivative market maturity does not have an impact on commodity exposure. Leverage positively affects all the industries at the 5% significant level or better except for the basic materials, telecommunication and utility industries. The relation between R&D expenses and exposure is no longer significant at the industry level. The impact of GDP on commodity exposure is only significant in basic materials and energy industries. The positive relation between derivatives turnover and commodity exposure is significant for the consumer cyclical industry, basic materials, energy, and healthcare sectors. Furthermore, the coefficient of DERIV for the energy industry, 0.19, is the largest compared to the remaining industries, implying that the maturity of derivative markets has the most significant impact on commodity exposure among all nine sectors. In terms of the coefficient magnitudes of other prominent factors across industries, leverage (*DA*) and GDP also display the largest coefficients for the energy industry, 0.148 and 0.124, respectively. Hence, our findings on industry analysis indicate that country-level determinants of derivative market maturity and GDP and a firm-level determinant of leverage, are most effective for the energy industry. Our findings regarding prominent determinants in industry analysis are generally consistent with those in Table 5.

5. Conclusion

Using a multi-country sample our research examines the extent to which firms are exposed to commodity price movements and investigates the determinants of commodity exposure for the 1998–2018 period. To the best of our knowledge, we are the first paper to conduct a large longitudinal study with a panel dataset of 90,513 observations from 23 OECD countries. We employ the two-stage approach developed by Jorion (1990) to firstly estimate the extent of corporate commodity price exposure across country and industry. We then examine the determinants of corporate commodity exposure classified for the full sample and industry.

We find that all countries experience significant exposure to commodity price movements. More specifically, North American firms experience the highest level of significant commodity price exposure - with 18% and 15% of firms in Canada and the U.S. significantly impacted by volatile commodity prices. In contrast, only 7% of firms in Turkey and Norway are significantly exposed. The majority of the 23 OECD countries are positively exposed to commodity price movements except for Japan, Great Britain, and Portugal whereby a higher proportion of firms are negatively exposed. Surprisingly, we find that all industries experience significant exposure to commodity price movements ranging from 8 to −11% except for the energy sector whereby 38% of firms experience significant price exposure due to the volatile attributes of energy commodity price changes.

Our multivariate analysis reveals that firm size is inversely related to commodity exposure. While the proportion of R&D expenses over revenues, leverage, and country GDP is positively associated with commodity exposure. We also report a positive relation between *(DERIV)* the depth of financial markets and the ability of firms to hedge or manage risk. Our results are robust to additional tests and industry analysis. The significant determinants obtained in industry analysis are generally consistent with the findings in the main regression analysis, especially regarding the prominent impact of financial market maturity *(DERIV)* and commodity exposure for the basic materials, consumer cyclical, energy and healthcare industries. Our results for industry analysis suggest that the determinants of leverage, GDP and derivative market maturity on commodity price exposure are mostly prominent for the energy industry.

Managers operating firms in the traditional energy and mining sector have long recognized the impact of volatile commodity prices on firm value. Our research finds evidence that all industries have significant exposure to commodity price movements which is of importance to managers who may be unaware of the impact of corporate commodity price exposure on firm value. Our findings are of interest to shareholders and future investors concerned with the extent and determinants of commodity price exposure across industries operating in OECD countries.

Credit author statement

Han – initial econometrics, initial draft; **Laing, Lucey** - conceptualisation, data management, research management, **Vigne** – editing and overview.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Appendix A

Table A1
Determinants of commodity price exposure – pooled OLS

Panel A: Pooled OLS	(1)	(2)	(3)	(4)	(5)
	Panel A: Full sample	Panel B: $\alpha_3^i < 0$	Panel C: $\alpha_3^i > 0$	Panel D: Sig. exposed	Panel E: Excluding GFC
SIZE	−0.022***	−0.022***	−0.023***	−0.040***	−0.024***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
QUICK	−0.005***	−0.005**	−0.005**	−0.005	−0.005***
	(0.002)	(0.011)	(0.023)	(0.569)	(0.002)
MTBV	−0.006***	0.001	−0.011***	−0.029***	−0.006***
	(0.000)	(0.337)	(0.000)	(0.000)	(0.000)
R&D	0.008***	0.009***	0.008***	0.006**	0.008***
	(0.000)	(0.000)	(0.000)	(0.030)	(0.000)
DA	0.062***	0.059***	0.074***	0.095***	0.067***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP	0.042***	0.042***	0.047***	0.070**	0.055***
	(0.000)	(0.000)	(0.000)	(0.013)	(0.000)
DERIV	0.052***	0.065***	0.041***	0.020	0.060***
	(0.000)	(0.000)	(0.002)	(0.453)	(0.000)
Constant	0.453***	0.393***	0.455***	0.868***	0.345***
	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)
Observations	90,513	43,788	46,725	9307	75,767
R-squared	0.116	0.106	0.146	0.198	0.123

Notes: This table presents the results for the ordinary least squares (OLS) regression analysis examining the determinants of corporate commodity exposure. Year, industry, and country control variables are included in the OLS analysis. The dependent variable is the square root of absolute commodity price exposure coefficient (estimated via equation [1]. Columns (1) to (4) present the results for the full sample, firms with positive exposure, negative exposure, and significant exposure at the 5% level or above, respectively. Column (5) presents the results for the full sample but excludes the global financial crisis period (GFC)) of 2007–2009. Robust p-values are in the parenthesis. ***, and ** indicate significance at the 1, and 5 levels, respectively.

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