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On the dynamic links between commodities and Islamic equity

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ABSTRACT

This paper investigates whether commodities offer potential diversification benefits for Islamic equity index investors in light of possible financialization of commodity markets. Using MGARCH-DCC and Wavelet Coherence analyses, our findings reveal that correlations between commodity markets and the Dow Jones Islamic Market World Index are time-varying and highly volatile throughout the January 1999–April 2015 period. A substantial and persistent increase was observed in the return correlations between commodities and Islamic equity at the onset of the 2008 financial crisis. However, trends in the recent two years suggest that this association is heading towards its pre-crisis levels, offering again diversification benefits for Islamic equity holders. These benefits vary across different commodities in various time scales. Overall, gold, natural gas, soft commodities, grains and livestock are better portfolio diversifiers than oil and other metals. Relative to medium-to-long term investors, short-term investors (less than 32 days horizon) gained better diversification benefits in most commodities during bullish, bearish and market recovery periods. These findings have implications for investors who are heterogeneous in risk tolerance and time preference as well as for policymakers who are concerned with market stability.

1. Introduction

Have commodities and equity become a "financialized market of one"? Is such oneness persistent? Do diversification benefits still exist? Evidence behind these enquiries offers important insights for policymakers, governments, traders and investors, and constitutes the main motivation for this paper. To assess the viability of commodities as an alternative asset class for Islamic equity investors, we present evidence on the extent to which returns in commodities and Islamic equity markets move in sync in both time and frequency domains. Our findings reveal that, throughout the January 1999–April 2015 period, correlations between commodities and Islamic equity were highly volatile and time sensitive.[1] While there had been a minimal correlation between commodities and Islamic equity prior to 2008, the relationship has strengthened since 2008, possibly attributed to the anomaly arising from the global financial crisis. Trends in the recent two years, however, suggest that the links between commodities and Islamic equity are heading towards their pre-crisis equilibrium, offering again potential diversification opportunities for investors. Divergence in correlations reveals that the behaviour of commodities is heterogeneous with varying potential for diversification. Overall, gold, natural gas, soft commodities, grains and livestock are better portfolio diversifiers than oil and other metals. Relative to medium-to-long term investors, short-term investors (less than 32 days horizon)

[1] The extended period of study until April 2015 allows for the capturing of information from recent events such as the dramatic drop in oil prices, the "peaking" possibility of the commodity super-cycle, the recovery of the US economy, the greater economic uncertainty in the Eurozone and China's economic growth trajectory, the heightened geopolitical risks in the Middle East, the growth of socially responsible investments, including Islamic finance, the tighter financial regulation and the higher bank capital requirements.

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gained better diversification benefits in most commodities during bullish, bearish and market recovery periods.

Tightened correlations and heightened asset volatilities suggest that commodities and equity tend to move towards a "market of one" during global economic downturns. For Islamic equity investors, this implies that diversification benefits may not be as strong when it is needed the most. In most cases, such "oneness" is persistent in the medium-to-long-term. However, evidence of financialization of commodity markets in the short run remains equivocal as inferred from our analysis. Against this backdrop, our findings contribute to two strands of research: the possible existence of financialization for policy and commercial considerations in different market conditions, and the potential benefits of investment diversification across different time scales.

From a traditional perspective, commodity and equity markets are inversely related and, therefore, commodities are considered to be good portfolio diversifiers (Kang, 2012). However, the increased financialization of commodity markets and the impact of financial factors on commodity price volatility have contested this interpretation.[2] With exchange-traded derivatives on commodity markets being 20 to 30 times larger than physical production and with massive speculations on temporary price movements, the real markets are now transformed into financial markets driven by market sentiments rather than fundamentals (Domanski and Heath, 2007; Silvennoinen and Thorp, 2013). Therefore, the ensuing short-term commodity price movements cannot be fully explained by the supply and demand of commodity users (United Nations, 2012).[3] Contemporary trends in commodity markets have cast scepticism on the diversification benefits of commodity investments. An increasing correlation across equity and commodity returns would discourage investors from choosing commodities as a refuge during periods of stress in traditional asset markets. If more investors are including commodities in their portfolios, bad news in one market, as a result of a growing set of common state variables driving stochastic discount factors, may cause liquidation across several markets (Kyle and Xiong, 2001). This will generate more variation in correlation and volatility, and minimize diversification benefits for both equity and commodity portfolio managers (Kyle and Xiong, 2001; Silvennoinen and Thorp, 2013). On the other hand, studies have postulated that "real economy" factors such as the increasing demand from large developing countries and regular supply shocks are key to explaining commodity price volatility, and that the underlying factors that influence commodity prices are distinct from those that affect the value of stocks and bonds (Daskalaki and Skiadopoulos, 2011; Geman and Kharoubi, 2008).[4] Understanding the dynamic link between commodities and equities is, therefore, important.

To date, studies on the link between commodities and equities have mainly focused on mainstream conventional equity indices such as the US S&P 500 and Dow Jones global equity indices. With the launch of Islamic equity indices, Islamic funds and global sukuk in several markets since the 1990s, Islamic finance industry has been fast emerging as a viable market offering alternative asset classes. Although the industry has a small share of global financial market with a total asset size of US$ 2 trillion in 2014, it is set to grow 15–20% annually in many of its core markets and is expected to expand the international reach of issuers and investors. Growing demands from a significant, and relatively unbanked, Muslim population (23.4% of global population in 2010) as well as faith-based and socially responsible investors have been key growth drivers of the Islamic finance industry.[5] Within the Islamic asset allocation universe, equity funds represent one-third of Islamic funds worldwide. Islamic equity indices have proven to be valuable to Islamic fund managers, who have benefited from standardized screening methodologies and the growing number of Shari'ah-compliant securities, as well as to those investors searching for portfolio diversification and ethical investment opportunities (Islamic Financial Services Board, 2014). The screening excludes businesses engaged in immoral activities (e.g., weapons, gambling) and firms that exceed a given limit of leverage and interest-bearing investments. As a result, large non-compliant firms are typically excluded from the pool of investable assets. This restricts the Shari'ah compliant investable universe such that the portfolio exhibits more volatile returns due to under-diversification, composition of smaller firms, and sector concentration (Hussein and Omran, 2005).[6] Yet, some studies have shown that levered firms tend to exhibit an inverse relationship between current returns and stock volatility (Black, 1976; Christie, 1982). In particular, the low leverage and asset-backed nature of Islamic equities imply that real and financial sectors are closely linked, and that exposure to volatility spillovers are limited (Majdoub and Mansour, 2014). Hence, the viability of Islamic equity as a diversifier to the conventional equity portion of the portfolio has been put under scrutiny in previous literature.[7]

Limited investment opportunities in the Islamic market render the commodities market a natural complement to Islamic investment. Tangible and spot commodities meet the requirements of non-interest-bearing transactions and ethical screening. Our study contributes to the literature by focusing on the time-varying relationship between commodities and Shari'ah-compliant equities.[8] We examine whether Islamic investors could retain the opportunity to reap diversification benefits by incorporating various types of commodities into their equity portfolios across short, medium and long term horizons in different market

[2] Financialization of commodity refers to "a situation in which the price of an individual commodity is not only determined by its primary supply and demand, but also by several financial factors and investors' behaviour in derivative markets" (Creti et al., 2013, p. 17). United Nations Conference on Trade and Development (UNCTAD) defines the term "financialization of commodity trading" as referring to "the increasing role of financial motives, financial markets and financial actors in the operation of commodity markets" (United Nations, 2011). Financial contracts on commodities have been present since the 18th century in the rice market in Japan (Kolb and Overdahl, 2007). See Creti and Nguyen (2015) for other perspectives of financialization of the commodity markets.

[3] Price volatility has been attributed to greater market participation by financial investors who tend to trade in various markets. This phenomenon led the UNCTAD to call for an urgent global policy response to prevent recurrent price instability in the financial markets, rather than in the physical markets (United Nations, 2012).

[4] Global economic growth especially in emerging market economies (notably India and China) has been the main driver of growing demand for commodities. These economies have witnessed progressing urbanization, increasing industrialization, changes in consumption behaviour, growing populations and higher income growth in the recent decade. From the supply side, there have been low investments in commodity production and infrastructure projects for a long period due to low commodity prices in the 1990s and moderate global demand growth. Adverse weather conditions, geopolitical uncertainties, export restrictions, and subsidies have contributed to supply shocks (G20 Study Group on Commodities, 2011).

[5] Other factors that have contributed to the growth of Islamic finance industry include the increased investments in public infrastructure projects, strong economic growth in countries where the industry exists and the abundance of petrodollar liquidity. The risk-sharing characteristics and the prohibition of speculation in Islamic finance offer a value proposition that promotes financial stability and healthy levels of social capital, which appeals to policymakers, regulators and investors (Askari et al., 2011; Ng et al., 2015).

[6] As of March 2015, the Dow Jones Islamic Market World Index has only 2590 components compared to the global universe of 7257 components in the Dow Jones Global Index. Islamic equity indices are typically growth and small-cap focused, while conventional indices are value and mid-cap oriented (Girard and Hassan, 2008). The effect of small firms and sector concentration on performance is debatable. Hussein and Omran (2005) argue that basic materials, consumer cyclicals, industrial, telecommunication industries and small firms are the driving forces in the positive abnormal returns of Islamic index.

[7] Concerning the mainstream conventional financial market, studies on global stock return co-movements and time-varying world market integration have been, inter alia, conducted by Bekaert and Harvey (1995); Bekaert et al. (2009) and Baele et al. (2010).

[8] There are several core Islamic finance markets in Organization of Islamic Cooperation (OIC) member countries. Energy, food and agriculture sectors are the top sector clusters within the 57 OIC member countries that provide the best opportunities for sector investment strategy. The US$ 1.3 trillion energy sector exports in 2013 accounted for 43% of global exports while food and agriculture exports amounted to 8% of the world's total. The rise in infrastructure spending and industrial growth in some OIC markets (with more than US$ 2 trillion planned projects) also provides positive investment opportunities to the metal sector (Thomson Reuters and DinarStandard, 2015).

conditions. To the best of our knowledge, this study is the first to investigate such a relationship in both time and frequency domains. We consider 17 commodities from five categories, namely energy (crude oil and natural gas), precious metals (gold and silver), industrial metals (aluminium, copper, zinc, lead and nickel), grains and livestock (corn, soybeans, wheat and cattle), soft agriculture (cocoa, coffee, sugar and cotton). Such a variety of commodities allows us to examine whether commodities can be considered as a homogeneous asset class vis-à-vis Islamic equity.

A battery of econometric models is combined to capture the dynamic and multi-time scale nature of our research. First, the multivariate generalized autoregressive conditional heteroskedasticity dynamic conditional correlation (MGARCH-DCC) model is used to assess the evolution of volatilities and correlations between commodity and Islamic equity over time as well as their potential suitability as hedges for each other. This model has been widely used in related studies (Büyükşahin et al., 2010; Choi and Hammoudeh, 2010; Creti et al., 2013; Vacha and Barunik, 2012). Second, we apply the Wavelet coherence analysis for the study of time series in the time-frequency domain to uncover the dynamics of correlations between commodities and equity. The application of wavelets uncovers complex price-correlation patterns without resorting to ad-hoc specified time or frequency frameworks. This model has, among others, been used by Madaleno and Pinho (2014) (oil and stock interactions), Vacha and Barunik (2012) (co-movement of energy commodities), and Dewandaru et al. (2014) (Islamic and conventional equity markets). Specifically, we first use MGARCH-DCC because variations in correlations and volatilities in higher frequency levels are richer and, subsequently, to have a better picture, we employ Wavelet coherence to assess the co-movement between the assets on medium and high scales. Since commodity and equity markets are complex systems of interacting agents with varying term objectives and heterogeneous risk tolerance, these models collectively provide a more in-depth and robust analysis that seeks to reinforce the understanding of the subject matter.

This paper is organized as follows. Section 2 discusses relevant and recent literature on the link between commodity and mainstream equity as well as the performance of Islamic equity. Section 3 discusses the data and stylized facts and Section 4 outlines the methodology. Section 5 presents the results and discusses the possible explanations for the findings. Section 6 concludes with research implications.

2. Literature on commodity and equity

2.1. Link between commodity and mainstream conventional equity

Traditional wisdom suggests that commodities and equities do not move in sync and are negatively correlated (Bodie and Rosansky, 1980; Bodie, 1976; Fama, 1981). This feature of commodity returns has been observed over long-term horizons and, hence, makes the commodity market an attractive venue for portfolio diversification. For example, over the 1959–2004 period, Gorton and Rouwenhorst (2006) document that commodity futures offered the same average returns and risk premiums as US equities, while having negative correlations with equity returns. Kang (2012) reports that the S&P Goldman Sachs Commodity Index had correlations of −0.02 and −0.08 with global equity and fixed income respectively from December 1972 to June 2012. Such negative correlations can be attributed to the different behaviours of commodities over business cycles. Commodities are real assets that have an intrinsic value and tend to move in parallel with inflation. Relative to equities, commodities offer an effective hedge against inflation, unexpected inflation and changes in expected inflation (Kat and Oomen, 2007). Commodity futures are also less risky than equities as "crashes" in commodities most likely occur on the upside (Gorton and Rouwenhorst, 2006). In addition, traditional risk factors historically affecting equity returns have had limited forecasting power in commodity markets (Erb and Harvey, 2006).[9]

Yet, recent empirical studies have suggested that the relationship between commodities and stock returns follows a dynamic pattern, and that the observed correlations vary from one study to another. One study shows that the conditional correlations between commodity futures and S&P 500 returns have felt over time since the 1980s and tend to fall in periods of above-average volatility in stock markets (Chong and Miffre, 2010). With the exception of industrial metals having higher co-movement with equity markets in 2003, both equity and commodity market returns tend to exhibit almost no relation in the 1990s and during most of the 2000s (Delatte and Lopez, 2013). In another study, it was found that equity and commodity return series fluctuated substantially (as low −0.5 and as high +0.5) throughout the 1991–2008 period. Much of the time, the dynamic conditional correlation estimates were close to zero. In fact, the sharp increase of correlations in fall 2008 was lower than their peaks in the past decade (Büyükşahin et al., 2010). These findings of low or negative correlations are possibly due to samples from relatively tranquil periods in the financial market and the economy.

Recent developments in commodities and financial markets, however, have questioned the role of commodities as a diversifying asset class and a refuge during financial turmoil. Many recent studies are sceptical on the diversification proposition because of the increasing integration between traditional and commodity markets, particularly since the early 2000s. This growing link has, inter alia, been attributed to the sustained global demand-driven commodity price shock (Kilian, 2009), the increase of financial institutions' share of open interest in commodity futures markets (Tang and Xiong, 2012), and the 2008 global financial crisis. For example, Delatte and Lopez (2013) find that the returns of most commodities and major equity indices tend to move together most of the time, i.e., the dependence between commodity and stock markets is not different between bearish and bullish periods. Silvennoinen and Thorp (2013) find that correlations between S&P 500 returns and the majority of commodity returns gradually increased in many cases over the 1990–2009 period, and rose sharply in the recent crisis. Evidence of significant volatility transmission among commodity markets and the S&P 500 index since 2008 was also identified by Creti et al. (2013). Interestingly, the largest drop in correlations was at the time of the crisis but only for a very short period. This temporary decoupling can be attributed to the collapse of the stock market that reduced the conditional links between stock and commodity returns. Based on these findings, Creti et al. (2013) suggest that the financial crisis has increased the financialization of most commodities. These recent findings show that diversification benefits of commodities to equity market investors have weakened during the crisis. However, it is worth noting that there has been a correlation reversal between commodities and equities in the last few years based on recent market research and financial reports (Bain, 2014; Kaminska, 2014; Sheppard, 2014; Terazono, 2015).

The correlations between equities and different types of commodities can also vary substantially. Correlations between equities with energy and non-energy commodity indices can range between −0.40 and 0.45 (Büyükşahin et al., 2010). The relationship between oil prices and various sector equity returns remained ambiguous for the 1992–2012 period, with oil being mostly the lagging variable (Madaleno and Pinho, 2014). Since the 2008 crisis, energy and industrial metals (Brent oil and copper) have been the most integrated with equity markets (Delatte and Lopez, 2013). Gold is considered as a safe-haven asset given its negative and diminishing correlations in times of declining

[9] There are several options for inclusion of commodities into investment portfolios: shares of commodity producers, futures contracts (directly or through exchange traded funds and exchange traded notes), commodity indices, and commodity in kind. For recent studies on commodities, please see Berger and Uddin (2016); Maghyereha et al. (2016), Nicola et al. (2016), among others.

stock prices (Baur and McDermott, 2010). Other precious metals, however, have experienced increasing correlations with equities after the 2003 Iraq war (Choi and Hammoudeh, 2010) and also after the 2008 financial crisis (Creti et al., 2013). In terms of agriculture commodities, sugar has no particular link with the US stock markets, while the speculation phenomenon is highlighted for coffee and cocoa (Creti et al., 2013). In a study regarding the volatility behaviour of oil, industrial commodity and equity markets in a regime switching environment, Choi and Hammoudeh (2010) find that Brent oil and WTI crude oil exhibit higher volatility persistence over time as a reaction to geopolitical crises, while copper is sensitive to financial crises. Such heterogeneity suggests that a re-examination of the commodities-equities nexus is still a worthwhile pursuit.

2.2. Performance of Islamic equity

Despite its appealing principle of risk sharing, the viability of Islamic equity as an alternative asset class in practice is a subject of debate. Findings have not been conclusive and can be classified into four strands. The first strand demonstrates that there are no significant differences in performance between Islamic and conventional equity indices. This implies that ethical and financial screening does not have adverse effects on Islamic index performance. For example, Hussein (2004) finds that Islamic index performs as good as the FTSE All-World index over the 1996–2003 period. After controlling for market risk, size, book-to-market, momentum, local and global factors, Girard and Hassan (2008) find similar reward-to-risk ratios and diversification benefits for both the FTSE Islamic indices and their conventional counterparts from 1999 to 2006 (see also Abbes (2012)). The second strand points to the underperformance of Islamic indices in bearish market conditions, a finding particularly evidenced during the Dotcom crisis (2000–2003) and possibly attributed to the relatively high concentration of these indices in the technology sector (Hussein and Omran, 2005; Hussein, 2004, 2007).

The third and most widely documented strand of findings relates to the overall higher performance of Islamic equity indices, particularly during the 2008 financial crisis. Recent studies such as Ho et al. (2014) reveal that Islamic indices (Dow Jones, Morgan Stanley Composite Index, Financial Times Stock Exchange, Russell, Kuala Lumpur, Jakarta and Swiss) outperformed their conventional benchmarks during the 2008 global financial crisis, while Dow Jones, Kuala Lumpur and Swiss Islamic indices had better risk-adjusted returns during the Dotcom crisis. However, results remain inconclusive during non-crisis periods. Examining 24 global and regional indices (MSCI, S&P and Dow Jones), Ashraf and Mohammad (2014) find that Islamic indices generally performed better than conventional indices from 2002 to 2012 and exhibited lower systematic risk in the bearish period. Although there were no abnormal returns on a global basis, there were positive abnormal returns in regional indices from Europe and Asia. In another study by Al-Khazali et al. (2014), global, European and US Islamic indices dominated their conventional peers in the 2007–2012 period, although conventional indices stochastically dominated Islamic indices in all markets at the second and third orders, except in the European market.

The degree of dependence, patterns of causality, co-movements and linkages between Islamic and conventional indices and their link to other macroeconomic factors have recently emerged as an important research focus, constituting the fourth strand of literature. In a study on the dynamic dependence of Islamic with conventional indices for the 1999–2013 period, Hammoudeh et al. (2014) find that the Dow Jones Islamic Market Index is significantly dependent on three major global conventional equity indices (Asia, Europe, and the US) and factors common to the global financial system such as oil prices, stock market implied volatility, the US 10-year Treasury bond interest rate, and the 10-year European Monetary Union government bond index. The dependence appears to be time-varying and asymmetric between bull and bear market conditions. Yilmaz et al. (2015) discover that the influence of firm fundamentals and real economic factors in driving Islamic equity returns have weakened in the last decade because of the financialization process. As such, Islamic equity indices are, through financial contagion channels, likely susceptible to global shocks affecting the financial system. In terms of causality, Ajmi et al. (2014) demonstrate a significantly positive causality between both Islamic and conventional equity markets, as well as causality between Islamic equity market and other financial and risk factors. They also find a link between the Islamic equity market and interest rates and interest-bearing securities. In contrast, Shamsuddin (2014) reveals that the aggregate portfolio of Islamic equities is immune to interest rate risk and that some Islamic sector portfolios have lower exposure to such risk compared to their mainstream counterparts.

Concerns regarding the spillover of one market or region to another have increasingly gained attention in the literature. On the one hand, Dania and Malhotra (2013) find evidence of a significantly positive spillover from conventional market indices to Islamic indices in North America, European Union, Far East and Pacific markets. On the other hand, Majdoub and Mansour (2014) find no spillover effects from the US market into the emerging Islamic equity markets of Turkey, Indonesia, Pakistan, Qatar and Malaysia. Examining co-movements of stock markets on multi-timescales, Dewandaru et al. (2014) find that while Islamic markets in the West and emerging markets were less exposed to structural shocks during the subprime crisis, Islamic markets in Asia-Pacific economies experienced, because of their less diversified portfolios, higher long-term volatility through traditional trade linkages with the US. However, Asian Islamic markets have lower exposure to financial leverage, thus providing hedging benefits for opportunistic investors who employ leveraged strategies with short-to-medium-term horizons (see also Rizvi et al., 2015). On balance, these studies suggest that Islamic equity is not necessarily decoupled from the conventional financial system, and may not offer the desired diversification benefits at all times.[10] Building on this body of existing research, our paper seeks to shed additional light onto the viability of commodity investment vis-à-vis Islamic equity, a subject which has not been extensively explored.

3. Data and stylized facts

We take a passive investment perspective in analysing the relationship between commodities and equity index investments.[11] We use log returns of daily spot prices for 17 commodities derived from the Dow Jones Commodity Index over the 20 January 1999–10 April 2015 period to assess correlations across asset classes. Spot prices are used in our analysis to minimize issues concerning rollover of futures contracts, which is an essential consideration in volatility analysis (Creti et al., 2013; Vivian and Wohar, 2012). Spot returns are also the main drivers of the variation in commodity returns over short-term horizons while roll returns are important factors that contribute to commodity excess returns over longer horizons (Kang, 2012; Stockton, 2007). The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), energy commodities refer to crude oil (OILC) and natural gas (GASN), the soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC). As commodity markets are heterogeneous, the variety of commodities used in this paper offers potential insights into sector exposures in determining

[10] Other recent literature on Islamic equity markets include Álvarez-Díaz et al. (2014); Majdoub et al. (2016); Sensoy et al. (2015).

[11] Based on modern portfolio theory, the relevant information matrix for passive investor includes the expected returns, variances of returns and cross-asset correlations (Büyükşahin et al., 2010).

the risk and return of commodity indices. Price series are quoted in US dollars.

For equity, we adopt the corresponding daily data from Dow Jones Islamic Market World Index (DJ Global Islamic Index), the first global Islamic index established in 1999 to track globally traded stocks that pass rule-based screens, e.g., excluding companies that do not comply with leverage caps or lines of business typically viewed as incompatible with the Shari'ah. DJ Global Islamic Index is allocated to 59 countries, with the US having the highest allocation of companies (21.98%), followed by Taiwan (9.62%), Japan (8.65%), South Korea (6.99%), India (5.68%), Hong Kong (4.75%), United Kingdom (4.52%), Canada (3.98%), Malaysia (3.86%) and a blend of other developed, developing and emerging markets. The index comprises 2589 companies from 26 industries, ranging from technology equipment (231 companies), industrial goods (204 companies), pharmaceuticals and medical research (198 companies) to fossil fuels (179 companies), mineral resources (168 companies), food and beverages (154 companies), among others. In terms of market capitalization, the US has the highest allocation (60.48%), followed by Japan (5.48%), United Kingdom (5.37%), Switzerland (5.09%) and other markets.[12]

DJ Global Islamic Index is developed based on a well-recognized Shari'ah screening methodology and is a widely adopted Shari'ah-compliant benchmark (Hammoudeh et al., 2014; Rahman et al., 2010).[13] To be accepted as Shari'ah-compliant, a company must meet the following screening criteria: (i) the qualitative screening approach – any involvement in activities such as sale and production of alcoholic beverages, broadcasting and entertainment, conventional financial services, gambling, hotels, insurance, media agencies (except newspapers), pork-related products, restaurants and bars, tobacco, weapons and defence; (ii) the quantitative screening approach – all of the following must be less than 33%: (a) the total debt divided by trailing a 24-month average market capitalization; (b) the sum of a company's cash and interest-bearing securities divided by the trailing 24-month average market capitalization; and (c) accounts receivables divided by the trailing 24-month average market capitalization. It can be inferred from these criteria that the screening process would result in a set of equities that are relatively resistant to external shocks due to lower leverage.[14]

Table 1 reports the descriptive statistics of returns for DJ Global Islamic Index (ISLX) and commodities. Average returns are quite small relative to standard deviations (StD). All the series, except for natural gas, coffee, corn and wheat, are negatively skewed suggesting a high probability of negative returns. Large values of kurtosis (Kurt) indicate that the return distributions have fat tails. Returns are not normally distributed at 5% significance level based on Jarque–Bera (JB) test. On average, crude oil, gold, copper and lead provided the highest returns compared to other assets. The lowest yields are displayed by cotton, coffee, natural gas, and aluminium. Natural gas, nickel, coffee, and crude oil are among the most volatile assets. The least volatile ones are livestock, Islamic equity, and gold. As for coefficients of variation (CV/volatility per unit of return), the riskiest assets are cotton, natural gas, and coffee; while the least volatile per unit of return are gold, cattle and copper.

Table 1
Descriptive statistics.

	Mean	Max	Min	StD	Skew	Kurt	CV	JB
Equities								
ISLX	0.013	9.775	−8.186	1.065	−0.30	9.92	80.10	8504.9*
Precious metals								
GOLD	0.034	8.824	−9.811	1.153	−0.13	9.46	34.21	7360.8*
SILV	0.027	12.470	−19.489	1.974	−0.93	10.99	72.29	11,855.4*
Oil and gas								
GASN	0.008	18.762	−16.699	3.108	0.08	5.37	407.93	996.2*
OILC	0.035	13.342	−16.544	2.190	−0.32	6.53	62.04	2269.5*
Softs								
COCO	0.017	9.971	−10.007	1.908	−0.16	5.71	110.91	1312.8*
COFF	0.006	21.202	−13.386	2.194	0.27	8.87	371.78	6136.2*
COTT	0.002	8.542	−7.119	1.732	−0.03	4.32	769.96	307.6*
SUGA	0.013	8.414	−12.364	2.073	−0.24	5.02	164.48	762.6*
Grains and livestock								
CORN	0.014	8.661	−8.127	1.735	0.03	5.13	127.56	802.5*
SOYB	0.014	6.705	−7.340	1.546	−0.21	5.15	110.39	845.4*
WHEA	0.016	8.795	−9.973	1.906	0.05	5.06	121.42	753.2*
CATT	0.019	5.422	−6.356	0.906	−0.17	5.18	46.71	856.5*
Industrial metals								
ALUM	0.009	5.927	−8.257	1.338	−0.26	5.66	149.83	1293.1*
COPP	0.034	11.902	−10.380	1.690	−0.12	7.67	50.29	3849.3*
LEAD	0.033	12.839	−13.033	2.017	−0.24	6.93	60.94	2756.2*
NICK	0.025	13.157	−18.221	2.315	−0.14	6.82	92.59	2590.1*
ZINC	0.020	9.326	−11.127	1.839	−0.20	6.32	91.48	1973.3*

Notes: This table reports the descriptive statistics of returns for Dow Jones Islamic Market World Index (ISLX) and commodities. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC). JB refers to the empirical statistic of the Jarque–Bera test for normality, and * denotes the rejection of the null hypothesis of normality at the 1% significance level.

The discussion above is supplemented with Fig. 1, which presents the price dynamics of DJ Global Islamic Index (ISLX) and the five categories of commodities (normalized, 20/01/1999 = 100). It can be observed that the price patterns of the five different types of commodity prices and the DJ Global Islamic Index are not similar during the examined period. For example, precious metals and softs reached their peak in 2011, while other commodity groups reached their highest peak in 2008.

4. Methodology

4.1. Multivariate GARCH: conditional correlation returns and volatilities

We apply the multivariate GARCH-DCC (MGARCH-DCC) model introduced by Engle (2002) to assess the time-varying volatility and correlation between commodities and Shari'ah-compliant equities. A Dynamic Conditional Correlation (DCC) improves modelling flexibility by relaxing the assumptions about the invariability of means and variances of variables and co-movements. This is done by calculating a current correlation between the variables as a function of past realizations of both the volatility within the variables and the correlations between them. The link between variables can be observed to vary over time in a way that not only depends upon whether and to what degree the variables are moving in the same direction but also takes into account the variance history that each series has experienced. The DCC approach allows series to have periods of positive, negative, or zero correlation. Thus, both direction and strength of the correlation can be observed.

[12] Calculated as of end March 2015 (DJ Global Islamic Index Factsheet).

[13] Dow Jones Islamic Market World Index provider has an independent Shari'ah Supervisory Board and its screening criteria have been adopted by the Auditing and Accounting Organization of Islamic Financial Institutions (AAOIFI). The index helps lower research, monitoring and compliance costs of investors and asset managers who seek to invest in Islamic investments (Hammoudeh et al., 2014).

[14] Although the Shari'ah compliant investable universe is smaller, the screening process ensures that Islamic equity investors are not disadvantaged compared with their non-Islamic (DJ Global or Sustainability) counterparts. Furthermore, high correlation patterns are observed between the Islamic and Global indexes, and to a slightly lower degree, for the Islamic and Sustainability index-pairs (see Fig. A in Appendix). Detailed results are available upon request.

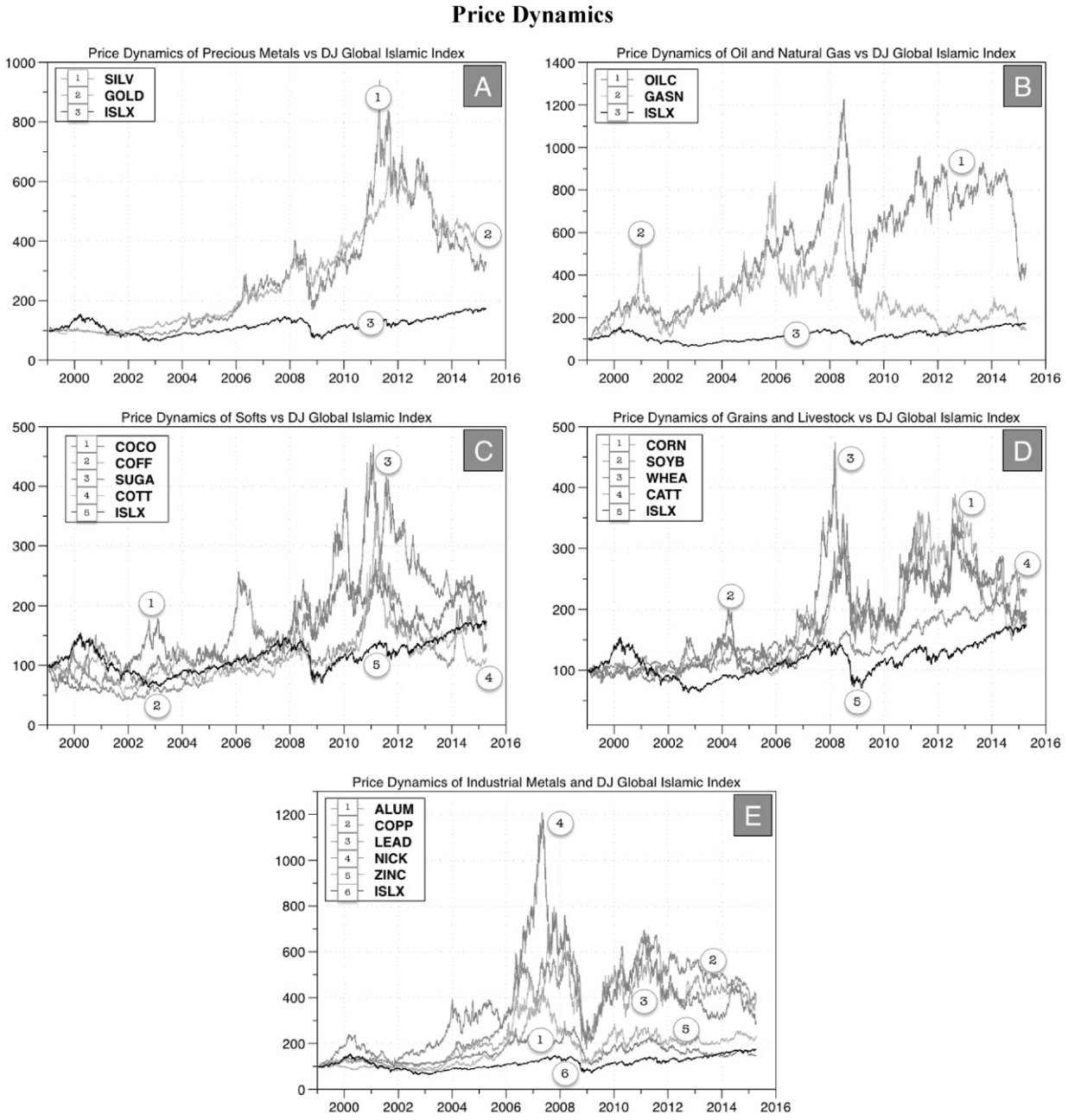


Fig. 1. Price dynamics of commodities and Islamic equity (normalized prices). Notes: This figure shows the daily price behaviour of Dow Jones Islamic Market World Index (ISLX) and commodities from January 1999 to April 2015. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC).

The correlation will increase and become positive when two series move in the same direction. When the series move in opposite directions, the correlation decreases and may become negative (Lebo and Box-Steffensmeier, 2008). Thus, the estimates of dynamic correlation can be used to analyse how significant events have an effect on the integration between the variables.

First, in search for a suitable distribution, we run maximum likelihood tests on two kinds of distribution of returns, namely the standard normal and *t*-distributions. Next, we use a two-step approach for the estimation of DCC models: (1) using a GARCH model to obtain univariate volatility parameters; (2) using residuals as inputs for the estimation of time-varying correlations (see Pesaran and Pesaran, 2009 for details of mathematical derivations).

4.2. Wavelet coherence

In contrast to the GARCH-DCC method, the Wavelet Coherence technique allows us to assess the co-movement between Islamic equities and commodities in both time-frequency spaces, hence, complementing our MGARCH-DCC results. The wavelet coherence method, used by Grinsted et al. (2004) and Aguiar-Conraria and Soares (2011), employs a bivariate framework, which is based on a continuous wavelet transform (with Morlet set to 6),[15] allowing for various forms of localization. The technique allows us to analyse correlation patterns between financial

[15] We use the wavelet coherence package for MATLAB by Grinsted et al. (2004). The package is available at: http://www.glaciology.net/wavelet-coherence.

data during different regimes without having to sub-divide the data into different sample periods. In view of its ability to decompose the time-varying co-movements into different investment horizons, the Wavelet coherence facilitates tailored strategies to various investors with different investment horizons. Standard time series econometric methods analyse the time and frequency components separately, whereas wavelet coherence allows for a three-dimensional analysis by simultaneously considering the time and frequency components, as well as the strength of the correlation between the time-series components. In sum, the wavelet coherence method has four main advantages: (1) allowing the measurement of a dynamic relationship between return series rather than assuming a static relationship (Bodart and Candelon, 2009); (2) the ease to identify structural breaks[16] when a complete breakdown in correlation or a shift in the relevant frequency band occurs; (3) identifying the causal relationship at various frequencies; and (4) wavelet analysis is model-free, making it a useful tool compared to other methods that depend on parameters as well as the estimation method (Vacha and Barunik, 2012). Wavelet coherence is defined as follows (Grinsted et al., 2004):

$$R_n^2(s) = \frac{\left|S\left(s^{-1}W_n^{XY}(s)\right)\right|^2}{S\left(s^{-1}\left|W_n^X(s)\right|^2\right)\cdot S(s^{-1}\left|W_n^Y(s)\right|^2} \tag{4.2.1}$$

where S is a smoothing operator; without smoothing, the wavelet coherency would be identical to 1 at all scales and times. Smoothing is achieved by convolution in time and scale.[17]

$$S(W) = S_{scale}(S_{time}(W_n(s))) \tag{4.2.2}$$

where S_{scale} and S_{time} represent smoothing on the wavelet scale axis and in time, respectively. Typically, we use such smoothing operator that is similar to characteristics of the underlying wavelet. In our case, since we use the Morlet wavelet, the more suitable smoothing operator is the one given by Torrence and Webster (1999):

$$S_{time}(W)_s = \left(W_n(s) * c_1^{\frac{-t^2}{2s^2}}\right)\Big|_s ; S_{time}(W)_s = (W_n(s) * c_2\Pi(0.6\,s))\big|_n \tag{4.2.3}$$

where c_1 and c_2 are normalization constants and Π is the rectangle function, while 0.6 factor is the scale decorrelation length for the Morlet wavelet (Torrence and Compo, 1998).

The wavelet coherence coefficient is in the range $0 \le R_n^2(s) \le 1$ and measures the local linear correlation between two stationary time series at each scale. $W_n^{XY}(s)$ is the cross-wavelet power, and it uncovers the region in time-scale space in which the time series shows high common power. It can be viewed as the local covariance between the two time series at each scale. The cross-wavelet power of two time series $x(t)$ and $y(t)$ is defined as:

$$W_n^{XY}(s) = W_n^X(s)W_n^{*Y}(s) \tag{4.2.4}$$

where $W_n^X(s)$ and $W_n^{*Y}(s)$ are continuous wavelet transforms of two time series $x(t)$ and $y(t)$, respectively. The symbol * denotes a complex conjugate.

The wavelet coherence phase differences show the lead–lag relationships between the return series. The wavelet coherence phase is defined as follows:

$$\phi_n^{XY}(s) = \tan^{-1}\left(\frac{I\left\{S\left(s^{-1}W_n^{XY}(s)\right)\right\}}{R\left\{S\left(s^{-1}W_n^{XY}(s)\right)\right\}}\right) \tag{4.2.5}$$

where I and R are the imaginary and real parts, respectively, of the smooth power spectrum.

Fig. 4 below shows the estimated wavelet coherence and the phase difference for all examined pairs of commodities and equity from scale 1 (two days) up to a scale 8 (256 days, approximately one market year). Time is displayed on the horizontal axis, while the vertical axis shows the frequency (the lower the frequency, the higher the scale). Regions in time-frequency space where the two time series co-vary are located by the wavelet coherence. Warmer colours (red)[18] represent regions with significant interrelation, while colder colours (blue)[19] signify lower dependence between the series. Cold regions beyond the significant areas represent time and frequencies with no dependence in the series. Hence, both the frequency and the time intervals where the commodities and equity move together significantly can be identified. Since a continuous wavelet transform at any given point employs information of neighbouring data points, areas at the beginning and end of the time interval should be interpreted with caution. Thus, only scales up to 256 days are included, while the results regarding scale below 32 days need to be interpreted with the MGARCH analysis. An arrow in the wavelet coherence plots represents the lead/lag phase relations between the examined series. A zero phase difference means that the two time series move together on a particular scale. Arrows point to the right (left) when the time series are in phase (anti-phase). When the two series are in phase, it indicates that they move in the same direction, and anti-phase means that they move in the opposite direction. Arrows pointing to the right-down or left-up indicate that Islamic equity returns lead commodity returns, while arrows pointing to the right-up or left-down show that commodities are leading. Overall, the areas representing a stronger co-movement in the time-frequency space represent lower diversification benefits for Islamic equity investors.

5. Results and discussion

We first examine the linkages between commodities and Islamic equities using MGARCH-DCC model to track the time-varying properties of the variables in terms of volatilities and correlations (Figs. 2 and 3, respectively). We then employ the wavelet coherence technique to investigate the relationship between the series on a multi-scale, time-frequency domain (Fig. 4). Results displaying scale below 32 days (short term) are interpreted with MGARCH-DCC analysis, while scales from 32 to 256 days (medium to long term) are presented based on wavelet coherence analysis. We report both the unconditional and conditional volatilities and correlations, and discuss the general commodity-Islamic equity and specific commodity-Islamic equity patterns at length.

5.1. Unconditional volatilities and correlations

The maximum likelihood estimates of λ_1 and λ_2 (volatility parameters) together with Δ_1 and Δ_2 (mean-reverting parameters) for each series of returns, and the comparison of the values of multivariate normal and Student's t-distributions are presented in Table A (Appendix). The sum of the estimated coefficients (λ_1 and λ_2) is less than one, indicating that the dynamic conditional correlations are mean reverting, i.e., indices are not following an Integrated GARCH (IGARCH) process. In addition, all estimates of volatility decay parameters are highly

[16] See Gallegati and Semmler (2014).
[17] The time convolution is applied using a Gaussian window, while the scale convolution is done with a rectangular window.
[18] Light grey in the printed version of this paper.
[19] Dark grey in the printed version of this paper.

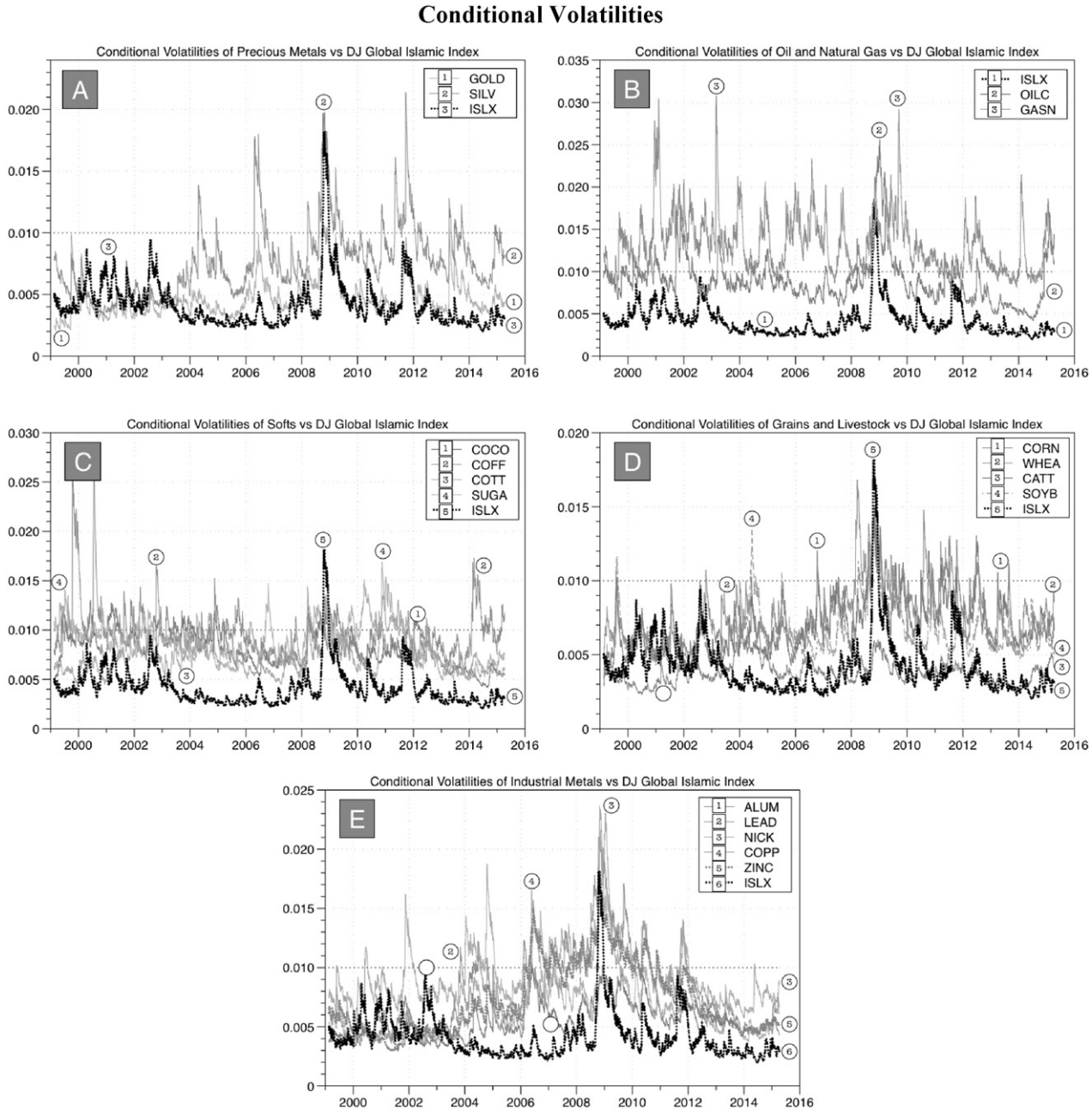


Fig. 2. Conditional volatilities of commodities and Islamic equity (MGARCH-DCC). Notes: This figure shows the conditional volatility of Dow Jones Islamic Market World Index (ISLX) and commodities from January 1999 to April 2015. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC).

significant. The *t*-distribution approach is more suitable for analysing the series with fat tails based on the higher value of maximum likelihood estimate for the *t*-distribution (283,328 > 281,496) and a degree of freedom (7.8) that is less than 30.

Unconditional volatilities (correlations) are represented by the on-diagonal (off-diagonal) values in Table B (Appendix). Cattle, Islamic equity and gold appear to be the least volatile assets (0.004–0.005), whereas energy items, coffee and nickel have the highest variances (0.010–0.014). Aluminium, silver, grains and the rest of soft commodities and industrial metals have moderate volatility ranging between 0.006 and 0.009.

Unconditional correlations assume that the relationship between Islamic equities and commodities is constant and does not change over time. The results indicate that industrial metals are the most correlated commodities with Islamic equities ranging from 27.8% to 40.7% followed by crude oil (29.3%) and silver (23.6%). Natural gas and gold are among the least correlated assets in relation to Islamic equities, with correlations of 7.4% and 11.4% respectively. Equities' association with soft commodities is in the range between 13.1% and 19.3%, whereas grains and livestock fall within 14.4% and 20% range. All commodities have positive correlations with Islamic equities.

5.2. Conditional volatilities and correlations

5.2.1. General commodity–equity patterns

The results of conditional volatilities and correlations demonstrate that the assumption of invariability of volatilities and correlations does not hold. With respect to conditional volatilities, metals and energy

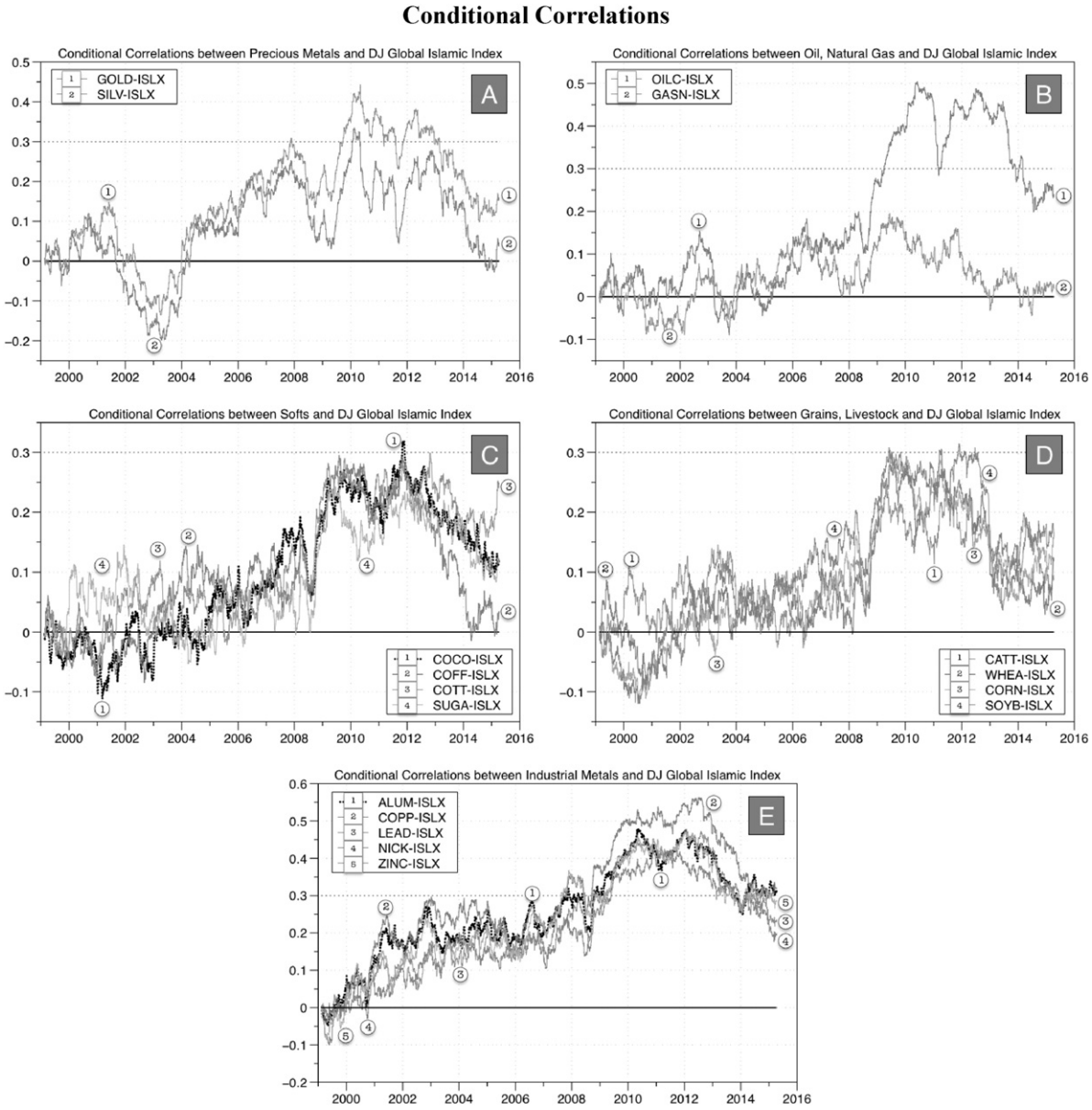


Fig. 3. Conditional correlations of commodities and Islamic equity (MGARCH-DCC). Notes: This figure shows the time-varying correlation coefficients between Dow Jones Islamic Market World Index (ISLX) and commodities from January 1999 to April 2015. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC).

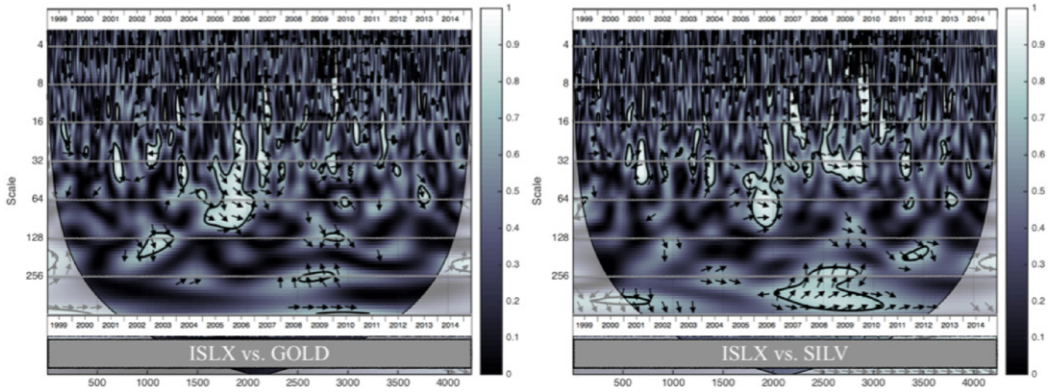
commodities were more volatile than grains, soft agriculture and livestock, especially when markets experienced high level of uncertainty during the 2008 global financial crisis (Fig. 2).

With regard to conditional correlations over the short run (using 20 days trailing window) (Fig. 3), all types of commodities generally exhibited low correlation with Islamic equities (below 0.3) prior to 2008, although they had been volatile and steadily increasing since 2000 (see also Creti et al. (2013) and Choi and Hammoudeh (2010)). The low correlation in the beginning of the sample period corresponds to the rise in commodity prices and drop in equity prices. The surge in demand for commodity by strong growth in emerging markets, an increase in commodity-related financial instruments and financial deregulation in the US have led to higher commodity prices.[20] Correspondingly, 2001–2003 was marred by accounting scandals (Enron and WorldCom), the dot-com crash, attack on the World Trade Centre, Argentina's sovereign debt default, and the Turkish banking crisis. Islamic equity was particularly affected by the dot-com bust given its substantial allocation to technology stocks.

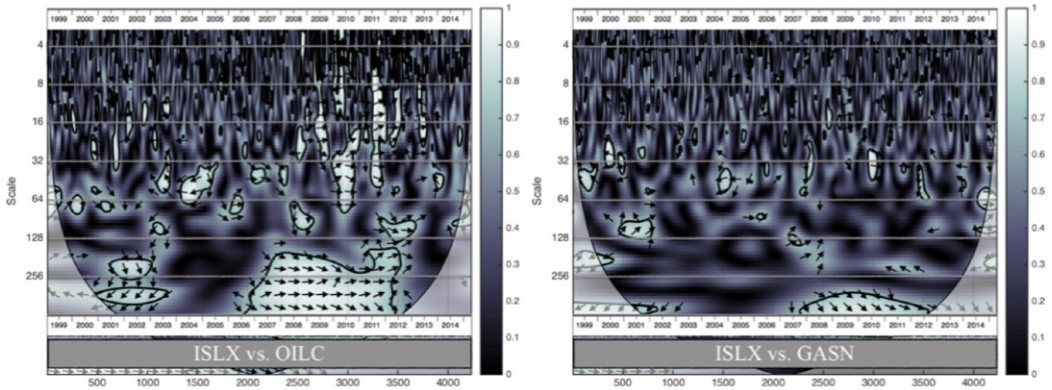
We detect an upward shift in correlations during the 2008 global financial crisis, with correlations staying high up to 2012. A similar observation unveiling the peaking of correlations during the 2008 global financial crisis has been found in recent literature (Creti et al., 2013; Delatte and Lopez, 2013; Silvennoinen and Thorp, 2013). The heightened correlation is reflective of several plausible macroeconomic, political, and financial behavioural factors coalescing from 2008 to 2012. First, the crisis caused a widespread panic and a negative sentiment at the global scale that affected most markets in similar ways (Bain, 2014). The growing dependence and spillover to most asset markets were likely due to liquidity constraints faced by investors who

[20] China alone accounted for almost 50% of the global consumption of most industrial metals by 2010.

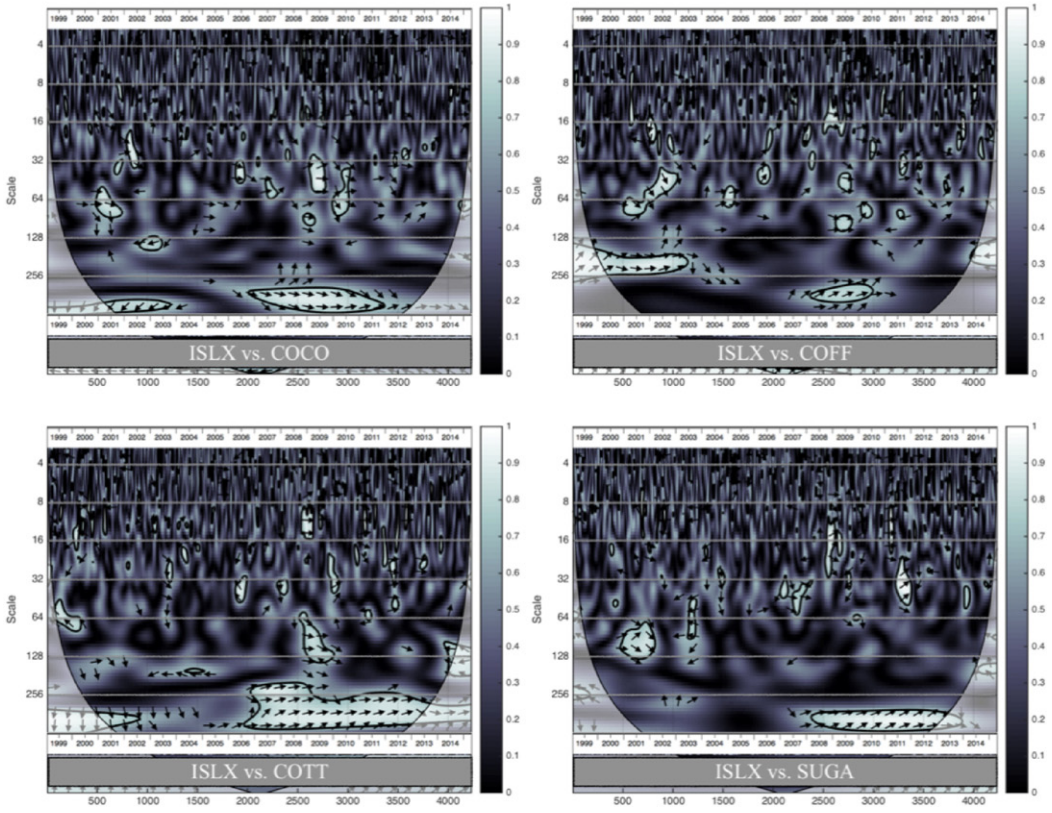
Precious Metals and DJ Global Islamic Index



Oil and Natural Gas and DJ Global Islamic Index



Soft Commodities and DJ Global Islamic Index



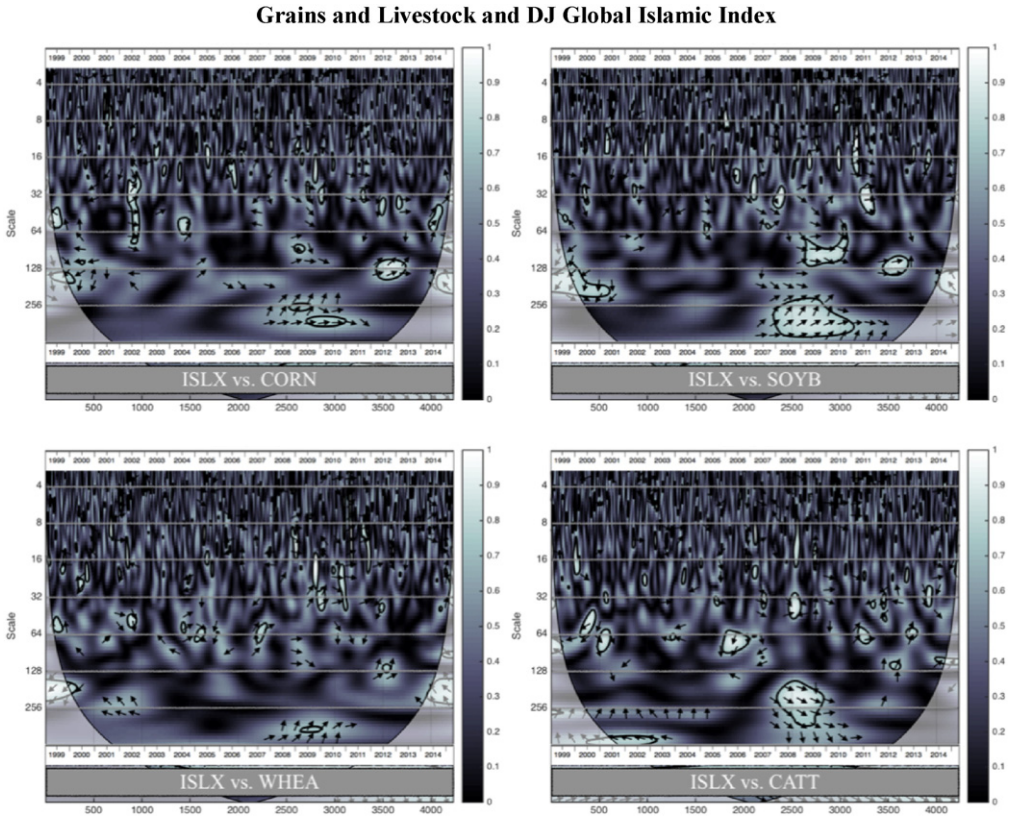


Fig. 4. Wavelet coherence results. Notes: This figure presents the Wavelet coherence of commodities and Dow Jones Islamic Market World Index (ISLX) pairs. Time and frequency are represented on the horizontal (time period from January 1999 to April 2015, with 1000 = Y2003, 2000 = Y2007, 3000 = Y2001 and 4000 = Y2015) and the vertical axis, respectively. Frequency is covered to days. The warmer the colour of a region, the greater the coherence is between the pairs. The black solid line isolates the statistical significant area at the 5% significance level. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC).

conducted fire-sale of assets to restore their balance sheets (Delatte and Lopez, 2013). During times of heightened economic uncertainty, market participants shorten their horizons such that different market prices become simultaneously driven by short-term behaviour. Second, the implementation of accommodative monetary policies in developed economies, accompanied by a massive stimulus package in China, contributed to the increase of aggregated demand for all goods and the rise of commodity prices (G20 Study Group on Commodities, 2011).[21] The prevailing global monetary conditions made commodities and equities increasingly appealing to investors given the low opportunity cost of holding commodities. The expansionary policy may also increase investor confidence and create positive expectations towards a healthy growth trajectory. This raises the future outlook of inflation, which enhances the attractiveness of commodities as a traditional hedge against inflation. At the same time, low interest rates may have prompted investors to search for higher yields, shifting part of their portfolio towards commodities. The rise in equity prices since March 2009 was attributed to short-term macroeconomic news that drove market sentiment amidst high level of economic uncertainty as well as substantial stock buybacks by large corporations and sovereign wealth funds (Bain, 2014).

Third, financial investors have significantly increased their investments in commodity futures markets in 2008, influencing the formation of futures prices, which are the benchmark for spot prices (Girardi, 2012). In particular, financial actors have been buying large amounts of futures contracts between 2004 and 2008, exerting a huge upwards pressure on commodity prices. They temporarily exited those markets between the late 2008 and early 2009, which caused a fall in prices. Investors became bullish again from mid-2009, triggering the new 2010–2011 price peaks in different commodities markets. Several studies have argued that this supports the existence of the financialization of commodity markets (e.g., Creti et al., 2013). Fourth, greater correlations and price movements in the commodity markets towards the "wrong direction" may have been exacerbated by high frequency and algorithmic financial traders in recent years. Algorithmic models that draw similar conclusions result in trading decisions and market movements similar to herding behaviour. Such behaviour leads to a commodity price bubble and causes price signals to spill over from equity markets to commodity markets, irrespective of whether there is an actual shift in the fundamentals in commodity markets (United Nations, 2011). Empirical analysis by Bicchetti and Maystre (2013) reveal that synchronized price movements at high frequencies and the rise in correlation are likely to be evidence of distortions arising from the financialization of commodity markets rather than driven by commodity fundamentals.

In most cases, correlations between Islamic equity and commodity returns have dropped persistently since 2012. In fact, over the last two years, correlations have fallen back to pre-2008 levels. This phenomenon, however, questions the manifestation of the financialization of commodity markets. Causes of this correlation reversal vary. According

[21] The US Commodity Futures Trading Commission's index investment data demonstrates a significant increase of notional values in most commodities between December 2007 and December 2011. For example, the short notional value of corn increased from US$ 1.9 billion to US$ 6.3 billion, gold from US$ 1.1 billion to US$ 5.4 billion, and crude oil from US$ 7 billion to US$ 18 billion.

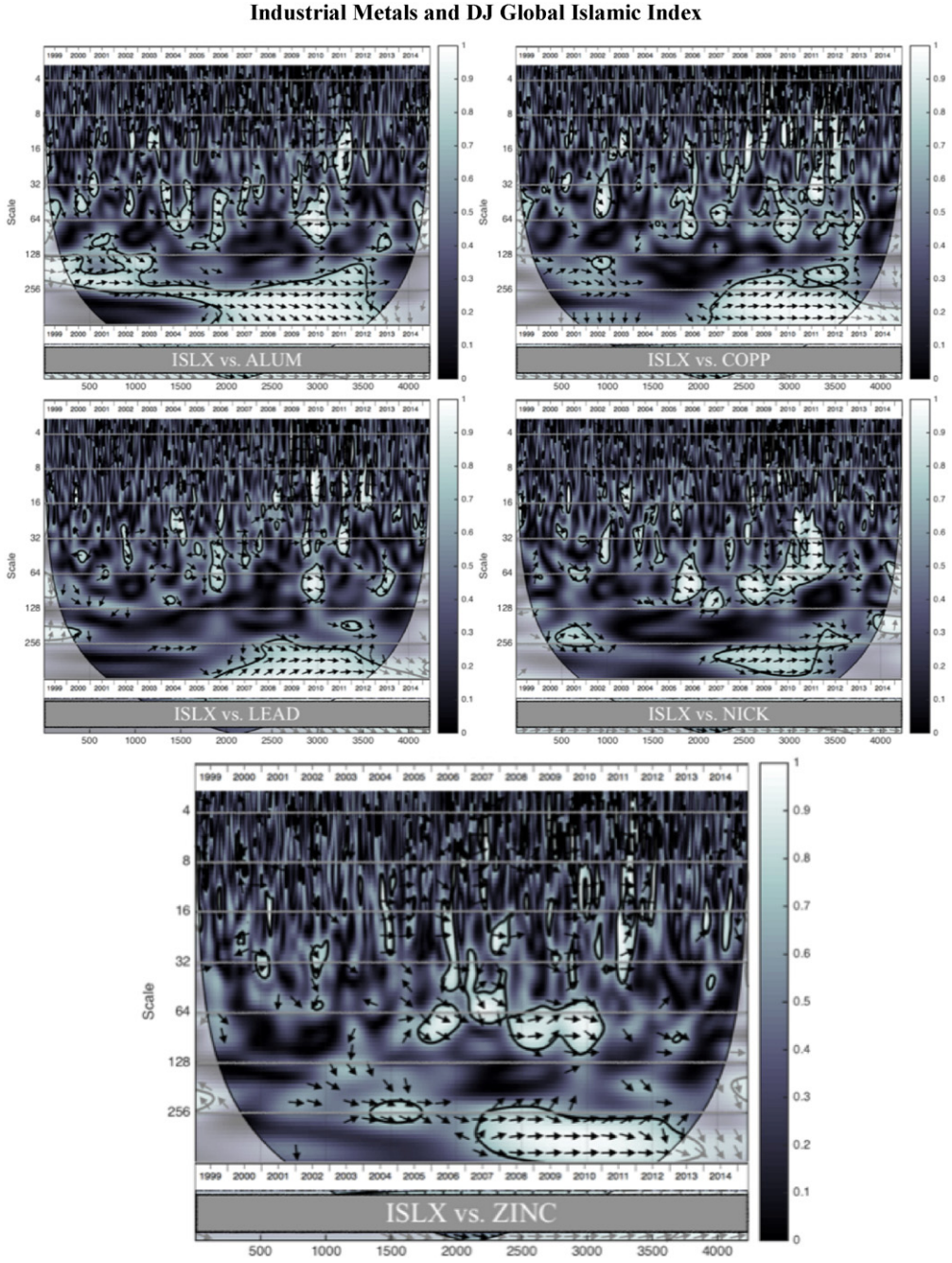


Fig. 4 (*continued*).

to the physical supply and demand view, commodity markets are now normalizing and will likely return to "an era where they are more influenced by individual supply and demand fundamentals" (Terazono, 2015). Bain (2014) suggests that commodity valuations have been impacted by the uncertainty of China's economic growth trajectory. The reorientation of the economy away from investment-driven growth and the slowdown in the real GDP growth in China are among the factors leading to commodity price weakness. The risk of deflation in the euro-zone may have further reduced investors' interest in commodities since 2012. Based on the financialization view, the reduction of activity in commodities markets by financial investors, particularly banks and hedge funds, have led to the decrease of correlations. Facing tighter regulation, growing capital requirements and the "peaking" possibility of the commodity super-cycle, banks such as Deutsche Bank and JPMorgan have been recently exiting or reducing their exposure in the commodity markets (Sheppard, 2014). Banks have been winding down their commodity divisions since 2013 as commodities are becoming less attractive than they used to be (Kaminska, 2014). It remains unclear whether quantitative easing taper fears have been the main driver of the correlation reversal (Bicchetti and Maystre, 2013).

5.2.2. Specific commodity class-equity patterns

The correlation dynamics between Islamic equity and both precious metals – gold and silver – follow a similar pattern over the short run (20 days trailing window). Fig. 3A shows that there were negative correlations up to −20% in the 2002–2004 period (which, among others, witnessed the 9/11 event and Iraq war) with a steady increase to 25% until 2008. While the linkage weakened during the financial crisis

(silver: 15%, and gold: 5%), it regained momentum since 2009. Correlations reached a peak in the first quarter of 2010, with Islamic equity–gold strengthening as much as 30%, and with Islamic equity–silver as high as 40%. Since 2013, the association between Islamic equity and precious metals began to revert to its pre-crisis levels. By the first quarter of 2015, the correlation between gold and Islamic equity reached almost 0%, while silver settled around +15%. The weakening of correlation is attributed to the divergence of equity and precious metal prices. This evidence suggests that gold maintains its role as a "safe haven" during market turmoil since gold price increases during or in expectation of volatile financial market as opposed to equity prices.

To assess whether the dependencies vary across different frequencies (longer investment horizons), we use the wavelet coherence approach as discussed in Section 4.2 above. We find in Fig. 4 that "cold" zones cover major parts of the 64–256 days scale suggesting close to zero linkage between Islamic equities and precious metals throughout the period of our study. However, at the 32–128 days scale, the relationship with gold had strengthened throughout the 2005–2008 period and with silver during the 2006–2009 period. The downward pointing arrows indicate that Islamic equity was leading gold during the period. This is probably due to the tendency of investors channelling more funds into equity during bullish market conditions while retaining a small investment portion in precious metals as a cushion for potential shocks. As for the low frequency level (scale of 256 days), gold maintains a very weak correlation with Islamic equities, which suggests that gold has better hedging properties for long-term investors. In contrast, silver has slightly stronger linkage with the Islamic equity, especially during the 2008 financial crisis.

On the short-run relationship between energy commodities and Islamic equity, we find that both oil and gas exhibit a similar degree of correlations with Islamic equity from 1999 to 2007 (Fig. 3B).[22] However, there has been a significant divergence of correlations since 2008 until mid-2013. Oil and stock price crashes at the onslaught of the global financial crisis resulted in dramatic increase in correlation between oil and Islamic equity from around 15% in 2008 to 50% in 2010. The crisis prompted a huge sell-off of assets and cut in production by OPEC in the midst of a highly uncertain economic environment. Oil prices dropped 70% within 6 months from US$133 per barrel of oil in July to US$41 per barrel of oil in December 2008. Since 2013, there has been a diminishing dynamic correlation between oil and Islamic equity, corresponding to the rise of stock price and the fall of oil price. The recent oil price crash has less association with equity shocks and was due to other factors such as weak demand, surplus in oil supply, large inventories especially in the US, sharp appreciation of the US dollar, and OPEC abandoning price targets in favour of market share (World Bank, 2015).[23] Short-term correlation between Islamic equities and crude oil has been reverting to the pre-crisis level of 20% in recent years.

Natural gas retained its low correlation with Islamic equity over the period of study (−10% to 20%), suggesting plausible hedging benefits for portfolio asset allocation (Fig. 3B). The low correlation is expected to persist because factors driving prices for natural gas are distinctive from those of equities. Interestingly, the short-run association between the two assets weakened during and after the global market turbulence, unveiling its potential as a "safe haven" for short-term investors. Since 2012, the short-run correlation between Islamic equities and natural gas is steadily declining, approaching the zero point (see Creti et al., 2013; Silvennoinen and Thorp, 2013). Hence, natural gas displays two plausible diversification characteristics for Islamic portfolios: as a hedge and a safe haven.

Over the medium to long run, the association of natural gas with stocks is much thinner ("blue" zones) on the scale of 32–256 days compared to that of crude oil. The "red" zone for crude oil possibly indicates a strong negative linkage with Islamic equity over the 2001–2003 period in the high scale (256 days) and a strong positive relationship from 2007 to 2013 in the medium and high scales. This suggests that hikes in the oil–equity correlations can be a long-run phenomenon, consistent with Zhang and Li (2016). Natural gas has a strong positive relationship with Islamic equity only in the high scale (beyond 256 days) throughout 2008–2011. Hence, natural gas is a better diversifier than oil in almost all time scales. In general, the findings from wavelet coherence analysis support the results from MGARCH-DCC.[24]

With regard to soft commodities, grains and livestock, short-term conditional correlations with Islamic equity have been fluctuating minimally from −10% to 10% prior to 2008 (Fig. 3C and D). Trade barriers, production subsidies, and climate changes could be among the forces that have prevented strong price linkages with equity (G20 Study Group on Commodities, 2011). From 2008 to 2012, especially in the high scale domain, there is clear evidence of increasing, but still low (from approximately 0%–20% to 20%–30%), in short-term correlations with the Islamic equity index. Our finding differs from Lehecka (2014)'s observation of increased correlations between food commodity and stock index returns after September 2008. This difference is possibly due to the use of a different equity index (MSCI World Index that measures the equity performance of 24 developed markets) and the non-dynamic correlation model used by Lehecka (2014). The fact that short-term correlations have dropped since 2012 to pre-crisis level (around 10%) suggests that soft commodity, grains and livestock can be potentially good portfolio diversifiers.[25] "Blue" zones in the wavelet plot cover most of the area (32–256 days), suggesting that the overall correlation between these commodities and Islamic equities is low.

On industrial metals (Fig. 3E), short-term correlations indicate that their relationship with equity has strengthened since 2008, with a two-fold increase from a correlation of 20%–30% in 2008 to 40%–55% in 2012 (highest correlation is between copper and equity). Derived from the Wavelet plots, the behaviour of individual industrial metal with Islamic equity is somewhat similar on the medium to high scale (32–256 days), with red zones from 2007 to 2013. Such high correlation could be explained by two factors. First, the performance of Islamic equity index is driven mainly by the industrial, technology, basic materials sector premiums, oil and gas, among others (Dewandaru et al., 2015). The basic materials and industrial sector in the equity index comprise a range of subsectors such as industrial metals, mining, and construction materials. Second, over the years, commodity indices have also increased weight towards energy and industrial metals, making these commodities closer to business cycle and financial assets (Bain, 2014). Our findings are broadly consistent with previous literature. Following the 2008 financial crisis, industrial metals have become among the most integrated to equity markets, with copper showing the greatest integration (Delatte and Lopez, 2013). Copper also exhibits higher volatility persistence over time in reaction to financial crises (Choi and Hammoudeh, 2010). However, declining industrial metal prices in the past few years amidst rising stock prices have contributed to the drop in correlations between the two asset classes. Metal prices are falling due to capacity increases and slowing demand in China as well as new low-cost mining capacity mainly in Australia and Brazil in recent years. The slower investment in construction and infrastructure sectors in China has also reduced the consumption of copper on a substantial scale (World Bank, 2015).

[22] Increase in oil price from 2003 to 2008 was mainly associated with rising demand from China and other emerging markets (Jammazi, 2012).

[23] Crude oil is considered as inflationary commodity since general price level tends to increase as the oil price escalates (Hooker, 2002; Hunt, 2006; Reboredo, 2013). This has an impact on cash flow of firms and bottom line, which is reflected in low stock prices.

[24] In contrast to crude oil, natural gas prices fluctuate mainly due to seasonal effect (winter). It experienced the largest spikes at the end of 2005 (Hurricanes Rita and Katrina) and mid-2008 (financial crisis). Starting from year 2010 and onwards, the price of natural gas maintained its stability unlike the growing trend of equity prices.

[25] The decline of agricultural prices in recent years is due to the large harvest in the Americas and rising stocks (World Bank, 2015).

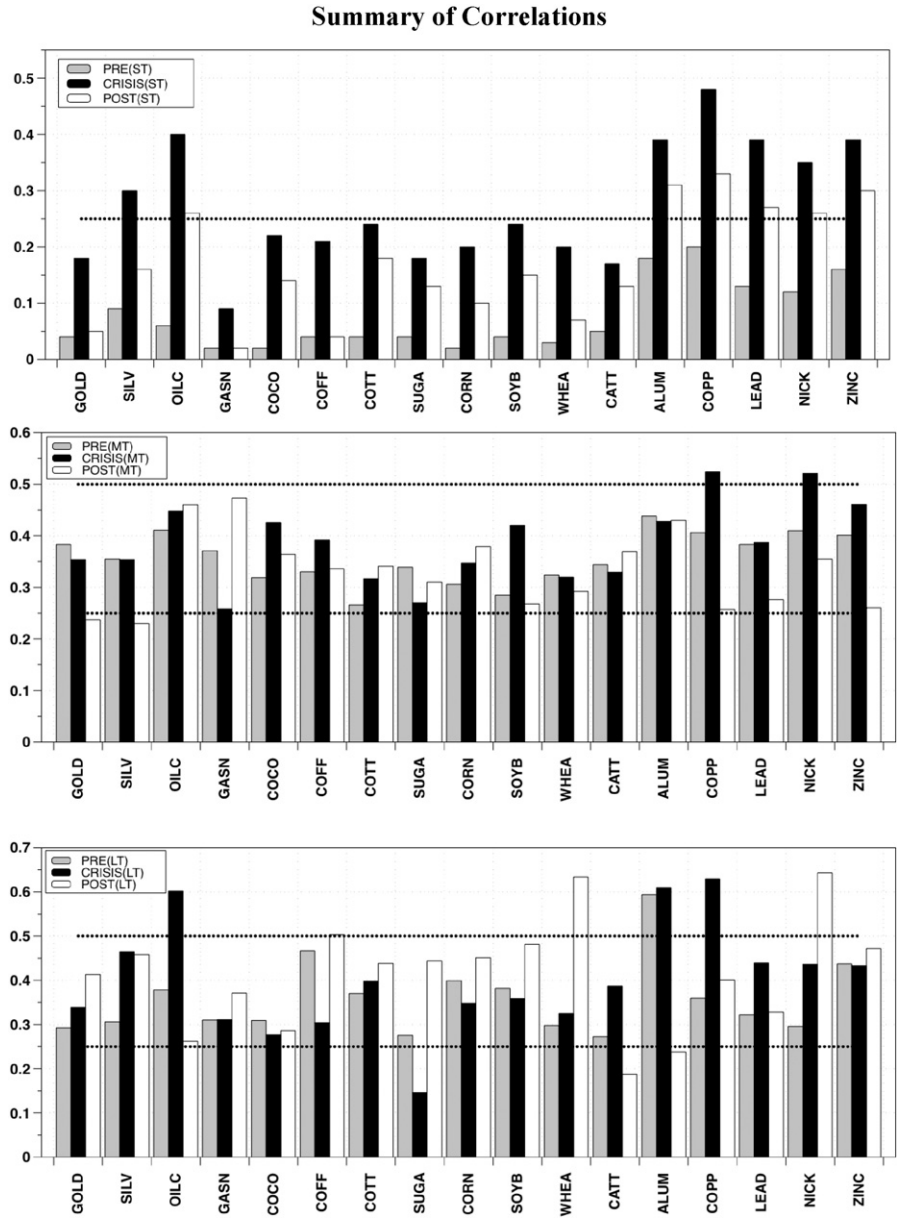


Fig. 5. Summary of correlations across time horizons for the sample sub-periods. A. Correlations for short-term horizon (low scale: 20 days). B. Correlations for mid-term horizon (medium scale: 32–128 days). C. Correlations for long-term horizon (high scale: 128–256 days). Notes: panels A–C are the overall summary of the results. The figures present correlations and coherency for commodities and DJ Islamic Stock Market World Index across three time horizons (short, medium and long terms) during the pre-2008 global financial crisis, crisis and post-crisis periods. The commodities are clustered into five categories. Precious metals include gold (GOLD) and silver (SILV), Energy commodities refer to crude oil (OILC) and natural gas (GASN), the Soft agriculture comprises cocoa (COCO), coffee (COFF), cotton (COTT) and sugar (SUGA), Grains and livestock encompasses corn (CORN), soybeans (SOYB), wheat (WHEA) and cattle (CATT), and Industrial metals include aluminium (ALUM), copper (COPP), lead (LEAD), nickel (NICK) and zinc (ZINC). ST = Short-term (based on correlations from MGARCH DCC results). MT = medium-term (based on Wavelet coherence results). LT = long-term (based on Wavelet coherence results). Periods: pre-crisis (up to 14/09/2008); crisis (from 15/09/2008 to 30/09/2013); post-crisis (from 01/10/2013 until 10/04/2015).

To supplement our analysis, we applied the cross-wavelet transform to find regions in the time-frequency space where the time series exhibit high common power. In unreported findings, we show that all commodities have in general a weak covariance with the Islamic equity except during the 2008 global financial crisis period, thereby supporting our main findings in the wavelet coherence analysis.[26]

Figs. 5 provide the overall summary of the results across three time horizons (short, medium and long term) during the pre-2008 global financial crisis, crisis and post-crisis periods. The *Y*-axis represents the mean of wavelet coherence localized in time and frequency for each time horizons, while the bar colours discriminate across different investment horizons for each commodity.[27]

[26] Results based on cross-wavelet transform are available upon request.

[27] For completeness, we also analysed the differences in means of the correlations between Islamic-commodity and non-Islamic (DJ Global and Sustainability) commodity pairs for the full sample period, as well as for various sub-periods (see Table C in Appendix). Although the co-movement between Islamic and non-Islamic indexes is strong, their respective correlations with commodity markets can significantly differ from each other. In the short and medium range, the co-movement of precious metals (silver and gold) and oil with Islamic equity is significantly stronger than with global equity. In the longer run, however, their co-movement with Islamic equity becomes lower than with global equity. For soft agriculture we see the opposite: mostly stronger co-movement in the median and long range; weaker co-movement in the short run (although not always significant). The co-movement for grains and livestock is mostly stronger (with the exception of the post-crisis period). The same kind of behaviour is observed with respect to sustainability equity.

6. Conclusion and research implications

Islamic equity index investors are relatively under-diversified since they are subject to religious constraints. From this perspective, it is important to verify whether alternative markets could reduce their market exposure to risk and provide diversification opportunities. The commodity market is a natural choice since spot trading is permissible according to the principles of Shari'ah. Applying MGARCH-DCC and Wavelet Coherence analyses, we examine the extent to which the commodities market co-moves with Islamic equity market. Our findings reveal that, throughout the January 1999–April 2015 period, the return correlations are time-varying, i.e., vary over different phases, suggesting that not all commodities make equally good diversifiers at all times. Gold, natural gas, agriculture, grains and livestock offer good diversification opportunities for short-term investors (below 32 days horizon) relative to oil and other metals before the 2008 financial crisis. Natural gas is the best diversifier in the short run during and after the crisis. Compared to short-term investors, medium-term investors (32–256 days horizon) generally do not gain substantially more diversification benefits (except for sugar during the crisis) across different market conditions. Except for cotton, sugar, cocoa and soybean, long-term investors (more than 256 days) share similar benefits from investing in the types of commodities like short-term investors.

The time-varying dimensions could be captured by investment managers in their rebalancing activity in both passive and active investment approaches, allowing risk and return to be managed appropriately in accordance with investors' specific objectives. Our results offer insights into a blend of passive and active investment approaches in a multi-asset portfolio. Different market environments tend to suit active or passive approaches. The 2008 global financial crisis is a prime example that underscores the need to be scrupulous about the management of investment risks. Passive Islamic investment managers can include both Islamic equity index and selected commodity indices into passive Islamic exchange-traded funds when the asset classes are not highly correlated. For Islamic investors seeking to outperform index benchmarks and to optimize from forces of change in financial markets, active and value-oriented investment strategies would stand to benefit from the dynamic assessment of the link between different commodities and Islamic equity index. While passive index investment may introduce significant concentration and benchmark risks, active investment management is capable of generating outperformance (alphas) and managing the risks inherent in the adoption of a benchmark (beta of a portfolio's performance). This could plausibly explain why short-term investors, who are attuned to more active management, gained better diversification benefits than medium-to-long term investors during the 2008 crisis.

In our view, the high correlation in some of the commodity-equity series in the long-term may not necessarily imply the existence of financialized markets. It is, therefore, important to have a balanced approach in both regulations and in investment. For regulators, it is important to ensure that markets are robust to derive the full benefits of wider participation of investors. Pure financial trading products can be monitored within the framework of financial stability (see, for example, recommendations from IOSCO on regulation and supervision of commodity derivative markets). Principles and lessons from Islamic finance can be drawn to enrich such framework.

While demand for commodity may be influenced by similar factors driving the demand for equity, the supply profile of commodities differs from equity. Commodities' supply is relatively inflexible over the short horizon, suggesting that periods of correlation with equity are typically short-lived. Unlike other financial assets, commodities are tangible assets that will eventually be driven by the demand and supply of goods (Bain, 2014). In the spirit of Baele et al. (2010), future research assessing the supply and demand determinants would shed more light on commodity and Islamic equity return co-movements. Although correlations have now abated over the short-term horizon especially in recent years, the market is still in the state of flux. The tendency of a potential re-financialization can again result in ineffective diversification. Such concern warrants the need to have well-functioning markets as proposed by the G20 Study Group on Commodities (2011) and United Nations (2012).

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eneco.2016.06.011.

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