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Luca Severin Ernst

GOLD AS AN EFFECTIVE DIVERSIFIER FOR GLOBAL EQUITIES: EVIDENCE FROM DEVELOPED AND EMERGING MARKETS

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Knowledge Field: International Economics and Finance

Adviser: Prof. Dr. Rafael Felipe Schiozer

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Luca Severin Ernst

ABSTRACT

Finding financial assets with a low or even negative correlation to equities has become notoriously difficult in the face of global co-integration and the financialization of commodity markets. Gold remains to be one of the assets in which investors around the world place their trust as a stabilizing force in times of adverse markets, and it is often referred to as a safe haven in the financial media. The present thesis examines gold's diversification potential for a broad cross-section of developed and emerging markets from the perspective of both foreign and domestic investors. The empirical analysis is based on two models; (i) a linear regression model with different regressors to capture extreme market conditions, and (ii) a GARCH-DCC(*1,1*) model to analyze the dynamic time-varying correlations. Both approaches provide compelling evidence and support previous research that the safe haven potential of gold increases as stock returns deteriorate, i.e. when diversification is most needed. In addition, the paper finds that gold displays safe haven benefits for numerous markets with increasing global uncertainty. But with peaking volatility, financial contagion seems to predominate, and gold is no longer an effective measure to protect investors' wealth in most markets. As regards emerging economies, the findings align with previous studies indicating that gold's diversification potential is very limited for foreign investors. For domestic investors, in turn, gold proves to be a potential hedge and/ or safe haven asset for numerous emerging markets.

KEY WORDS: DIVERSIFICATION, SAFE HAVEN LITERATURE, GOLD, EQUITIES, VOLATILITY, UNCERTAINTY, DEVELOPED AND EMERGING MARKETS, LINEAR MODEL, GARCH-DCC(*1,1*), TIME-VARYING CORRELATION, DYNAMIC CONDITIONAL CORRELATION, COMMODITIES, JAPANESE YEN

RESUMO

Encontrar ativos financeiros com uma correlação baixa ou mesmo negativa com as ações tornou-se notoriamente difícil em face da co-integração global e da financeirização dos mercados de commodities. O ouro continua sendo um dos ativos nos quais os investidores em todo o mundo depositam sua confiança como uma força estabilizadora em tempos de mercados adversos, e é frequentemente referido como um "safe haven" na mídia financeira. A presente tese examina o potencial de diversificação do ouro para uma ampla seção transversal de mercados desenvolvidos e emergentes, da perspectiva tanto de investidores estrangeiros quanto domésticos. A análise empírica é baseada em dois modelos; (i) um modelo de regressão linear com diferentes regressores para capturar condições extremas de mercado, e (ii) um modelo GARCH-DCC(*1,1*) para analisar as correlações dinâmicas entre tempo e variação. Ambas as abordagens fornecem evidências convincentes e apoiam pesquisas anteriores de que o potencial de refúgio seguro do ouro aumenta à medida que os retornos de estoque se deterioram, ou seja, quando a diversificação é mais necessária. Além disso, o documento conclui que o ouro apresenta benefícios de refúgio seguro para numerosos mercados com crescente incerteza global. Mas com o pico da volatilidade, o contágio financeiro parece predominar e o ouro não é mais uma medida eficaz para proteger a riqueza dos investidores na maioria dos mercados. No que diz respeito às economias emergentes, as conclusões alinham com estudos anteriores, indicando que o potencial de diversificação do ouro é muito limitado para os investidores estrangeiros. Para os investidores nacionais, por sua vez, o ouro prova ser um ativo potencial de hedge e/ou um "safe haven" para numerosos mercados emergentes.

PALAVRAS CHAVE: DIVERSIFICAÇÃO, LITERATURA SOBRE "SAFE HAVEN", OURO, AÇÕES, VOLATILIDADE, INCERTEZA, MERCADOS DESENVOLVIDOS E EMERGENTES, MODELO LINEAR, GARCH-DCC(*1,1*), CORRELAÇÃO VARIÁVEL NO TEMPO, CORRELAÇÃO CONDICIONAL DINÂMICA, COMMODITIES, IENES JAPONESES

Table of contents

List of figures

List of tables

1 Introduction

"If there ever is a free lunch in economics or finance, it is provided by the diversification of an investment portfolio" – Jaffe, 1989

This quote emphasizes the importance of risk diversification among global investors and portfolio managers, a feature that has become increasingly important over the last two decades due to the increasing co-integration of financial assets and recurrent periods of unexpected declines in yields and excessive volatility. Modern portfolio theory suggests that the allocation of "funds to assets that are negatively correlated or less than perfectly positively correlated" help to considerably reduce the overall risk of a portfolio (Bekiros, Boubaker, Nguyen & Uddin, 2017a). Hence, the risk adjusted return can be improved by holding a diverse portfolio of differently correlated assets. Since the wake of the 2008 global financial crisis, there has been a renewed interest in finding assets that inherit the above-mentioned characteristic of low or even negative correlation with equities to protect investors' wealth in times of adverse markets. While most financial assets experienced a stark decline between July 2007 and March 2009, the nominal gold price has increased by 42% (cit. in Baur & McDermott, 2010). The widespread belief that gold acts as a safe haven in times of market turbulence has been further reinforced and the financial media often referred to it as a "safe haven". In addition, many investors view gold as a hedge against inflation and a weakening dollar, based on the mere assumption that the metal's nominal value (measured in U.S. dollar) tends to rise with a falling dollar (Capie, Mills & Wood, 2005).

In the aftermath of the crisis, numerous studies examined the diversification potential of gold and tested its alleged safe haven potential. The results are largely unanimous and show that gold is proving to be a hedge or safe haven, at least for some markets. Nevertheless, most publications in this realm base their findings on a relatively small number of countries and, with a few exceptions, tend to look at things only from the perspective of foreign investors, i.e. return series denominated in U.S. dollar. Moreover, research that examines the diversification potential of gold for a wide range of emerging markets and additionally from the perspective of domestic investors is limited. As regards the recency of data, most findings are outdated and mainly draw conclusion based on data up to 2010.

The recent surge in volatility linked to the financial market turmoil in early 2020 and the relatively high co-movement among most financial assets serve as an important motivation to further examine gold's diversification potential. Behavioral finance, more specifically the prospect theory, argues that individuals are more sensitive to losses as to gains. Ang, Bekaert & Liu (2005) conclude that investors who find themselves in the situation of extreme losses "will engage in abrupt switches between assets", suggesting that such price movements can be rather informative (cit. in Ciner. Gurdgiev & Lucey, 2013). Therefore, the average correlation between gold and global equities is less informative as the extremes of the respective time series provide more meaningful insight. Based on this and the correlation's time-varying nature, I apply two different statistical approaches to assess gold's diversification potential on

average (i.e. its hedging potential) and in times of economic crisis (i.e. its safe haven benefits). To test these hypotheses, I firstly implement a linear model based on two distinct quantile approaches, i.e. an extreme negative return- and an excess volatility-based approach. Secondly, I use a GARCH-DCC(*1,1*) model, which provides estimates for the daily dynamic time-varying correlation coefficients. I then assess the retrieved results in more detail applying the same quantile restrictions as for the regression model. In addition, I benchmark gold's performance against a broad commodity index (BCOM) and the Japanese yen, both financial assets that are said to provide protection during market shocks.

I find that gold acts as a stabilizing force and inherits the potential to reduce financial losses in periods of market distress for numerous developed and emerging markets. Moreover, the correlation coefficients between gold and stocks tend to decrease with deteriorating market conditions, making it an ideal safe haven candidate. While gold displays little hedge/ safe haven potential for foreign investors in emerging markets, I find the asset to be an effective diversifier for several emerging markets from the perspective of domestic investors. In addition, the broad commodity index does neither act as a hedge nor safe haven given its positive correlation with the selected indices across all market conditions. The Japanese yen, on the other hand, shows some diversification benefits. However, these largely disappear, as opposed to gold, when equities show extreme negative returns.

With the present thesis I aim to fill the aforementioned research gap by focusing on a broad cross-section of developed and emerging markets and to draw a conclusion about gold's relevance as a stabilizing force during adverse markets. Instead of solely focusing on the BRIC economies, I contribute to the existing literature by also including Argentina, Chile, Colombia, Czech Republic, Greece, Hungary, Korea, Malaysia, Mexico, Peru, Philippines, Poland, South Africa, Taiwan, and Thailand. Moreover, I distinguish between data denoted in USD as well as in the respective domestic currency of each country. This allows me to draw a conclusion from the perspective of both foreign and domestic market participants, a differentiation that provides valuable insights and is often omitted in the existing literature. The data covers the last two decades and thus numerous events of high volatility and economic crisis, including the latest COVID-19 related market turbulences and gold's upward trajectory in the first half of 2020. Gold's recent positive returns are largely driven by global uncertainty as well as increasing flows into gold ETFs. With this paper I further aim to provide an updated overview of the applicability of gold as a hedge or safe haven for financial investors and to assess whether there exist differences in its ability to diversify equity between developed and emerging markets, as proposed by Baur & McDermott (2010), who argue that gold is neither a hedge nor a safe haven for the BRIC economies.

2 Literature review

This section provides relevant background information and facts about gold as well as a brief insight into the diversification literature. Moreover, I discuss recent demand trends and two additional asset classes with alleged diversification potential, i.e. commodities and the Japanese yen, as they are of relevance later in this study. Lastly, I outline the most important strands of research closely related to this paper.

2.1 The history of gold

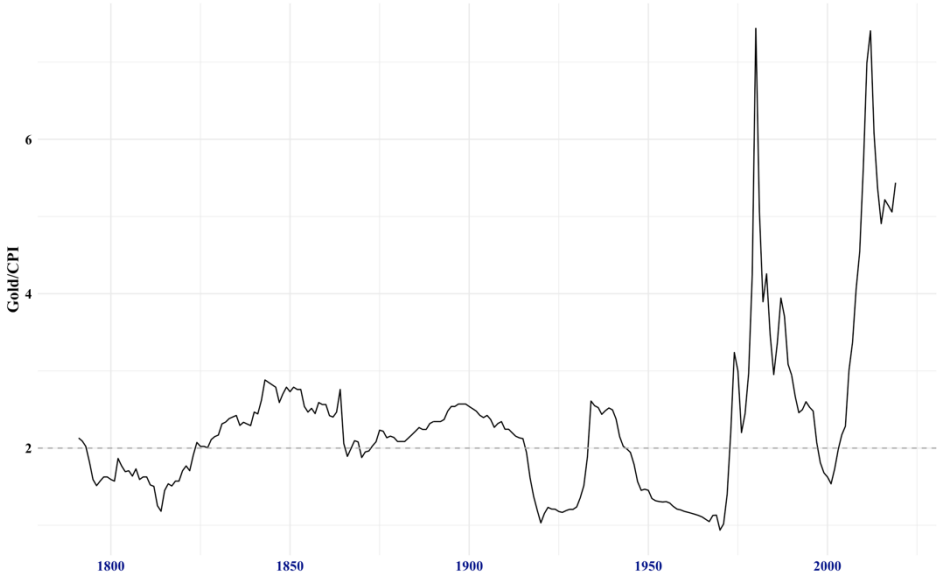
The Gold Standard

The Gold Standard refers to a system under which most countries fixed the value of their currencies to a specified amount of physically held gold or linked their monetary system to a regime that pursued this strategy (WGC, 2020e). During this time, "domestic currencies were freely convertible into gold at the fixed price and there was no restriction on the import or export of gold" (WGC, 2020e). Fixed currencies in terms of gold imply that also the exchange rates among participating countries were fixed. Technically, central banks were pressured to convert fiat money into gold on demand and had to adhere to minimum legal quotas of gold to currency, strictly limiting the amount of fiat money in circulation. The international settlement in gold was another characteristic of this era, which ensured that the international monetary system was self-correcting in theory. Countries with a payment deficit would therefore "experience an outflow of gold, a reduction in money supply, a decline in the domestic price level, a rise in competitiveness and, therefore, a correction in the balance of payments deficit" and vice versa in case of a balance of payments surplus (WGC, 2020e). The gold standard evolved around 1870 and remained intact until the end of the First World War in 1914. Prior to the gold standard, money existed mainly in form of gold, silver, copper coins, or specie-backed bank issue notes.

The Bretton Woods System

Once the Second World War ended, it quickly became evident that a new international system was needed to put into place in order to replace the gold standard. The Bretton Woods conference held in the USA in 1944, laid the foundations of the Bretton Woods System with the dollar at its core (WGC, 2020d). Motivated by the desire for stability and prosperous international trade, fixed exchange rates were introduced. The newly drawn up system pegged the dollar to gold at an existing parity of 35 U.S. dollars per troy ounce (WGC, 2020d). All participating currencies had fixed but adjustable exchange rates against the dollar thereafter. Numerous economic and geopolitical reasons caused the system's dissolvement in August 1971, officially announced by the former American president Nixon. The USA suspended the "on-demand convertibility of the dollar into gold for central banks of other nations" (WGC, 2020d). Subsequently, the whole system collapsed and gold trades freely on global financial markets ever since.

Figure 1 The real gold price between 1791 and 2019



Note: The historical gold price and the U.S. CPI was retrieved from MeasuringWorth (2020)

Figure 1 shows that the real price of gold (i.e. annual average nominal price of gold divided by the U.S. annual CPI) remained at constant levels throughout approximately two centuries. This steady trajectory suddenly came to an end with the aforementioned demise of the Bretton Woods currency regime in the early 1970s, as shown in figure 1. Put differently, the metal's real price remained relatively constant until the early 1970s. Its past price stability was fundamentally driven by the fact that the U.S. operated under various currency regimes backed by gold and silver from 1791 until 1971, which suddenly terminated with the collapse of the Breton Woods System (Erb & Harvey, 2013). The resulting erratic increase in volatility can be seen in figure 1. The subsequent free trade of gold on the financial markets suddenly put gold in the spotlight of many investors around the world. Gold as a viable investment vehicle rapidly became subject of discussions among investors and fund managers. Furthermore, a wide range of research has been dedicated towards its alleged properties such as serving as an inflation hedge, currency hedge, or effective diversifier for numerous financial assets.

2.2 Facts about gold

The majority of gold that has been mined up until today, which amounts to approximately 200,000 metric tons, still exists today and could come back to the market through recycling for instance (WGC, 2020c). New annual gold supply is not increasing by much and is comparatively small to the above ground level supply (Adams, 2018). Hence, gold's supply is relatively inelastic due to its difficulty to mine as well as "the long lead-in times between the establishment of a new mine and commencement of commercial production", which can take up to five years (Baur & McDermott, 2010). Best estimates according to the World Gold Council (2020c) suggest that global gold mining adds roughly 2,500 – 3,000 metric tons of gold per annum. In addition, recycled gold accounts for just over one-third of the

total global supply and is an important source to meet global demand (WGC, 2020c). The actual demand for gold is relatively diverse, while gold jewelry continues to be the largest source of gold per sector. According to the World Gold Council (2020a), demand for jewelry has declined steadily over the last decades, but still accounts for about 50% of its total demand. Investment demand is the second largest, accounting for about 20% of total gold holdings, and the annual volume of gold purchased by global investors has grown by 235% over the last three decades (WGC, 2020a). Since 2016, there have been substantial inflows into gold exchange traded funds (ETFs) such as SPDR Gold Shares (GLD) or iShares Gold Trust (IAU), both backed by physical gold. Gold ETF investors tend to be among the most conservative investors so that many gold ETFs now generate their returns not from gold futures but from physical gold holdings, thereby providing a sense of protection and safety that comes with an investment in real assets (Adams, 2018).

Erb & Harvey (2013) argue that the positive price elasticity of gold, one way of referring to momentum investing, characterizes its investment demand. The authors further suggest that a relatively small number of marginal momentum buyers could potentially push up both the nominal and real price of gold much higher, especially if they neglect valuation principles. Central banks come in third place and their behavior towards gold has significantly changed after the financial crisis in 2008. While European central banks have considerably slowed down or even stopped selling their gold reserves, emerging market economies have substantially increased their purchases (WGC, 2020b). Gold is also widely used and applied in modern technology and its novel application in medicine continues to drive its demand in this field (WGC, 2020b).

The gold price is influenced more by changes in demand than by changes in supply, and its demand is often sentiment driven. Thus, certain investors perceive that gold inherits special properties that makes it different from other commodities (Adams, 2018). For instance, Aggarwal & Lucey (2007) show that the gold market exhibits certain psychological price barriers. Prices with round numbers like 500 or 1,000 USD act as such mental barriers. For the first time in history, gold broke through the 2,000 USD per ounce mark on August 4, 2020, after a rally largely driven by uncertainty and fears regarding the global COVID-19 pandemic (Horowitz, 2020). Other authors argue that income or a quality suit remains relatively constant when measured in gold (cit. in Erb & Harvey, 2013). This discussion about the "golden constant" is quite revealing, because the value of your income is determined by the amount of goods and services you can buy. However, your income measured in gold is irrelevant (Adams, 2018). Moreover, if this reasoning were correct, gold would serve as an effective long-term inflation hedge because the metal would maintain its purchasing power, implying that inflation has been a fundamental driver of the gold price and that the real return on gold is zero (Erb & Harvey, 2013). The authors' study (2013) contradicts this assumption and shows that gold displays considerable price variability between the dissolution of the Bretton Woods System and March 2012, which is also visible in figure 1.

2.3 Recent trends in demand

The global demand for gold was 6% weaker, with 2,076 metric tons in the first half of 2020, as compared to last years. The global COVID-19 pandemic is largely responsible for the slump in consumer demand, however, providing strong support for gold investments (Saefong, 2020). Central banks and governments around the globe responded with large liquidity injections and interest rate cuts, which led to record inflows of 734 metric tons into gold-backed ETFs (Saefong, 2020). This positively influenced the gold price in turn, which gained 17% over the first six months of 2020 (Saefong, 2020). Gold's steep upward trend in recent months, combined with global uncertainty, brought gold back into the focus of investors. The theory that gold acts as a safe haven in times of global uncertainty and financial crisis has once again been taken up by financial media.

2.4 Diversification literature

The diversification literature tends to distinguish between a "hedge", a "diversifier", and a "safe haven". Baur & Lucey (2010) were the first to formally distinguish between the three and came up with a clear-cut definition for each of the above, which I recap below to avoid confusion as the paper proceeds.

Hedge

"A hedge is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio on average" (Baur & Lucey, 2010). Put differently, a hedge does not necessarily have the specific property of reducing losses in times of severe market conditions as the asset could exhibit a positive correlation in such volatile periods and a negative correlation in normal times. However, it is of importance that the average correlation is zero or negative (Baur & Lucey, 2010).

Diversifier

"A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average" (Baur & Lucey, 2010). As the correlation property is only required to hold on average, a diversifier does not have the specific property of reducing losses in periods of market distress.

Safe Haven

"A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil" (Baur & Lucey, 2010). A safe haven asset can exhibit positive or negative correlation during normal or bullish market conditions. Subsequently, a safe haven only exhibits non-positive correlation in times of increased volatility and severe market distress. Consequently, acting as a stabilizing force in times of adverse markets and reducing losses in times when investors need it the most.

2.5 Other potential diversifiers

In this section I provide a brief overview of the commodity markets and the Japanese yen (JPY), both of which are generally believed to offer significant diversification benefits when held in a mixed investment portfolio. I use a broad commodity index as well as the JPY/USD trading pair in the empirical analysis to evaluate gold's performance and to draw a conclusion as to whether gold is truly superior in times when diversification is most needed.

Commodity markets

Historically, commodities have been praised for their low or even negative correlation with stock markets and thus provided valuable diversification benefits. However, the behavior of commodity returns and their co-movement with other asset classes, especially stock markets, has significantly changed since 2008. This increase in correlation from virtually zero to significantly positive levels between commodities and equities implies that the diversification benefits in a mixed asset portfolio are no longer as strong as previously anticipated. This phenomenon is referred to as the "financialization of commodity markets" in financial literature and has been partially triggered by large flows into commodity investments from institutional investors since 2004 (Cheng & Xiong, 2014). A feasible explanation for these inflows after the millennium is the fact that traditional assets like stocks and bonds did not perform well after the crash of the Dot-com bubble in 2001. As equity returns were negative on average and bond returns extremely low for a few years, it is likely that investors were seeking other more attractive investments. Consequently, commodity prices increased, which in turn attracted even more inflows from (institutional) investors. Thus, the success of commodity markets after the Dot-com bubble became a somewhat self-fulfilling prophecy (Adams, 2018). However, an increase in correlation does not necessarily imply that commodities are no longer useful diversification tools as the general correlation coefficient simply provides information regarding its average linear dependency (Adams, 2018). Yet, non-linear dependencies cannot be measured, nor can one accurately identify the direction of the impact. In order to truly examine an assets diversification benefits it is more conclusive to assess its behavior during periods of high volatility, i.e. when diversification is needed the most.

A study from Bekiros, Nguyen, Sandoval & Uddin (2017b) concludes that commodity futures markets are still widely decoupled from equity markets and only show strong intra-category connections (cit. in Bekiros et al., 2017a). This relatively weak link between equity and commodity futures depicts a desirable feature in portfolio diversification (Bekiros et al., 2017a). The fact that the average correlation does not provide a final verdict about an asset's diversification benefits and the findings of Bekiros et al. (2017a), serve as the primary rational to include a commodity index as a benchmark in the empirical analysis.

Japanese yen

The Japanese yen is widely acknowledged to be a safe haven currency, which appreciates in value during times of ascending global uncertainty and intensified risk aversion among investors (Botman, Filho & Lam, 2013). By applying a factor model which captures linear and non-linear linkages between currencies, stocks, and bonds, Renaldo & Söderlind (2010) find that the yen appreciates in value against the U.S. dollar for falling U.S. stock prices and increasing U.S. bond prices and foreign exchange (FX) rate volatility. They conclude that the yen, as well as the Swiss franc and the Euro, "have significant safe haven characteristics and move inversely with international equity markets and FX volatility" (Renaldo & Söderlind, 2010). In another study performed by De Bock and de Carvalho Filho (2013), the authors find that the Swiss franc and the JPY are the two sole currencies which "on average appreciate against the U.S. dollar during risk-off episodes[1]" (cit. in Botman et al., 2013). According to Botman et al. (2013) safe haven currencies are usually characterized by low interest rates, a strong net foreign asset position, as well as deep and liquid financial markets, criteria which is all met by Japan (Botman et al., 2013).

Based on the alleged safe haven quality of the yen, I select the historical time-series of the JPY/USD trading pair and use it as a benchmark for gold's performance in the empirical analysis from the perspective of foreign investors.

2.6 Foundations in theory

The available literature in this realm is extensive and the study of gold's diversification properties has been of interest and subject to various studies since the collapse of the Bretton Woods System. The asset's role as a potential portfolio diversifier, given its relatively low correlation with other financial assets experienced intensified interest among global investors after the 2008 financial crisis (Baur & Lucey, 2010). Consequently, numerous empirical studies have been dedicated towards the gold's potential hedging and/ or safe haven attributes. Subsequently, different important strands of research in this area are introduced, focusing on studies closely related to the present thesis.

Numerous early studies have examined the correlation between gold and other major asset classes such as stocks, which revealed that it is low or either negative on average. This can be explained by the difference between the determinants of gold prices and other financial assets according to Jastram & Leyland, 2009 and Cheng, Su & Tzou, 2009 (cit in. Alkhazali & Zoubi, 2020). Hence, a low or even negative co-movement with equity implies that holding gold in a portfolio might indeed be advantageous in the quest of diversification benefits.

[1] The onset of a risk-off episode is defined as a large increase in the VIX relative to its 60-day historical moving average (Botsman et al., 2013)

One of the first studies in this area has been performed by McDonald & Solnik in 1977, who analyze "the relationship between gold prices in London and the S&P500 index using monthly data from 1948 to 1975" (cit. in Hoang, Lean, & Wong, 2013). The authors are further interested in the relationship between gold and gold mining stocks, which they test with a linear two-factor model. While the authors observe that there is indeed a positive relationship between the two, they could not find a significant relationship between gold and stock returns (Hoang et al., 2013). Thus, their findings imply that gold as well as gold mining stocks are beneficial in order to diversify an investor's portfolio.

A few years later, Sherman (1982) studies the effects of holding gold in equity and bond portfolios, combining a classical mean-variance (MV) approach, the Capital Asset Pricing Model (CAPM), as well as analyzing correlation coefficients. "Using monthly London data from 1976 to 1981, he finds that gold has a weak beta, a positive alpha and a weak correlation with other assets" supporting previous studies and implying that adding gold to a market portfolio is both profitable and beneficial in order to reduce an investor's overall risk exposure (cit. in Alkhazali & Zoubi, 2020). In a subsequent paper, Sherman (1986) praises gold's great flexibility in overall portfolio management and vouches for the gold's diversification benefits, its potential to protect capital against inflation, and its enhanced rate of return.

In 1989, Jaffe examines gold's role in modern portfolio management, its correlation with other major assets as well as its relationship with inflation by regressing the return of gold against changes in the Consumer Price Index (CPI). While gold is a risky asset by itself, Jaffe concludes that it has valuable diversification benefits and possibly yields higher expected returns. However, he did not find compelling evidence that gold hedges inflation nor that gold helps to forecast the change in CPI (Jaffe, 1989). Chua, Stick & Woodward (1990) confirm Jaffe's finding regarding gold's inability to effectively hedge against inflation and state that "gold has, indeed, been found to maintain its purchasing power over the long run. On a monthly-by-monthly or even year-by-year basis, however, gold has not proved steadfast". However, as shown in figure 1 and according to Erb & Harvey (2013), gold exhibits substantial price variability since the 1970s, which is in contradiction to its potential as a viable long-term hedge against inflation. Moreover, the trailing 10-year gold return exhibits negative returns between 1988 and 2005, which further suggests that gold has failed to live up as an attractive inflation hedge (Erb & Harvey, 2013). Conclusively, the authors find that inflation does not predict gold returns or vice versa, gold does not hedge for (un-)expected inflation, and the variation in the real price of gold accounts for most of the variation in the nominal price of gold.

Investigating gold bullion as well as gold stocks based on the CAPM, Chua et al. (1990) further emphasize gold's role as a meaningful investment for portfolio diversification from the view of an U.S. investor. Interestingly, however, they find that the beta of gold bullion remained virtually indistinguishable from zero during both the 1970s and the 1980s, while the beta for gold stocks (e.g. gold miners) more than doubled during the same period (Chua et al., 1990). Hence, their findings imply

that holding gold stocks will contribute more to the systematic risk of a portfolio compared to simply holding gold bullion.

Hilier, Draper & Faff (2006) show that the inclusion of precious metals (i.e. gold, platinum, and silver) in a U.S. and global equity portfolio helps to reduce systematic risk. Particularly during times of high volatility[2], precious metals exhibit certain hedging capabilities (Hilier et al., 2006). Furthermore, the authors perform a portfolio analysis where they measure the relative reward to risk ratio of pure equity portfolios against hybrid portfolios, i.e. stock portfolios including various weights of specific precious metals. They further distinguish between a pure "buy and hold strategy" versus a "rebalancing strategy". The authors come to the conclusion that out of the three aforementioned precious metals, gold is the optimal asset to invest in as part of a hybrid strategy and that the "buy and hold strategy" universally outperforms the "rebalancing method" (Hilier et al., 2006). The authors do not account for transaction costs, which are likely to further deteriorate the results of the switching strategy. Their final analysis examines potential efficiency gains from precious metals and concludes that the optimal weight is 9.5% based on a bootstrapped mean-variance optimization algorithm applied to historical returns from January 1987 to July 2002.

During the financial crisis and after the collapse of the Lehmann Brothers in 2008, markets revealed important and different dynamics. Financial contagion, increased co-integration among financial assets, and severe losses increased the demand for quality assets that exhibit lower correlation coefficients. While most financial assets have experienced negative returns, the nominal gold price has risen substantially during this period (Baur & McDermott, 2010). Hence, gold was once again referred to as a "quality" asset given its relatively low or even negative correlation with equity markets within this period. Investors realized that holding gold potentially protects their capital and acts as a stabilizing force in turbulent times. Thereafter, a propagated number of empirical studies were dedicated towards gold's promising safe haven potential in periods of high volatility and extreme negative returns. Findings unequivocally suggest that gold acts as a diversifier, hedge, and safe haven for certain equity markets in turbulent times (Alkhazali & Zoubi, 2020). However, gold's hedging and safe haven capabilities are not equally pronounced (even absent) among different financial markets, which is assessed in greater detail during the course of this thesis.

Baur & Lucey (2010) investigate the constant and time-varying relationship between gold returns and U.S., U.K., and German equity and bond returns between November 1995 and November 2005. The authors examine whether gold is a suitable hedge and/or safe haven for given markets. They apply a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model and regress daily gold returns on stock and bond returns including two interaction terms to test whether gold indeed acts as a safe haven if equity or bond markets experience extreme negative returns that are located in the q%

[2] The authors define high volatility as "market volatility of more than 2 standard deviations above mean volatility" (Hilier et al., 2006)

lower quantile of given return distribution, i.e. 5%, 2.5%, and 1% quantile. Their findings are based on domestic currencies, thus, focusing on the characteristics of gold for local investors. They find that the gold serves as a safe haven for all three markets for domestic investors. However, gold does not act as a safe haven for bonds, nor is it a hedge in the U.S. and U.K. based on their data (Baur & Lucey, 2010). Interestingly, gold's safe haven property is rather short-lived as suggested by the authors subsequent portfolio analysis. While gold returns are usually positive on the day of an adverse shock, "the gold price declines in the days following the extreme negative shock and the initial positive effect is reduced to zero after about 15 days" (Baur & Lucey, 2010). This quick reversal and the relatively short-lived safe haven benefits can be explained with the property that gold also acts as a hedge for certain equity markets (Baur & Lucey, 2010). According to the authors, a hedge correlates negatively on average with another asset, which explains that gold returns tend to fall as soon as stock prices experience positive returns following periods of extreme losses. Their study provides important insights in gold's potential ability as a hedge and safe haven asset in times of market distress. However, the number of markets under review is limited and they do not consider the role of exchange rates for their hypothesis.

Baur & McDermott (2010) build on the above study with numerous important extensions. The multi-country analysis pursued by the authors investigates major developed and emerging countries, consequently allowing them to test gold's safe haven properties across a relatively wide selection of global equity markets (Baur & McDermott, 2010). They further distinguish between a weak or strong safe haven in order to investigate the extent to which gold helps to protect an investor's wealth during extreme market conditions. Closely following Baur & Lucey's (2010) econometric model, the authors define extreme market conditions threefold. Firstly, the lower q% quantiles of the respective return distributions. Secondly, the upper q% quantiles of the lagged conditional volatility of the world portfolio, serving as a proxy for global uncertainty. And thirdly, a less statistical approach by defining certain periods of global economic crisis. Moreover, their findings are based on a multi frequency approach (i.e. daily, weekly, and monthly data) and they also test for currency effects, which possibly influence gold's safe haven property. The authors findings conclude that gold indeed acts as a safe haven asset for the majority of the developed countries under consideration. The results are most significant for daily frequency and extreme negative returns, i.e. 1% quantile of the return distribution. This implies "that investors react to short-lived and extreme shocks by seeking out the safe haven of gold" (Baur & McDermott, 2010). However, weekly or monthly data does not suggest the same impulsive reaction from investors. Their results are, however, different for emerging markets, where gold does not seem to exhibit the same safe haven properties as opposed to developed markets. Gold, at its best, acts as a weak safe haven for a handful emerging markets under consideration. Thus, the authors conclude that emerging market investors who face significant losses may readjust their portfolio by increasingly reweighting their assets towards developed markets, rather than seeking out the safe haven of gold (Baur & McDermott, 2010). Australia and Canada display another interesting observation, as for both markets gold does neither act as a hedge nor a safe haven in the timeframe under investigation. For the authors

these results are explicable given the nature of these stock markets. Both, Australia and Canada, "have significant mining interests in their national stock markets, which would tend to cause stocks and commodity prices (including gold) to co-move" (Baur & McDermott, 2010). The authors assumption about gold's feebly diversification potential for emerging market investors might be subject to two biases. Firstly, there is a possible sample size bias as they base their findings only on the BRIC countries. Secondly, both Russia and China are two major global gold producers, same rationale as for Australia and Canada applies, which possibly explains a stronger co-movement.

Ciner et al. (2013) investigate the return interdependencies of stocks, bonds, gold, oil, and exchange rates based on a quantile regression and a dynamic conditional correlation (DCC) approach between 1990 and 2010. Quantile regression is chosen as previous work has shown the important different dynamics markets exhibit in times of high volatility. The latter method has the advantage that it relies on time-varying correlations between the variables, a characteristic that also is of relevance according to preceding studies. Against the conclusion of the studies performed by Baur & Lucey (2010) and Baur & McDermott (2010), the observed reactions in the gold market after extreme negative shocks are never significant. A reason for these diverging results, according to the authors, is the different and more recent data, during which gold has significantly increased in valuation. They further argue that gold's increase in popularity as an investment vehicle and its interlinked financial instrumentation, such as a higher demand for ETF's and gold-linked traded indices, has potentially led to propagated co-movement between gold and equity (Ciner et al., 2013). Hence, the gold's decreased notion of being a safe haven in turbulent markets among investors. However, their findings suggest that gold performs well as a safe haven against a declining U.S. dollar. Capie et al. (2005) make a similar observation and find that gold serves as a hedge against fluctuating exchange rates values of the dollar, however, more effectively in times of unpredictable political events. Ciner et al. (2013) further observe a significant spike in gold returns in times where the dollar experiences strong declines in value. This observation confirms gold's role as a monetary asset according to the authors. Although gold has on average an insignificant correlation with bonds, they find that gold can serve as a safe haven for bonds, which is explicable given the notion that the behavior of financial assets in the tails of their distributions can substantially deviate from their average behavior, i.e. around the mean (Ciner et al., 2013). However, this is contradictory to the findings of Baur & Lucey (2010), who find that "gold is generally not a safe haven for bonds in any market."

Gürgün & Ünalmıs (2014) analyze the hedge and safe haven potential of gold for a large cross-section of emerging and developed countries from the perspective of both foreign as well as domestic investors. Moreover, they split their data into a set pre- and post-2008 financial crisis in order to identify potential differences. They find that, from the perspective of domestic investors, gold serves as both a hedge and safe haven in most markets. Moreover, the results are still persistent after the financial crisis. Their

model further concludes that gold offers advantages as a safe haven to a larger number of markets when negative equity returns become stronger.

Beckmann, Berger & Czudaj (2015) test the hypotheses laid down by Baur & Lucey (2010) and investigate gold's behavior by splitting the regression model into two regimes (i.e. average market regime vs. high volatility regime) by augmenting the model to a smooth transition regression (STR). The authors include a broad set of 18 individual markets and five regional indices quoted in local currency over a sample period from 1970 to 2012, relying on monthly data. Their findings suggest that gold generally serves at least as a weak form hedge and safe haven for equity in most markets. Yet, the metal's ability depends on the specific economic characteristics of each market (Beckmann et al., 2015). They argue that their research is superior to previous studies, based on their STR approach, which allows for a smooth rather than a merely discrete transition between the two extreme regimes. Yet, the transition between regimes tends to be very fast in most cases, making previous more discrete frameworks not obsolete. The researchers do not adequately account for potential currency effects, as they solely rely on prices quoted in local currencies. Hence, "there is a potential confounding role being played by the exchange rate in the results" (Beckmann et al., 2015).

Another interesting study is performed by Hoang et al. in 2013, where they tested whether gold quoted in Paris helps to diversify a French portfolio relying on data from 1949 to 2012. In order to do so, they test various portfolios with varying gold weightings for first, second, and third order stochastic dominance (SD). Their econometric approach does not rely on a normal distribution of the return series, which is a major advantage compared to a more common mean-variance optimization as reasoned by the authors. They find that portfolios including gold (even very small weights) stochastically dominate (i.e. outperform) the ones in absence of gold. Consequently, the inclusion of gold maximizes the expected utility of French investors, with stronger effects during volatile periods. On the contrary, gold does not seem to be beneficial for bond or risk-free investments, as the portfolios without gold positions stochastically dominate those with gold (Hoang et al., 2013). Alkhazali & Zoubi (2020) extended the SD approach and examined the role of gold as a diversifier for eight Dow Jones Islamic stock index portfolios between 1996 and 2017. Their findings are significant and merely congruent with the ones found by Hoang et al. (2013). For all eight Islamic stock indices the portfolios that include gold stochastically dominated the ones in absence of gold on the first, second, and third order. Conclusively, their results suggest that risk-averse Islamic investors should allocate gold to their portfolio in order to maximize their expected utility.

3 Empirical analysis

This section presents the empirical analysis of the research work. I describe the applicable financial time series, the subsequent data preparation process and its summary statistics. In addition, I introduce the two main econometric methods, including a detailed model structure for each framework.

3.1 Data selection and preparation

The data I selected for this study covers a broad cross-section of global equity markets and is based on approximately twenty years of daily data. I chose daily frequency because investors tend to seek a safe haven for a relatively short period of time, according to Baur & Lucey (2010) and Baur & McDermott (2010) for instance. Asynchronous trading (i.e. different closing hours of respective markets compared to gold) has a certain impact when dealing with high frequency data. However, this potential issue can be minimized by selecting the optimal lag for given return series.

In order to cover a wide range of developed and emerging markets and to identify various possible interdependencies between gold and individual markets, I use the appropriate MSCI market classification[3] for the selection of the indices. With few exceptions due to limited or insufficient data availability[4], the results are based on the MSCI developed and emerging markets classification, using the underlying historical time-series of each country's MSCI net index in both USD and domestic currency denotation. This currency differentiation allows a conclusion to be drawn from the perspective of both foreign and domestic investors. I chose net indices over price indices in order to capture the entire performance of each market index and to avoid potential amplification of negative returns. This is of importance as the findings are partly based on the left tail of the return distribution, i.e. extreme negative returns.

To adequately account for the changes in the gold price over the past twenty years, I use the historical time-series of the nearby Commodity Exchange Inc. (COMEX) gold future contract due to its high trading volume and liquidity. For simplicity reasons and to cover a wide range of different commodities, I chose to use the Bloomberg Commodity Index (BCOM)[5] and the performance of the yen is measured based on the JPY/USD currency pair.

I retrieved all data from Thomson Reuters Eikon database with exception of the JPY/USD exchange rate, which I accessed via Yahoo Finance. To ensure an adequate set of past observations and to cover major events such as market crashes or unusual price movements, the time-series for the developed market portfolio covers the period between August 01, 2000 and July 31, 2020. For the emerging markets portfolio, a slightly shorter period from January 03, 2001 until July 31 is chosen, as the inception

[3] For a full overview visit: https://www.msci.com/market-classification
[4] Omitted MSCI emerging markets: Pakistan, Qatar, Saudi Arabia, and UAE
[5] Refer to Appendix 1 for its constituents and weights as of 2019

date for the MSCI emerging market indices was only beginning of January 2001 and back tested data will not be used.

I performed thorough data cleansing in order to ensure that there are no inconsistencies among the various indices as well to avoid duplicate entries such as public holidays. In order to remove them, all values at time t, which are congruent with the closing price at time $t-1$, are subsequently eliminated. Consequently, this results in 5,217 observations of daily closing prices for the developed market portfolio indices, COMEX Gold, JPY/USD trading pair, BCOM as well as 5,099 total observations for the emerging markets portfolio indices. I then use the remaining closing prices to calculate the daily log returns r_t^i[6]. Furthermore, I chose linear interpolation over simply omitting all the non-available (N/A) closing prices. Linear interpolation refers to the process of estimating the N/A value based on the closest known values of the respective time series.

3.2 Descriptive statistics

Table 1 provides an overview of the summary statistics of the daily return data denoted in USD[7]. The table contains the name of each financial asset/ country, its mean, the respective maximum and minimum, its standard deviation, its skewness, and its kurtosis. The applied Jarque-Bera (JB) test, a widely used statistical test for normality, confirms the assumption that the return series do not follow a standard normal distribution with statistical significance at the 1% level. The skewness and kurtosis for given return series provide further evidence for their non-normality[8].

While gold exhibits the highest annualized mean return with 9.8%, the MSCI Greece index in turn exhibits a high negative return of -13.1%. Greeks negative performance is mainly explicable due to the country's government-debt crisis, which started in late 2009. Thus, most constituents of the Greek index must have experienced extreme negative returns and did not recover well. In terms of standard deviation, a measure of market volatility, gold yields 0.011, the fourth lowest value after MSCI Malaysia and BCOM, both with 0.010, and JPY/USD with the lowest volatility of 0.007. These values are within expectation, implying that stock returns have a higher absolute dispersion from the mean and are therefore more volatile over the period. This observation is also reflected in the daily maximum and minimum return. Gold for instance shows less pronounced values than the MSCI USA index for instance (i.e. 8.6% compared to 11% and -9.8% compared to -12.9%).

The skew coefficients obtained are in most cases significantly different from zero. Gold returns are negatively skewed at -0.265, implying that the return distribution is slightly asymmetrical with longer tails to the left. This result does not confirm the finding of Lucey, Tully & Potì (2004) who find that

[6] $r_t^i = \log\left(\frac{p_t^i}{p_{t-1}^i}\right) - 1$

[7] For a complete overview of the summary statistics denominated both in U.S. dollar and domestic currency refer to Appendix 2

[8] Any given standard normal distribution is characterized by a skewness of 0 and a kurtosis of 3

gold exhibits a positive and desirable skewness between August 1988 and September 2003. However, the majority of MSCI indices under investigation exhibit a lower skew coefficient than gold. Risk averse investors tend to favor assets that are on average slightly positively skewed, as this means that extreme returns are more often positive than negative.

With regard to the fourth moment of the distribution, risk averse investors usually prefer a lower excess kurtosis, as this implies returns dispersed near their mean. While gold exhibits a relatively low excess kurtosis at 5.905, there are several MSCI indices exhibiting a lower value (i.e. MSCI Netherlands, New Zealand, Norway, Singapore, Sweden, South Africa, and Taiwan). However, they all have a higher standard deviation compared to gold, which is a relevant factor to consider in combination with the kurtosis. The excess kurtosis of the JPY/USD trading pair is very high at 112.959, making it highly leptokurtic. This unusual value can be explained by the fact that the Japanese yen has been extremely stable over the last two decades, resulting in many yields that are close to zero, which is also reflected by its annual average of 0.2%.

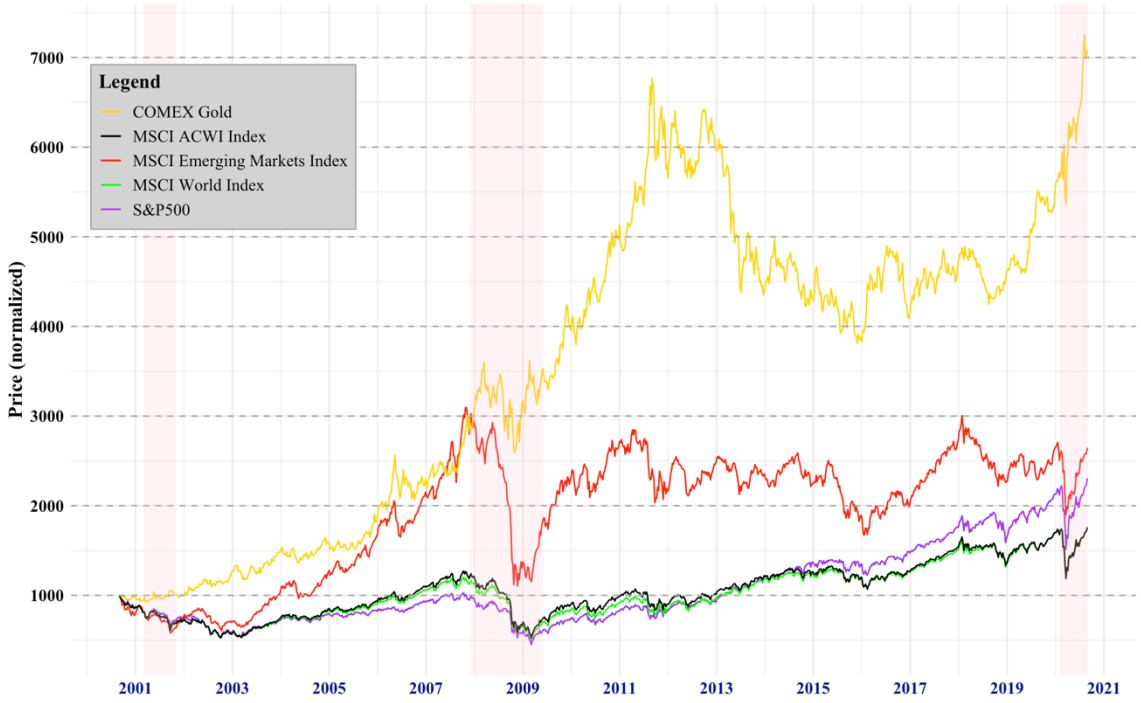
Table 1 Summary statistics

Index	Mean	Max.	Min.	Std. Dev.	Skew.	Kurt.	JB-Test
Diversifiers (31.07.2000 – 31.02.2020)							
COMEX Gold	0.098	0.086	-0.098	0.011	-0.265	5.905	7639***
BCOM	-0.004	0.056	-0.064	0.010	-0.241	2.977	1977***
JPY/USD	0.002	0.169	-0.163	0.007	0.529	112.959	2773354***
Developed Markets (31.07.2000 – 31.07.2020)							
Australia	0.085	0.088	-0.159	0.015	-0.882	10.065	22691***
Austria	0.020	0.134	-0.167	0.018	-0.396	8.803	16977***
Belgium	0.019	0.107	-0.182	0.015	-0.853	11.728	30524***
Canada	0.055	0.122	-0.142	0.014	-0.976	14.366	45680***
Denmark	0.101	0.107	-0.135	0.014	-0.382	7.331	11807***
Finland	0.006	0.159	-0.201	0.020	-0.254	6.984	10657***
France	0.023	0.120	-0.149	0.015	-0.259	7.918	13684***
Germany	0.033	0.115	-0.150	0.016	-0.252	6.684	9763***
Hong Kong	0.068	0.104	-0.124	0.013	-0.265	7.051	10867***
Ireland	-0.007	0.136	-0.189	0.018	-0.757	10.127	22788***
Israel	0.022	0.098	-0.116	0.013	-0.487	6.882	10501***
Italy	-0.007	0.125	-0.205	0.017	-0.607	11.038	26802***
Japan	0.029	0.114	-0.095	0.013	-0.181	4.642	4711***
Netherlands	0.044	0.105	-0.120	0.015	-0.307	7.373	11895***
New Zealand	0.110	0.102	-0.100	0.013	-0.408	5.206	6035.3***
Norway	0.053	0.153	-0.142	0.018	-0.537	7.875	13728***
Portugal	-0.007	0.129	-0.138	0.014	-0.308	8.659	16379***
Singapore	0.057	0.085	-0.098	0.013	-0.248	5.840	7467***
Spain	0.018	0.160	-0.172	0.017	-0.292	9.434	19418***
Sweden	0.035	0.140	-0.148	0.018	-0.115	5.730	7148***
Switzerland	0.064	0.097	-0.113	0.012	-0.247	7.019	10761***
UK	0.032	0.122	-0.141	0.014	-0.409	11.591	29342***
USA	0.070	0.110	-0.129	0.012	-0.402	11.943	31139***
Emerging Markets (01.01.2001 – 31.07.2020)							
Argentina	0.062	0.163	-0.511	0.027	-2.493	41.640	373587***
Brazil	0.059	0.166	-0.194	0.022	-0.511	8.882	16979***
Chile	0.049	0.164	-0.167	0.014	-0.661	16.062	55174***
China	0.102	0.140	-0.128	0.017	-0.119	6.396	8702***
Colombia	0.158	0.170	-0.219	0.017	-0.877	20.740	92027***
Czech Republic	0.079	0.197	-0.167	0.016	-0.364	13.817	40667***
Greece	-0.131	0.172	-0.251	0.024	-0.541	9.476	19322***
Hungary	0.073	0.203	-0.203	0.021	-0.210	9.462	19056***
India	0.090	0.195	-0.155	0.016	-0.385	10.678	24347***
Korea	0.131	0.250	-0.207	0.018	-0.158	14.480	44558***
Malaysia	0.088	0.072	-0.113	0.010	-0.528	8.732	16431***
Mexico	0.063	0.152	-0.112	0.016	0.016	7.114	10834***
Peru	0.165	0.124	-0.165	0.018	-0.604	8.024	13986***
Philippines	0.082	0.158	-0.145	0.015	-0.512	10.910	25505***
Poland	0.028	0.142	-0.176	0.019	-0.384	6.420	8879***
Russia	0.091	0.240	-0.256	0.022	-0.484	13.524	39050***
South Africa	0.071	0.124	-0.136	0.018	-0.394	4.495	4424***
Taiwan	0.092	0.082	-0.072	0.014	-0.102	2.963	1873***
Thailand	0.095	0.105	-0.181	0.015	-0.687	10.391	23336***

Note: The table presents the summary statistics of the different MSCI indices and diversifiers (COMEX Gold, BCOM, and Japanese yen) daily returns denominated in USD. The difference in the periodicity between the developed and emerging markets portfolio is due to the fact that the launch date of the MSCI emerging markets indices was only in January 2001 and therefore no backtesting was performed.

Figure 2 visualizes the historical price evolution of the underlying data, normalized at 1,000 U.S. dollar. Instead of plotting every single MSCI index against gold, I have chosen the MSCI ACWI, the MSCI World, the MSCI Emerging Markets index, and the S&P500. All indices are price indices, i.e. not including dividend payments. The three translucid red vertical bars are so-called recession bars[9], which indicate periods of economic contraction.

Figure 2 Normalized gold and global equity indices price evolution over the past two decades



Comparing the price trajectory of the S&P500, the MSCI ACWI, and the MSCI World index, it becomes evident that their correlation must be relatively close to one, as the purple, black, and green line show an almost congruent trajectory. Looking at the MSCI Emerging Markets index, a similar but less pronounced co-movement with the three precedent indices can be observed. However, all three indices show a clear upward trend after the 2008 financial crisis (i.e. second recession bar), the MSCI Emerging Markets index appears to have decoupled by mid-2011, with stagnant returns reversing around the 1,000 USD mark. The emerging markets index is more volatile for obvious reasons, with a very strong performance between 2002 and early 2008. The decline during the 2008 global financial crisis was considerably intensified compared to its developed counterparts with a drop of over 60% from its all-time high just over 3,000 to almost 1,000 in about nine months. Its subsequent recovery in turn was stronger compared to developed markets. A similar pattern is evident looking at this year's start of the global pandemic, i.e. the third recession bar. Emerging market equities fell even more than developed ones, and a similarly pronounced recovery began shortly afterwards. Although the four indices have

[9] The data is obtained from Federal Reserve Economic Data (FRED) and corresponds to the U.S. National Bureau of Economic Research's (NBER) recession data available at http://www.nber.org/cycles/cyclesmain.html

developed differently, they all move together and certain events (e.g. the three recession bars) show that they are highly correlated on average.

On examination of the gold price development, a certain but less pronounced co-movement with selected stock indices can be seen. Gold's performance over the last twenty years has been impressive, with an upward trend between the turn of the millennium and the end of 2011, closing above 1,900 USD per troy ounce on August 22, 2011 for the first time in history (Yousuf, 2011). Nevertheless, the gold failed to break through the 2,000 USD barrier and soon thereafter entered a five-year period with a strong decline to around 1,100 USD until early 2016. In autumn 2018, it entered a state of trend reversal and experienced positive returns with a rally that started in the first quarter of 2020.

However, the correlation between gold and stocks is of greater interest for this study than its overall performance. As shown in figure 2, gold returns are decoupled from equity returns in some periods, while in other periods they also exhibit substantial co-movement. As regards the three recession bars, gold yields on average were positive while equity returns were negative. This implies that gold possibly displays certain diversification potential for investors. Furthermore, the gold has a low or even negative correlation with global equities, especially at the beginning of turbulent market periods.

Figure 3 12-month rolling correlation between gold and global equity indices

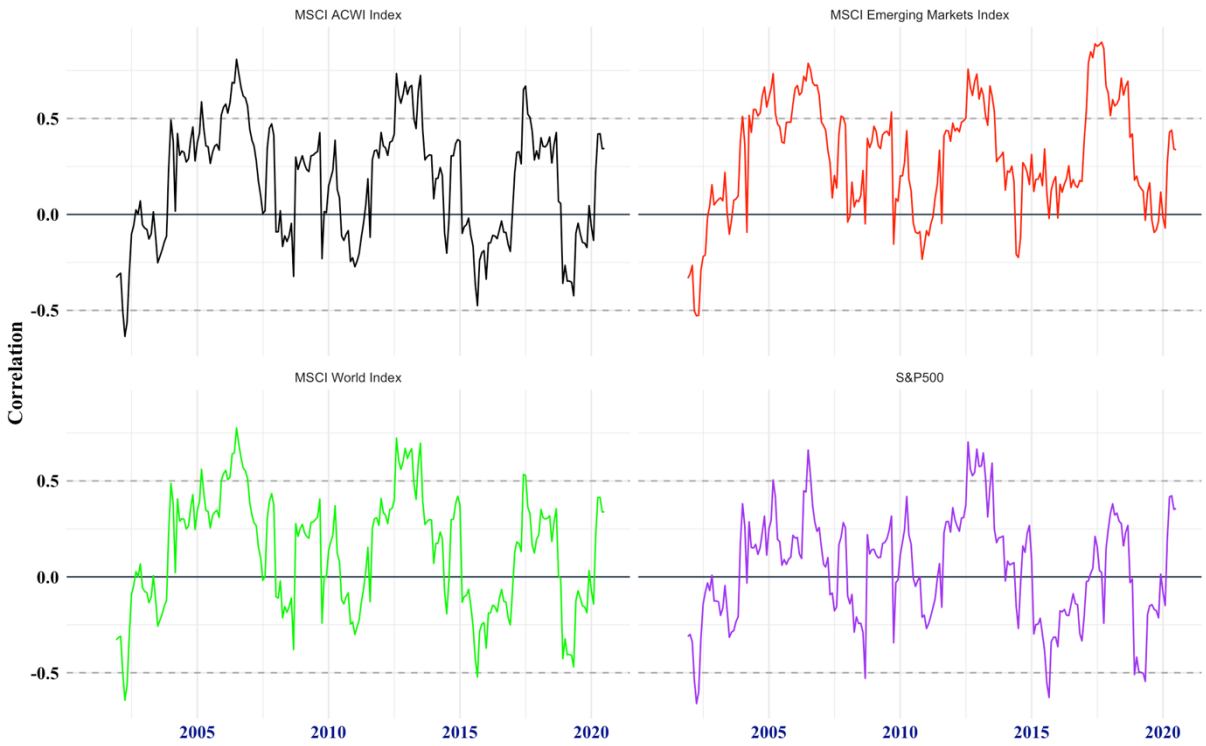


Figure 3 illustrates a 12-months rolling correlation between the above global indices and gold[10], which provides a more meaningful insight as the correlation between stocks and gold is clearly time dependent according to figure 2. For all four indices the order of magnitude varies considerably between about negative 0.6 and positive 0.75. Considering the four graphs individually, it is evident that their trend over the last two decades looks similar and that the average correlation appears to be slightly positive. This positive correlation on average suggest that gold is probably not a hedge according the above definition. Yet, the high negative coefficients during certain periods suggests that gold might be a valuable safe haven for some markets. The correlation is highest between gold and the MSCI Emerging Markets index, suggesting weaker diversification potential for emerging market investors. A hypothesis outlined by Baur & McDermott (2010), who state that gold does not provide meaningful diversification benefits for BRIC economies. However, there are periods with very low or even negative correlation coefficients, which serves as a motivation to examine gold's role as a diversifier more closely in the subsequent empirical analysis.

[10] A full overview of the dynamic time-varying correlations between gold and the individual MSCI indices for U.S. dollar return data is provided in Appendix 4

3.3 Econometric methodology

I use two different econometric frameworks to assess gold's diversification benefits:

(i) a linear regression model with different regressors; and
(ii) a dynamic conditional correlation (DCC) approach.

I explain the two approaches in more detail below.

3.3.1 Linear regression model

The first approach closely follows the model originally applied by Baur & Lucey (2010) and Baur & McDermott (2010) by regressing gold returns to stock returns, including dummy variables based on the q% lower quantiles of the underlying return distribution as well as on the q% upper quantiles of the VIX.

Model setup

Eq. 1 serves as the basic linear regression model in order to examine the relationship of gold and equity returns, where r_{Gold} stands for gold returns and r_{Equity} for equity returns. The error term is given by ε_t and the intercept a as well as the regression coefficient b_t are subject to the model estimation.

$$r_{Gold} = a + b_t\, r_{Equity} + \varepsilon_t \tag{1}$$

The regression coefficient is based on a dynamic process given by eq. 2. I then estimate parameters c_0, c_1, c_2 and c_3. As several previous studies have shown, the relationship between gold and global equities is not constant and tends to be influenced by extreme market conditions (Baur & McDermott, 2010). Therefore, I extend the regression model with three unique dummy variables D, which represent such adverse market conditions. I assigned a binary value of either one if the daily return of the respective equity index (i.e. defined ex-post) is located in the lower 5%, 2.5%, or 1% quantile of the return distribution, or zero otherwise. Put differently, the regressor which accounts for the 5% quantile gets assigned a one for all returns that are below its threshold. Same goes for the dummy that accounts for the 2.5% quantile. Hence, the number of days which get assigned a one for the 2.5% quantile are only half compared to the dummy variable accounting for the 5% quantile. This approach allows me to capture unordinary market movements and thus to examine the performance of gold during periods of severe market disruption, i.e. when diversification is needed the most. This is based on the assumption that contemporaneous changes in equity prices affect the price of gold (Baur & Lucey, 2010). Non-positive (and statistically significant) values for parameters c_1, c_2 and c_3 imply that gold is characterized as a weak (strong) safe haven for the respective quantile. Parameter c_0 defines whether gold classifies as a hedge for the respective market (Gürgün & Ünalmıs, 2014). Thus, if c_0 is zero or negative (and statistically significant), gold can be called a weak (strong) hedge, as the coefficient is estimated based on the entire return series.

$$b_t = c_0 + c_1 D\left(r_{Equity} q_5\right) + c_2 D\left(r_{Equity} q_{2.5}\right) + c_3 D\left(r_{Equity} q_1\right) \quad (2)$$

To account for the presence of heteroskedasticity in the underlying data, I use a standard generalized autoregressive conditional heteroscedasticity model GARCH(*1,1*) of the errors in eq. 3. While conventional time series are based upon the assumption of a constant variance, the ARCH process allows the conditional variance to change over time as a function of past errors, leaving the unconditional variance constant (Engle, 1982). The GARCH(*p,q*) process on top allows the inclusion of lagged conditional variance. I obtain the GARCH(*1,1*) regression model by letting the error terms be innovations in the linear regression at $t-1$ as explained by Bollerslev (1986). I estimate the GARCH(*1,1*) model with the "rugarch" package in R.

$$h_t = \pi + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (3)$$

Based on the findings of Baur & McDermott (2010), the relationship between gold and equities is also subject to changes based on the degree of uncertainty among investors. Hence, I use the CBOE Volatility Index (VIX) as a proxy for global uncertainty and it serves as a secondary approach to examine the gold-equity relationship during periods of high volatility/ uncertainty among investors. Therefore, I extend the regression model again with three different dummy variables D', which simulate highly volatile periods. D' in eq. 4 are equal to one if the respective value of the VIX lies in the 90%, 95%, and 99% quantile of the distribution, and zero otherwise. Hence, for the definition of the regressors I follow the same rationale as explained above with respect to the q% lower return quantiles. If parameter v_0 is zero or negative (and statistically significant), gold can be called a weak (strong) hedge, and if v_1, v_2 and v_3 are non-positive (and statistically significant), it implies that gold is characterized as a weak (strong) safe haven for the respective quantile.

$$b_t = v_0 + v_1 D'\left(r_{Equity} q_{90}\right) + v_2 D'\left(r_{Equity} q_{95}\right) + v_3 D'\left(r_{Equity} q_{99}\right) \quad (4)$$

Due to volatility clustering, I expect the dummy variables generated in eq. 4 to take a value of one over much longer periods of time, compared to eq. 2, where the dummy variables depend on the left tail of the respective return distribution (Baur & McDermott, 2010). In other words, extremely negative returns usually last only a single or a few days, while high levels of volatility accumulate over longer periods. The dummy variables retrieved confirm this assumption and show that the variables in eq. 2 are much less susceptible to clustering compared to the dummy values generated in eq. 4. I therefore expect that the results will differ between the yield-based and the VIX-based approach, providing further interesting insights.

In order to identify the optimal lag length for the above models, I apply both the Akaike and Schwarz information criteria and auto-correlation function (ACF) plots. For the majority of the return series, the

model fit is optimal at lag zero. Therefore, I decide to use contemporaneous stock returns for all return series.

To examine the diversification potential of the broad commodity index and the Japanese yen, I use the same econometric framework and criteria as for gold. I subsequently use these results to benchmark the diversification benefits of gold against other assets that have alleged diversification potential as a hedge or safe haven in times of market disruption.

3.3.2 Dynamic conditional correlation model

I base the second econometric model, which provides additional inference and serves as a robustness check, on a dynamic conditional correlation approach with suitable GARCH specifications, as suggested by Engle (2002) (cit. in Ciner et al., 2013). Moreover, I use the model to graphically illustrate the individual dynamic time-varying correlations between gold and each individual MSCI index as shown in Appendix 4.

The DCC model is ought to provide time-varying correlations, i.e. a different correlation coefficient for each individual day. Given the relatively high fluctuation of the correlation between gold and stock markets as shown by figure 3, it is intuitively useful to examine time-varying correlations instead of the overall correlation between two financial assets. This dynamic approach allows me to study the gold-equity relation at specific periods of time, which provides further insight into whether gold is considered a hedge and/ or safe haven for certain markets. Another advantage of this model is the fact that it accounts for correlation clustering, a stylized fact in financial time series (V-Lab, 2020).

Model setup

A multivariate GARCH model is a prerequisite for setting up the DCC model, as I want to model the conditional volatility of a vector of assets. In a first instance, I create univariate volatility models for every single asset. The DCC model basically decomposes the multivariate volatility problem into one of first modelling univariate volatilities[11] and subsequently estimating dynamic conditional correlations. The estimated univariate volatility models created in a first instance I then use for standardizing the individual residuals, which allows for the specification of the dynamic correlations of these residuals (ECLR, 2018). Finally, I am able to extract the estimated correlation and covariance matrices. This analysis focuses on the time-varying correlations between the different assets, which is the main reason why I have selected this model. I use the R packages “rugarch” and “rmgarch” in order to estimate the multivariate volatility model (i.e. DCC model) for my return series.

According to Engle (2002), the DCC model can be interpreted as a generalization of the constant conditional correlation (CCC) estimators introduced by Bollerslev (1990). In the CCC, the covariance matrix is defined as:

[11] The number of univariate volatility models depends on the amount of assets we use as input

$$H_t = D_t R D_t = \rho \sqrt{h_{iit}\, h_{jjt}} \tag{5}$$

with $D_t = diag(\sqrt{h_{11,t}}, \dots, \sqrt{h_{nn,t}})$, and R as the positive definite constant conditional correlation matrix (Ghalanos, 2019). The introduction of the DCC by Engle (2002) allows for the correlation matrix to be time varying and, hence, capturing the dynamics accordingly:

$$H_t = D_t R_t D_t \tag{6}$$

This model constrains the time varying correlation matrix R_t twofold, making it computationally more intensive. Firstly, it has to be inverted at every point in time and secondly, it has to be positive definite. Engle's (2002) DCC model achieves these constraints. As mentioned above, the GARCH-DCC(*p,q*) model is divided into a two-step approach. The initial step accounts for the conditional heteroskedasticity present in the data by estimating the given conditional volatility σ_t^i for n series of returns r_t^i based on a univariate GARCH model.

$$D_t^{i,i} = \sigma_t^i \; and, if \; i \neq j, D_t^{i,i} = 0 \tag{7}$$

D_t in eq. 7 represents the diagonal matrix of these conditional volatilities. Then the standardized residuals with unit conditional volatility are:

$$\varepsilon_t = D_t^{-1}(r_t - \mu) \tag{8}$$

Subsequently the matrix is defined by eq. 9, which is the CCC estimator (Bollerslev, 1990).

$$\bar{R} = \frac{1}{T}\sum_{t=1}^{T} \varepsilon_t \varepsilon_t' \tag{9}$$

The second step of the GARCH-DCC model involves generalizing the above estimator in order to adequately capture the dynamics in the correlation:

$$Q_t = \bar{\bar{R}} + \alpha(\varepsilon_{t-1}\varepsilon_{t-1}' - \bar{R}) + \beta(Q_{t-1} - \bar{R}) \tag{10}$$

Parameters α and β are jointly estimated by maximizing the log-likelihood and they are constrained in a way that $\alpha + \beta < 1$. Given the aforementioned consideration of correlation clustering, the correlation within the DCC model is likely to be high at time t, as it was already high at $t-1$. Hence, a shock occurring at $t-1$ does not instantly decay and therefore influences the correlation at time t. However, due to the above constraint $\alpha + \beta < 1$, the correlation itself fluctuates around the unconditional

volatility $\bar{R}$ and is mean reverting in itself (V-Lab, 2020). Ultimately, the DCC(*p,q*) process is then given by eq. 11.

$$Q_t = \bar{R} + \sum_{i=1}^{p} \alpha_i \left(\varepsilon_{t-1}\varepsilon'_{t-1} - \bar{R}\right) + \sum_{j=1}^{q} \beta_j (Q_{t-j} - \bar{R}) \tag{11}$$

This is a more generalized form that allows for additional lags in the conditional correlation, depending on the defined number of lags p and q, which are usually defined by means of information criterion. In the present analysis, I chose a GARCH-DCC(*1,1*) process in accordance with its broad applicability in quantitative finance and the fact that it tends to represent the optimal number of lags for financial time-series.

This approach allows for the extraction of a different correlation matrix for every single day. Thus, the dynamic time-varying correlations between the respective MSCI indices and gold are subject to further analysis. In accordance with the definition in chapter 2.4, I assess gold's potential as a hedge for a specific market by extracting its average correlation with equities over the entire periodicity. If this value is zero or negative, it means that gold serves as a hedge for a particular market. In addition, I use the same return- and VIX based quantiles to assess if gold displays safe haven characteristics for a certain country. Consequently, I extract the individual dynamic correlation coefficients for the q% lower quantiles (i.e. once for the 5%, 2.5%, and lastly 1% quantile) of the respective MSCI return series and calculate the average. I do exactly the same with the q% upper quantiles of the VIX. This allows a conclusion to be drawn regarding the correlation of gold with equities during periods of extreme negative returns or high volatility, as a non-positive coefficient indicates that gold moves inversely with equities when they experience high negative returns or in periods of high volatility.

4 Discussion

In this section I discuss the empirical results retrieved from the economic framework explained in the preceding chapter. Firstly, I introduce the results of the (i) linear model for both the MSCI developed and emerging markets. Secondly, I present and analyze the dynamic correlation estimates of the (ii) GARCH-DCC(*1,1*) model for both markets. In addition, I compare the findings to similar research in this field. Last but not least, I identify possible limitations and extensions to the present research.

4.1 Linear regression model

Tables 2 to 5 present the estimated regression coefficients using the linear model for the selected markets, once based on equity and gold yields denoted in U.S. dollar (panel A) and once denoted in domestic currency (panel B). The distinction between USD and local currency allows me to draw different conclusions and to capture the perspective of both domestic and foreign investors. The light green shaded areas are for visualization purposes and highlight the non-positive coefficient estimates as they are of higher relevance for this study. The statistically significant coefficients provide higher explanatory power for the gold equity relationship. Nevertheless, the light shaded green fields also provide valuable insights and are therefore included in the analysis.

MSCI developed markets

The coefficient estimates for the overall effect (i.e. hedge column), shown in table 2, yield a slightly negative value for Israel and a statistically significant negative value for the USA in panel A. In panel B, Israel and the USA are assigned a negative and statistically significant value and Italy, Spain, and Sweden yield negative coefficients. Hence, gold represents a weak hedge for Israel and a strong hedge for U.S. equity markets from a foreign investor's perspective. Furthermore, it defines as a weak hedge for Italy, Spain, and Sweden and as a strong hedge for Israel and the USA from a domestic investor's view.

A closer look at the coefficient estimates in both panel A and B of table 2 shows that the number of negative values increases towards the lower quantiles, indicating a non-linearity between equity and gold returns. This supports the hypothesis that the metal's diversification potential increases with declining stock returns. For the 1% quantile in panel A, gold serves as a strong safe haven for Ireland, Italy, and the USA and as a weak safe haven asset to Austria, France, the Netherlands, Spain, Switzerland, and the UK. Considering the same quantile in panel B, gold displays strong safe haven benefits for Germany, Ireland, Italy, Spain, and the USA and weak advantages in Austria, Canada, France, Hong Kong, Israel, the Netherlands, Norway, and Sweden.

Table 2 Developed markets linear model coefficient estimates – Return quantiles

Panel A					Panel B				
MSCI Developed Markets – in USD					**MSCI Developed Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Australia	0.156***	0.112***	0.096***	0.065**	**Australia**	0.046***	0.038	0.068**	0.075*
Austria	0.083***	0.038**	0.024	-0.007	Austria	0.021**	-0.017	-0.016	-0.008
Belgium	0.068***	0.040**	0.028	0.025	Belgium	0.023**	-0.001	0.020	0.006
Canada	0.172***	0.128***	0.100***	0.113***	**Canada**	0.061***	0.005	-0.018	-0.040
Denmark	0.100***	0.095***	0.078***	0.074**	Denmark	0.059***	0.067***	0.061**	0.079**
Finland	0.025***	0.013	0.016	0.033*	Finland	0.018***	0.015	0.030**	0.020
France	0.056***	0.030*	0.029	-0.041	France	0.022**	0.005	0.018	-0.015
Germany	0.046***	0.024	0.006	0.011	Germany	0.023**	0.016	-0.010	-0.067**
Hong Kong	0.024**	0.003	0.023	0.021	Hong Kong	0.018	-0.002	0.012	-0.005
Ireland	0.041***	0.015	-0.015	-0.061***	Ireland	0.005	-0.018	-0.044**	-0.088***
Israel	-0.002	-0.005	-0.006	-0.005	Israel	-0.038***	-0.038**	-0.038*	-0.030
Italy	0.040***	0.000	-0.003	-0.061***	Italy	-0.001	-0.038**	-0.038*	-0.092***
Japan	0.094***	0.045**	0.048**	0.084***	Japan	0.099***	0.102***	0.095***	0.117***
Netherlands	0.052***	0.020	0.031	-0.012	Netherlands	0.031***	0.031*	0.032	-0.031
New Zealand	0.155***	0.138***	0.133***	0.089***	New Zealand	0.104***	0.149***	0.175***	0.144***
Norway	0.121***	0.110***	0.109***	0.094***	Norway	0.041***	0.030	0.039	-0.004
Portugal	0.095***	0.042**	0.009	0.019	Portugal	0.034***	-0.011	0.009	0.040
Singapore	0.093***	0.077***	0.077***	0.105***	Singapore	0.007	0.016	0.039	0.065*
Spain	0.041***	0.010	-0.016	-0.010	Spain	-0.003	-0.025	-0.037*	-0.058**
Sweden	0.059***	0.063***	0.073***	0.043*	Sweden	-0.011	0.000	0.011	-0.030
Switzerland	0.115***	0.079***	0.041	-0.024	Switzerland	0.128***	0.197***	0.242***	0.404***
United Kingdom	0.087***	0.050**	0.018	-0.035	United Kingdom	0.056***	0.031	0.019	0.053
USA	-0.041***	-0.053**	-0.065**	-0.112***	**USA**	-0.041***	-0.053**	-0.065**	-0.112***

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

The bold countries are classified as major global gold producers

Note: The table presents the estimated regression coefficients for gold's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that gold is a (strong) hedge for given market. Non-positive and (statistically significant) estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that gold serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

Baur & Dermott (2010) argue that the "movements in the dollar are likely to be driving the co-movement of non-US stocks and the gold price both denominated in US dollar" as a falling dollar is likely to trigger an increase in the nominal value of non-US equities and the price of gold. Consequently, the dollar denomination of the MSCI indices is subject to influence of the exchange rate, resulting in a higher level of correlation compared to panel B, with domestic currency denomination. For the U.S. market this effect is obviously of no relevance and gold exhibits a statistically significant negative co-movement across all market conditions, i.e. different quantiles.

The present results align with the findings of Gürgün & Ünalmıs (2014), who state that the amount "of countries in which gold displays hedge and safe haven properties are higher when the returns of gold and equities are in domestic currency". The comparison of the green shaded areas between panel A and B in table 2 endorses this observation. Consequently, gold provides better diversification benefits for domestic investors in the case of Austria, Belgium, Canada, Germany, Hong Kong, Ireland, Israel, Italy, the Netherlands, Norway, Portugal, Spain, and Sweden. Another possible explanation offers the observation that declining equity prices tend to positively correlate with domestic exchange rates and vice versa (Gürgün & Ünalmıs, 2014). Following this rationale, the coefficients for the Japanese and Swiss markets should be the opposite, as both the yen and the Swiss franc are widely recognized as safe

haven currencies. The coefficient estimates, as shown in table 2, indeed confirm this assumption, as they are significantly higher for both indices in panel B compared to panel A. For Switzerland this effect is particularly strong, suggesting that holding gold in a local currency portfolio does not provide the desired diversification benefits due to the franc's tendency of strong appreciation in times of market distress. Therefore, if gold offers only hedging or safe haven advantages for domestic investors, but no or only limited advantages from the perspective of foreign investors, then the advantageous quality is partly driven by the currency effect, or, in other words, gold serves as a currency hedge.

Table 3 Developed markets linear model coefficient estimates – VIX quantiles

Panel A					**Panel B**				
MSCI Developed Markets – in USD					**MSCI Developed Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.90**	**0.95**	**0.99**		**Hedge**	**0.90**	**0.95**	**0.99**
Australia	0.156***	0.087***	0.070***	0.088**	**Australia**	0.046***	0.044	0.054	0.073
Austria	0.083***	0.066***	0.063***	0.131***	Austria	0.021**	0.052**	0.031	0.083
Belgium	0.068***	-0.004	0.010	0.081	Belgium	0.023**	0.012	-0.001	0.048
Canada	0.172***	0.035*	0.044*	0.054	**Canada**	0.061***	-0.106***	-0.086**	-0.069
Denmark	0.100***	0.044*	0.055*	0.135**	Denmark	0.059***	0.056**	0.041	0.067
Finland	0.025***	0.004	0.023	0.160***	Finland	0.018***	0.022	0.001	0.091
France	0.056***	0.005	0.010	0.136**	France	0.022**	0.015	-0.015	0.083
Germany	0.046***	-0.010	0.009	0.193***	Germany	0.023**	0.005	-0.013	0.118*
Hong Kong	0.024**	0.009	0.044	0.083	Hong Kong	0.018	0.012	0.052	0.084
Ireland	0.041***	0.008	0.026	0.145***	Ireland	0.005	0.018	0.025	0.100
Israel	-0.002	-0.017	0.038	0.104*	Israel	-0.038***	-0.061*	0.018	0.061
Italy	0.040***	0.004	0.016	0.080*	Italy	-0.001	0.015	-0.004	0.067
Japan	0.094***	0.079***	0.112***	0.228***	Japan	0.099***	0.147***	0.221***	0.305***
Netherlands	0.052***	-0.003	0.004	0.183***	Netherlands	0.031***	0.018	-0.013	0.121
New Zealand	0.155***	0.115***	0.093***	0.147**	New Zealand	0.104***	0.127***	0.143***	0.186**
Norway	0.121***	0.058***	0.050**	0.095**	Norway	0.041***	-0.031	-0.040	0.016
Portugal	0.095***	0.062**	0.081**	0.237***	Portugal	0.034***	0.066**	0.079**	0.163*
Singapore	0.093***	0.043*	0.016	0.095	Singapore	0.007	-0.013	-0.026	0.001
Spain	0.041***	-0.009	0.009	0.131**	Spain	-0.003	0.002	-0.017	0.089
Sweden	0.059***	0.015	0.025	0.086*	Sweden	-0.011	-0.046**	-0.076**	-0.045
Switzerland	0.115***	0.011	0.010	0.111*	Switzerland	0.128***	0.054**	0.029	0.055
United Kingdom	0.087***	0.023	0.019	0.116**	United Kingdom	0.056***	-0.017	-0.063*	0.031
USA	-0.041***	-0.073***	-0.032	0.046	**USA**	-0.041***	-0.073***	-0.032	0.046

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

The bold countries are classified as major global gold producers

Note: The table shows the estimated regression coefficients for gold's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that gold is a (strong) hedge for given market. Non-positive and (statistically significant) estimates for periods of high volatility (i.e. quantile columns 0.90, 0.95, or 0.99) imply that gold serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

The coefficient estimates in table 3 are based on the same methodology as above, but with different regressors according to eq. 4. Instead of focusing on the left tail of each MSCI return distribution, the q% upper quantiles of the VIX are used instead. While the hedge column remains unchanged for both panels, as it captures the overall effect between gold and stocks, there are some interesting observations on the different quantiles. Again, the same rationality applies in relation to falling dollar prices and rising nominal values of non-US indices (i.e. difference between panel A and B):

For the 90% quantile in panel A of table 3, gold only exhibits a statistically significant negative coefficient for the USA. In addition, gold displays slightly non-positive but statistically insignificant values at the 90% quantile for Belgium, Germany, Israel, the Netherlands and Spain, indicating a weak

safe haven potential. Capturing the effect for domestic investors, indicated by panel B, gold provides strong safe haven benefits at the 90% quantile for Canada, Israel, Sweden, and the USA and weak safe haven benefits to Norway, Singapore, and the UK. This effect is reinforced at the 95% quantile, where gold, although no longer considered a safe haven for Israel, offers certain additional benefits for Belgium, France, Germany, and Italy. However, only Canada, Sweden, and the UK display statistical significance for the 95% quantile.

While gold's safe haven properties tend to increase as equity returns decline, as shown in table 2, the opposite seems to be the case as volatility peaks. Comparing the 99% with the 95% quantile in panel A for instance, gold no longer acts as a stabilizing force from the perspective of foreign investors in any of the markets. A similar pattern is observable in panel B, where gold acts as a safe haven for twelve markets at the 95% quantile, but only as a weak safe haven (i.e. no statistical significance) in Canada and Sweden at the 99% quantile. Consequently, during periods of excessive volatility (i.e. the 99% quantile), the metal's safe haven capabilities show to deteriorate considerably. This observation confirms the initial assumption that investors tend to seek a safe haven in gold with rising uncertainty. In contrast to extreme negative returns, however, the flight to safety decreases from a certain point onwards when the volatility becomes too high. This in turn suggests that financial assets are subject to greater co-movement in times of extreme uncertainty among investors and that cash or risk-free assets are preferred.

Furthermore, the above finding is consistent with the study of Baur & McDermott (2010), who argue that volatility clustering and the absence of extreme negative return shock clustering serves as the main reason for the divergence of the two regression models. High levels of uncertainty, proxied by the three VIX quantiles, usually have high predecessor values due to the clustering effect. A certain spillover from equities to gold can be observed, especially when the market volatility starts to ascend, in other words when uncertainty among investors is rising, as during the recent global pandemic for example. Moreover, Baur & Lucey (2010) find that this spillover effect from equities to gold is rather short-lived (i.e. roughly 15 trading days), which explains why a reversal is to be expected and provides a possible explanation for gold's decreasing effectiveness with peaking volatility. Financial contagion, margin calls, and holding limits may provide further explanation for the observed decrease in effectiveness as the market volatility peaks. When strongly negative returns accumulate over a certain period, institutional investors holding gold, or commodities in general, are often obliged to start selling these positions, as commodities are usually confined by holding limits. Rising demand for liquidity to meet margin calls could put further pressure on gold. This often results into falling gold prices, which in turn leads to greater co-movement with other financial assets (e.g. financial contagion).

MSCI emerging markets

The coefficient estimates in panel A of table 4 show that gold indeed offers weaker diversification potential for emerging compared to developed markets. A hypothesis that has already been confirmed by Baur & McDermott (2010) or Beckmann et al. (2015). Nevertheless, the authors do not account for a broad cross section of emerging economies, but mainly focus their analysis on the BRIC countries. The strictly positive and statistically significant values in the hedge column of panel A provide strong evidence that gold does not serve as a hedge for foreign investors invested in emerging markets.

Table 4 Emerging markets linear model coefficient estimates – Return quantiles

Panel A					Panel B				
MSCI Emerging Markets – in USD					**MSCI Emerging Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Argentina	0.014***	0.003	0.000	-0.007	Argentina	0.113***	-0.051***	-0.176***	-0.245***
Brazil	0.062***	0.072***	0.059***	0.064***	Brazil	0.003	0.023	0.012	-0.013
Chile	0.082***	0.061***	0.064***	0.067**	Chile	-0.004	-0.003	-0.019	-0.053
China	0.025***	0.020	0.034*	0.056**	**China**	0.008	0.012	0.024	0.035
Colombia	0.069***	0.080***	0.084***	0.065**	Colombia	0.012	-0.013	-0.005	-0.031
Czech Republic	0.106***	0.090***	0.076***	0.030	Czech Republic	0.057***	0.073***	0.070***	0.101***
Greece	0.026***	-0.006	-0.029**	-0.040***	Greece	0.003	-0.015	-0.035***	-0.043***
Hungary	0.070***	0.058***	0.041**	0.032	Hungary	-0.001	0.008	0.017	0.019
India	0.045***	0.055***	0.059***	0.014	India	-0.048***	-0.015	-0.019	-0.019
Korea	0.035***	0.024	0.004	0.006	Korea	-0.035***	-0.040**	-0.038*	-0.040
Malaysia	0.079***	0.064**	0.099***	0.105***	Malaysia	-0.022	0.015	0.018	0.064
Mexico	0.067***	0.052***	0.027	0.002	**Mexico**	0.049***	0.044*	-0.003	-0.012
Peru	0.206***	0.182***	0.162***	0.157***	**Peru**	0.197***	0.167***	0.162***	0.166***
Philippines	0.046***	0.076***	0.104***	0.122***	Philippines	0.037***	0.092***	0.132***	0.189***
Poland	0.087***	0.061***	0.052***	0.047*	Poland	0.003	0.015	0.004	0.083**
Russia	0.039***	0.050***	0.035**	0.019	**Russia**	-0.011	-0.013	-0.018	-0.044**
South Africa	0.133***	0.139***	0.144***	0.136***	**South Africa**	0.133***	0.134***	0.146***	0.205***
Taiwan	0.029***	0.015	0.003	0.044	Taiwan	-0.025**	-0.032*	-0.049**	-0.037
Thailand	0.048***	0.056***	0.030	0.024	Thailand	0.003	0.033*	0.042*	0.093***

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

The bold countries are classified as major global gold producers

Note: The table presents the estimated regression coefficients for gold's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that gold is a (strong) hedge for given market. Non-positive and (statistically significant) estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that gold serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

Considering the different quantiles of panel A in table 4, the results suggest that holding gold offers marginal advantages as a safe haven in Argentina and strong benefits in Greece. However, the Greek estimates must be interpreted carefully, as the corresponding MSCI index yields the worst performance of the whole dataset with an average annual return of -13.1% throughout the last two decades (see 3.2 Descriptive statistics). Therefore, this unusual negative performance over an extended time period is most likely responsible for given results. Baur & McDermott (2010) as well as Gürgün & Ünalmıs (2014) find similar results. According to their reasoning it refers to the phenomenon that foreign investors active in emerging markets usually sell their positions and shift their funds to developed markets in response to a negative shock as a "flight-to-safety" rather than seeking a safe haven in an alternative investment such as gold.

Panel B, on the other hand, yields heterogeneous results that are different from the perspective of USD investors. The numerous coefficient estimates shaded in green indicate that the aforementioned currency effect is even stronger for emerging market economies. From a domestic investor's perspective, presented by panel B in table 4, gold exhibits negative and statistically significant coefficients in the hedge column for India, Korea, and Taiwan, indicating that the asset inherits a strong potential as a hedge for these countries. For Chile, Hungary, Malaysia, and Russia, however, gold displays only weak hedging potential, as the values are only slightly negative in absence of statistical significance. This is an important finding and shows that gold serves exclusively as a hedge and/ or safe haven asset for domestic investors in emerging markets. Additionally, these results provide evidence that gold does indeed deliver certain diversification benefits for emerging market participants, even if only for domestic investors.

As shown in panel B of table 4, gold classifies as a strong safe haven for Argentina, Korea, and Taiwan and as a weak safe haven for Chile, Colombia, Greece, India, and Russia in the 5% quantile. The 2.5% quantile suggests that Mexico is also benefiting slightly, and that gold is a strong safe haven for Greece in addition. While gold displays a negative and statistically significant value for Russia at the 1% quantile, it shows only weak properties for Korea and Taiwan on top of the previous markets. Moreover, Brazil joins the list of countries for which gold delivers marginal benefits as a safe haven. Once again, the number of markets for which gold serves as a safe haven is rising with falling stock yields, i.e. towards the lower return quantiles. Consequently, the demand for gold as a safe haven asset is partly driven by the degree of severity of the market downturn.

A higher co-movement between gold and domestic equities is expected for countries with significant mining activities. The strictly positive and mostly statistically significant values for China, Mexico, Peru, Russia, and South Africa in panel A of table 4 support this assumption. Yet, the currency effect appears to prevail for Russia and Mexico, as shown in panel B, for which gold delivers certain hedging and/ or safe haven advantages in the case of domestic investors.

The results obtained in panel A in table 5, confirm that the diversification benefits of gold for foreign investors in emerging markets are virtually non-existent. This again supports the above argument of "flight-to-safety" of foreign investors, who tend to relocate their funds to developed economies during unfavorable market phases. Gold seems to offer only negligible benefits as a safe haven in Argentina, India, and Thailand. However, these coefficients are neither statistically significant, nor are they largely different from zero. Panel B again shows heterogeneous results, indicating that gold has a different relevance for domestic investors. As regards the 90% quantile, gold offers Brazilian, Chilean, Colombian, Korean, and Russian investors strong safe haven benefits and potentially weak advantages for Argentinian, Hungarian, Indian, Mexican, Taiwanese, and Thai investors alike. Looking at the 99% quantile, it is noticeable that gold's safe haven properties are weakening. Not only does it serve as a safe haven asset for fewer markets, but also with less statistical significance and values closer to zero.

While gold serves as a safe haven for eleven out of nineteen markets in the 90% and 95% quantile, this applies to only nine indices in the 99% quantile, with Korea being the sole market exhibiting a negative and statistically significant coefficient. Thus, the pattern of diminishing diversification benefits with peaking volatility is comparable to one observed previously in table 3.

Table 5 Emerging markets linear model coefficient estimates – VIX quantiles

Panel A

MSCI Emerging Markets – in USD				
	COMEX Gold - Daily Frequency			
	Hedge	**0.90**	**0.95**	**0.99**
Argentina	0.014***	-0.001	-0.009	0.053
Brazil	0.062***	0.011	0.020	0.018
Chile	0.082***	0.009	0.011	0.030
China	0.025***	0.030	0.063*	0.092
Colombia	0.069***	0.063***	0.049*	0.065*
Czech Republic	0.106***	0.060***	0.070***	0.138***
Greece	0.026***	0.042**	0.073***	0.097**
Hungary	0.070***	0.032*	0.041*	0.062*
India	0.045***	0.044*	0.012	-0.006
Korea	0.035***	0.035*	0.022	0.064*
Malaysia	0.079***	0.064*	0.085*	0.166*
Mexico	0.067***	0.000	0.004	0.016
Peru	0.206***	0.134***	0.095***	0.032
Philippines	0.046***	0.070***	0.039	0.056
Poland	0.087***	0.042**	0.039*	0.089**
Russia	0.039***	0.024	0.039*	0.072**
South Africa	0.133***	0.099***	0.114***	0.126***
Taiwan	0.029***	0.029	0.035	0.121
Thailand	0.048***	0.032	0.037	-0.027

Panel B

MSCI Emerging Markets – in Domestic Currency				
	COMEX Gold - Daily Frequency			
	Hedge	**0.90**	**0.95**	**0.99**
Argentina	0.113***	-0.011	-0.029	0.046
Brazil	0.003	-0.067**	-0.055	-0.026
Chile	-0.004	-0.117***	-0.162***	-0.099
China	0.008	0.027	0.062*	0.078
Colombia	0.012	-0.066*	-0.106**	-0.068
Czech Republic	0.057***	0.079***	0.042	0.032
Greece	0.003	0.065***	0.101***	0.068
Hungary	-0.001	-0.016	0.011	-0.040
India	-0.048***	-0.027	-0.067**	-0.085
Korea	-0.035***	-0.075***	-0.155***	-0.200***
Malaysia	-0.022	0.004	0.006	0.060
Mexico	0.049***	-0.042	-0.065	-0.065
Peru	0.197***	0.114***	0.060**	0.017
Philippines	0.037***	0.038	0.012	-0.026
Poland	0.003	0.042	0.045	0.070
Russia	-0.011	-0.038**	-0.033	0.011
South Africa	0.133***	0.084**	0.137***	0.128
Taiwan	-0.025**	-0.023	-0.041	0.044
Thailand	0.003	-0.024	-0.007	-0.071

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

The bold countries are classified as major global gold producers

Note: The table shows the estimated regression coefficients for gold's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that gold is a (strong) hedge for given market. Non-positive and (statistically significant) estimates for periods of high volatility (i.e. quantile columns 0.90, 0.95, or 0.99) imply that gold serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

To benchmark gold's performance, I additionally apply the same model[12] to the BCOM index and the JPY/USD return series. I expect the commodity index to offer weaker diversification benefits compared to gold, taking the financialization of commodity markets into account. Nevertheless, the results are surprising, as the commodity index does not offer hedging or safe-haven advantages to both foreign and domestic investors for almost all selected markets (see Appendix 3, tables 10 & 11). From a domestic investor's perspective (see Appendix 3, panel B of table 11), Argentina is the only market where the commodity index provides certain safe haven benefits in the 5% quantile and strong safe haven advantages in the 1% quantile. Furthermore, the effect of falling coefficient estimates on deteriorating equity returns, which we see for gold, is not consistent for BCOM returns, suggesting a stronger linearity between the broad commodity index and equity returns. Hence, investors do not seem to seek safety in commodities when equities experience extreme negative returns. It can therefore be assumed that there remains relatively high co-movement between commodities and global equities, which does not make

[12] Return based quantile approach according to eq. 3

it an attractive diversifier in times of market disruption. However, individual commodities could provide completely different insights, an effect which cannot be captured with the chosen index.

The yen, on the other hand, offers certain hedging and/ or safe haven benefits for numerous markets (see Appendix 3, table 12). For foreign investors, the currency exhibits significant potential as a hedge for Hong Kong, the United Kingdom, and the USA and weak potential for Belgium, Canada, Finland, France, Germany, Israel, Netherlands, Spain, Sweden. In addition, the yen displays statistically significant safe haven benefits in the 5% quantile for Austria, Belgium, France, Netherlands, United Kingdom, and the USA and weak benefits to Canada, Germany, Hong Kong, Ireland, Israel, Italy, Norway, Spain, and Sweden. Interestingly, the currency's potential as a safe haven is greatest in the 5% quantile and deteriorates towards the lower quantiles. While the yen acts as a safe haven for 15 out of 23 countries in the 5% quantile, the currency only exhibits a negative and statistically significant value for the United Kingdom in the 1% quantile. While the yen offers foreign investors active in developed markets similar diversification potential as gold, it does not offer safe haven benefits in times of severe market distress, i.e. when a stabilizing force is needed the most. The results for the emerging markets are mostly homogeneous. For foreign emerging markets investors, the yen offers hedging and safe haven advantages for numerous economies. Chile, China, Mexico, and Russia exhibit negative and statistically significant coefficients in the hedging column (see Appendix 3, table 12). This provides strong evidence that that the yen serves as a hedge for given markets. Considering the 5% quantile, the currency shows strong safe haven properties in Brazil, Chile, and Mexico and seems to deliver weak advantages to Argentina, Colombia, Greece, Hungary, India, Peru, Philippines, Poland, and Russia. Again, the amount of markets for which the yen seems to be advantageous as a safe haven diminishes towards the lower return quantiles, which emphasizes the above observation. Compared to gold, the number of markets for which the yen defines as a hedge and offers certain safe haven potential is larger. However, it is important to note that in times of extreme negative returns (i.e. in the 2.5% or 1% quantile of the return distribution), the yen, unlike gold, no longer acts as a stabilizing force. Last but not least, the entire analysis of the yen is only based on USD data due to limited data availability and the fact that the market for different currency pairs is not very liquid, i.e. from the perspective of an emerging markets investor an investment in yen would not be very practical.

4.2 Dynamic conditional correlation model

Tables 6 to 9 illustrate the estimated correlation coefficients using the DCC model for the selected markets, once with equity and gold returns denoted in USD (panel A) and once in domestic currency (panel B). These coefficients are estimated based on eq. 11 outlined in chapter 4.2. In order to provide a brief recap, the DCC approach aims to model time-varying correlations between two financial assets. The hedge columns in both panel A and B show the average dynamic correlation between gold and the respective MSCI index. The remaining columns display the average correlation for the 5%, 2.5% and 1% quantile of the corresponding return distribution of a particular MSCI index. While the basic idea of

testing gold's hedging and safe haven capabilities for different countries and market conditions (i.e. extreme negative returns and high volatility) remains unchanged, the quantitative approach differs considerably. Thus, slightly different results are expected compared to the linear model. Again, the light green shaded areas are for visualization purposes and highlight the non-positive dynamic correlation coefficient estimates.

MSCI developed markets

According to panel A in table 6, gold appears to be merely a hedge for the U.S. market, and it does not offer advantages as a safe haven in any of the developed markets, with the exception of very weak potential for Israel and strong potential for the USA in the 2.5% and 1% quantile. Panel B displays heterogeneous results, where gold offers some but weak potential as a hedge for Israel, Sweden, and the USA. Its safe haven properties are most pronounced at the 1% quantile in panel B, where the metal provides strong safe haven benefits for France, Israel, Italy, New Zealand, Sweden, and the USA and weak benefits to Australia, Belgium, Germany, Ireland, the Netherlands, Spain, and the UK.

Table 6 Developed markets dynamic time-varying correlations – Return quantiles

Panel A					Panel B				
MSCI Developed Markets – in USD					**MSCI Developed Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Australia	0.217	0.200	0.201	0.187	**Australia**	0.073	0.065	0.060	0.059
Austria	0.142	0.128	0.117	0.084	Austria	0.042	0.011	-0.012	-0.041
Belgium	0.120	0.094	0.078	0.031	Belgium	0.058	0.023	-0.001	-0.030
Canada	0.219	0.204	0.184	0.174	**Canada**	0.083	0.047	0.020	0.005
Denmark	0.147	0.149	0.139	0.127	Denmark	0.086	0.066	0.052	0.037
Finland	0.081	0.056	0.051	0.048	Finland	0.043	0.017	0.010	0.001
France	0.102	0.086	0.062	0.031	France	0.040	0.006	-0.020	-0.050
Germany	0.092	0.074	0.052	0.031	Germany	0.046	0.008	-0.019	-0.033
Hong Kong	0.033	0.031	0.032	0.024	Hong Kong	0.026	0.023	0.026	0.024
Ireland	0.083	0.070	0.055	0.028	Ireland	0.027	0.001	-0.016	-0.035
Israel	0.022	0.012	-0.001	-0.007	Israel	-0.034	-0.044	-0.053	-0.056
Italy	0.094	0.086	0.088	0.058	Italy	0.013	-0.009	-0.029	-0.052
Japan	0.125	0.109	0.113	0.111	Japan	0.133	0.133	0.143	0.150
Netherlands	0.091	0.066	0.045	0.011	Netherlands	0.049	0.016	-0.011	-0.023
New Zealand	0.200	0.215	0.203	0.196	New Zealand	0.005	-0.017	-0.026	-0.054
Norway	0.206	0.202	0.205	0.202	Norway	0.051	0.049	0.048	0.047
Portugal	0.152	0.134	0.127	0.120	Portugal	0.045	0.025	0.022	0.011
Singapore	0.121	0.113	0.107	0.104	Singapore	0.015	0.016	0.013	0.020
Spain	0.095	0.090	0.090	0.074	Spain	0.010	-0.011	-0.032	-0.043
Sweden	0.111	0.100	0.093	0.071	Sweden	-0.002	-0.033	-0.048	-0.060
Switzerland	0.140	0.116	0.100	0.062	Switzerland	0.148	0.119	0.103	0.092
United Kingdom	0.134	0.107	0.090	0.062	United Kingdom	0.078	0.039	0.017	-0.010
USA	-0.021	-0.044	-0.057	-0.088	**USA**	-0.021	-0.044	-0.057	-0.088

The bold countries are classified as major global gold producers

Note: The table presents the estimated GARCH-DCC(*1,1*) coefficients between gold and each MSCI index based on daily data, which are estimated based on eq. 11 outlined in chapter 4.2. These coefficients represent the average correlation between gold and the distinct equity indices over the entire period (i.e. hedge column) and for the days of extreme negative returns (i.e. the q% lower return quantile columns). The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative values in the hedge column indicate that gold serves as a hedge for given market. Non-positive estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that gold offers certain safe haven benefits for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive coefficients.

As for the linear model, the same effect of gold's increasing safe haven benefits can be observed with deteriorating equity returns. While Israel, Italy, New Zealand, Spain, Sweden and the USA show a negative average correlation at the 5% quantile in panel B of table 6, Austria, Belgium, France, Germany, Ireland, the Netherlands, and the United Kingdom are additionally represented within the 2.5% and 1% quantile respectively. Therefore, gold delivers certain potential as a safe haven for these markets. In addition, the average correlation in both panel A and B is significantly lower as regards the 1% quantile compared to the 5% quantile for the majority of the indices, with the exception of Hong Kong, Japan, and Singapore. This supports the presumption of a non-linearity between equity and gold returns.

Both Australia and Canada show strictly positive average correlations across all return quantiles, which can be explained by the fact that both countries are major gold producers. Although the USA is also defined as a major gold producer, this does not seem to have a negative impact on gold as a mean of diversification. One possible reason could be that gold mining companies account for only a small fraction of the respective index composition. Moreover, the correlation between gold and Japanese equities remains relatively high across all market conditions and for both currency denotations, implying that gold on average co-moves with the market.

Table 7 Developed markets dynamic time-varying correlations – VIX quantiles

Panel A					**Panel B**				
MSCI Developed Markets – in USD					**MSCI Developed Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.90**	**0.95**	**0.99**		**Hedge**	**0.90**	**0.95**	**0.99**
Australia	0.217	0.167	0.162	0.163	**Australia**	0.073	0.059	0.058	0.060
Austria	0.142	0.100	0.081	0.054	Austria	0.042	-0.007	-0.026	-0.064
Belgium	0.120	0.047	0.031	0.016	Belgium	0.058	-0.004	-0.020	-0.053
Canada	0.219	0.130	0.137	0.140	**Canada**	0.083	-0.021	-0.025	-0.019
Denmark	0.147	0.107	0.120	0.142	Denmark	0.086	0.037	0.033	0.009
Finland	0.081	0.028	0.033	0.041	Finland	0.043	-0.020	-0.031	-0.053
France	0.102	0.028	0.028	0.029	France	0.040	-0.036	-0.050	-0.075
Germany	0.092	0.031	0.041	0.056	Germany	0.046	-0.025	-0.038	-0.057
Hong Kong	0.033	0.009	0.012	-0.002	Hong Kong	0.026	0.009	0.017	0.011
Ireland	0.083	0.040	0.030	-0.003	Ireland	0.027	-0.009	-0.014	-0.047
Israel	0.022	-0.005	0.003	0.010	Israel	-0.034	-0.047	-0.034	-0.014
Italy	0.094	0.027	0.030	0.034	Italy	0.013	-0.051	-0.064	-0.088
Japan	0.125	0.107	0.117	0.140	Japan	0.133	0.132	0.144	0.169
Netherlands	0.091	0.020	0.012	-0.001	Netherlands	0.049	-0.023	-0.045	-0.083
New Zealand	0.200	0.148	0.164	0.169	New Zealand	0.005	-0.064	-0.064	-0.082
Norway	0.206	0.185	0.190	0.208	Norway	0.051	0.058	0.058	0.069
Portugal	0.152	0.102	0.097	0.084	Portugal	0.045	0.009	-0.007	-0.048
Singapore	0.121	0.066	0.065	0.069	Singapore	0.015	-0.019	-0.019	-0.015
Spain	0.095	0.030	0.034	0.042	Spain	0.010	-0.049	-0.053	-0.062
Sweden	0.111	0.046	0.050	0.051	Sweden	-0.002	-0.085	-0.093	-0.105
Switzerland	0.140	0.070	0.072	0.084	Switzerland	0.148	0.089	0.070	0.048
United Kingdom	0.134	0.058	0.059	0.043	United Kingdom	0.078	-0.001	-0.011	-0.053
USA	-0.021	-0.073	-0.075	-0.115	**USA**	-0.021	-0.073	-0.075	-0.115

The bold countries are classified as major global gold producers

Note: The table presents the estimated GARCH-DCC(*1,1*) coefficients between gold and each MSCI index based on daily data, which are estimated based on eq. 11 outlined in chapter 4.2. These coefficients represent the average correlation between gold and the distinct equity indices over the entire period (i.e. hedge column) and for the days of high uncertainty (i.e. the q% upper VIX quantile columns). The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative values in the hedge column indicate that gold serves as a hedge for given market. Non-positive estimates for periods of high volatility (i.e. quantile columns 0.90, 0.95, or 0.99) imply that gold serves as a safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive coefficients.

Baur & McDermott (2010) make a similar observation and argue that "Japan's stock market performance differs from the other countries in that stock prices rather stagnated for a longer period. This causes gold to play a different role in Japan than in any other market".

Testing the gold equity relationship in periods of high volatility, as shown in table 7, suggests that the metal only defines as a weak hedge for the U.S. market in panel A. Moreover, the USA is the only country in panel A for which gold acts as a strong safe haven across all quantiles. Same obviously applies to panel B. The metal provides further, almost negligible advantages as a safe haven for Israel in the 90% quantile and for Hong Kong, Ireland, and the Netherlands in the 99% quantile. Considering panel B, gold exhibits marginal hedging potential for Israel, Sweden, and the USA. In contrast to the observation made for the linear model, the safe haven properties of gold are most pronounced in the 99% quantile. Thus, gold acts as a strong safe haven in Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, New Zealand, Spain, Sweden, the UK, and the USA and delivers some weak advantages for Canada, Ireland, Israel, Portugal, and Singapore.

While the results for the return-based quantile approach, as shown in table 6, provide similar observations to the linear model in terms of the increasing safe haven properties of gold as equity returns decline, the VIX based results for the DCC model are surprisingly different. The preceding regression analysis (see table 3) shows that gold's increasing safe haven benefits are limited when volatility is at extreme heights. However, the results of table 7 do not fully support this assumption. While the time-varying correlations are higher for 14 out of 23 indices in the 90% quantile compared to the 99% quantile in panel A, this is only the case for 5 markets in panel B. Based on this observation, the safe haven benefits of gold tend to increase with growing uncertainty from the perspective of domestic investors.

MSCI emerging markets

As regards the emerging markets portfolio, gold does not offer hedging or safe haven advantages to foreign investors in any of the markets, as shown in panel A of table 8, as all average dynamic correlations are strictly positive. Domestic investors, on the contrary, illustrated by panel B, enjoy considerable hedging benefits in India and Korea and weaker advantages in Brazil, Hungary, Malaysia, Russia, and Taiwan. For panel B, gold's safe haven properties are again most pronounced at the 1% quantile, where gold classifies as a strong safe haven for Brazil, Chile, India, and Korea. Additionally, gold displays viable safe have characteristics for Colombian, Greek, Hungarian, Malaysian, Mexican, Polish, Russian, and Taiwanese investors at given quantile. A renewed comparison of the 5% quantiles with the 1% quantiles in both panels of table 8 confirms the above observation that the correlation between gold and global equities tends to decrease with deteriorating market conditions. For emerging economies, the majority of markets meet this criterion apart from Czech Republic, Malaysia, Philippines, and Taiwan.

Table 8 Emerging markets dynamic time-varying correlations – Return quantiles

Panel A					Panel B				
MSCI Emerging Markets – in USD					**MSCI Emerging Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Argentina	0.073	0.069	0.066	0.053	Argentina	0.130	0.113	0.113	0.095
Brazil	0.148	0.138	0.124	0.113	Brazil	-0.006	-0.028	-0.041	-0.069
Chile	0.123	0.099	0.088	0.070	Chile	0.000	-0.028	-0.037	-0.059
China	0.046	0.053	0.052	0.048	**China**	0.021	0.032	0.032	0.022
Colombia	0.112	0.096	0.085	0.069	Colombia	0.010	-0.008	-0.024	-0.039
Czech Republic	0.165	0.167	0.172	0.187	Czech Republic	0.077	0.071	0.077	0.088
Greece	0.093	0.071	0.062	0.051	Greece	0.018	-0.001	-0.009	-0.020
Hungary	0.140	0.144	0.135	0.113	Hungary	-0.001	-0.017	-0.024	-0.042
India	0.067	0.070	0.058	0.043	India	-0.063	-0.049	-0.053	-0.071
Korea	0.064	0.058	0.051	0.049	Korea	-0.060	-0.072	-0.084	-0.102
Malaysia	0.083	0.081	0.081	0.084	Malaysia	-0.028	-0.033	-0.034	-0.024
Mexico	0.099	0.085	0.064	0.037	**Mexico**	0.034	0.004	-0.010	-0.036
Peru	0.317	0.311	0.301	0.269	**Peru**	0.285	0.280	0.273	0.246
Philippines	0.054	0.061	0.061	0.066	Philippines	0.015	0.016	0.013	0.003
Poland	0.162	0.164	0.163	0.163	Poland	0.005	-0.001	-0.009	-0.024
Russia	0.095	0.095	0.091	0.091	**Russia**	-0.008	-0.008	-0.010	-0.022
South Africa	0.238	0.230	0.222	0.201	**South Africa**	0.159	0.139	0.136	0.136
Taiwan	0.044	0.040	0.042	0.040	Taiwan	-0.037	-0.040	-0.036	-0.032
Thailand	0.069	0.065	0.056	0.059	Thailand	0.014	0.060	0.051	0.037

The bold countries are classified as major global gold producers

Note: The table presents the estimated GARCH-DCC(*1,1*) coefficients between gold and each MSCI index based on daily data, which are estimated based on eq. 11 outlined in chapter 4.2. These coefficients represent the average correlation between gold and the distinct equity indices over the entire period (i.e. hedge column) and for the days of extreme negative returns (i.e. the q% lower return quantile columns). The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative values in the hedge column indicate that gold serves as a hedge for given market. Non-positive estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that gold offers certain safe haven benefits for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive coefficients.

The correlation coefficients obtained in panel A of table 9 are very similar to those of panel A in table 8, with the exception of India and Mexico, for which gold offers marginal safe haven advantages in the 99% quantile. Apart from this, gold has no significant hedging or safe haven potential for foreign investors, and correlation coefficients are higher for 8 out of 19 indices in the 99% quantile than in the 90% quantile. The domestic currency sample, given by panel B in table 9, also resembles the one of table 8, except that Philippine and Thai investors can potentially protect their funds in periods of high volatility. Moreover, the average correlation in the 99% quantile is lower for the majority of markets apart from Czech Republic, Malaysia, Poland, Russia, and Taiwan. Thus, I find somewhat mixed results regarding peaking volatility and gold's diversification benefits, as the DCC model suggests that gold still acts as a stabilizing force for various markets in periods of extreme uncertainty.

For panel B in both table 8 and 9, Russia exhibits negative time-varying correlations across all market conditions and Mexico for most of them. Therefore, they depict the exception to the remaining three major gold producers; China, Peru, and South Africa. For Peru and South Africa, a significant co-movement between gold and domestic equities is observable across all market conditions, which suggests that companies involved in the gold production account for a substantial proportion of the respective index composition. China's non-negative correlation coefficients across all quantiles point to a similar conclusion. However, the values in panel A and B for both tables 8 and 9 are comparably lower

and closer to zero, indicating that gold production does not represent a significantly large share of China's economy.

Table 9 Emerging markets dynamic time-varying correlations – VIX quantiles

Panel A					Panel B				
MSCI Emerging Markets – in USD					**MSCI Emerging Markets – in Domestic Currency**				
	COMEX Gold - Daily Frequency					COMEX Gold - Daily Frequency			
	Hedge	**0.90**	**0.95**	**0.99**		**Hedge**	**0.90**	**0.95**	**0.99**
Argentina	0.073	0.049	0.062	0.076	Argentina	0.130	0.091	0.092	0.090
Brazil	0.148	0.089	0.092	0.086	Brazil	-0.006	-0.066	-0.090	-0.164
Chile	0.123	0.054	0.050	0.049	Chile	0.000	-0.073	-0.080	-0.103
China	0.046	0.022	0.022	0.006	**China**	0.021	0.010	0.015	0.003
Colombia	0.112	0.077	0.061	0.035	Colombia	0.010	-0.013	-0.035	-0.090
Czech Republic	0.165	0.134	0.161	0.213	Czech Republic	0.077	0.052	0.054	0.070
Greece	0.093	0.076	0.074	0.071	Greece	0.018	0.004	-0.008	-0.015
Hungary	0.140	0.095	0.096	0.098	Hungary	-0.001	-0.027	-0.047	-0.082
India	0.067	0.034	0.025	-0.001	India	-0.063	-0.079	-0.080	-0.112
Korea	0.064	0.033	0.036	0.041	Korea	-0.060	-0.122	-0.147	-0.151
Malaysia	0.083	0.048	0.048	0.057	Malaysia	-0.028	-0.062	-0.067	-0.059
Mexico	0.099	0.024	0.020	-0.004	**Mexico**	0.034	-0.051	-0.064	-0.089
Peru	0.317	0.276	0.256	0.219	**Peru**	0.285	0.236	0.212	0.160
Philippines	0.054	0.037	0.030	0.037	Philippines	0.015	-0.010	-0.026	-0.036
Poland	0.162	0.118	0.135	0.157	Poland	0.005	-0.020	-0.018	-0.003
Russia	0.095	0.056	0.065	0.076	**Russia**	-0.008	-0.054	-0.044	-0.044
South Africa	0.238	0.188	0.184	0.166	**South Africa**	0.159	0.121	0.106	0.088
Taiwan	0.044	0.028	0.028	0.031	Taiwan	-0.037	-0.051	-0.048	-0.038
Thailand	0.069	0.043	0.032	0.004	Thailand	0.014	-0.010	-0.019	-0.052

The bold countries are classified as major global gold producers

Note: The table presents the estimated GARCH-DCC(*1,1*) coefficients between gold and each MSCI index based on daily data, which are estimated based on eq. 11 outlined in chapter 4.2. These coefficients represent the average correlation between gold and the distinct equity indices over the entire period (i.e. hedge column) and for the days of high uncertainty (i.e. the q% upper VIX quantile columns). The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative values in the hedge column indicate that gold serves as a hedge for given market. Non-positive estimates for periods of high volatility (i.e. quantile columns 0.90, 0.95, or 0.99) imply that gold serves as a safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive coefficients.

4.3 Limitations and future research

The findings of this research have to be seen in light of some possible limitations. The data is constrained to twenty years as the database did not allow me to retrieve older data. However, it includes very recent price movements, which allow to capture the effects connected to the current COVID-19 pandemic and recent market turbulences. I base the entire empirical analysis on daily frequency and contemporaneous stock returns. The use of lower frequency data such as weekly or monthly data and/ or lagged return series would possible yield slightly different results due to factors such as asynchronous trading or the possible scenario that investors anticipate an upcoming crash and seek shelter in gold a few days in advance. In other words, I capture the relationship between gold and equities in times of adverse market conditions. However, it does not provide evidence for a possible anticipation effect which possibly causes a spillover from equities to gold days prior a market downturn. In addition, there exist numerous exogenous factors that influence the price of gold, as it is a widespread commodity with a limited supply, which I cannot adequately capture with the applied models. Due to the large number of markets and certain time constraints, I did not perform a subsample analysis. Such an analysis with a subsample from the period before and after the Lehman Brother collapse for instance would provide interesting insights into whether gold's role as a diversifier has changed after the financial crisis. However, a similar analysis has been conducted by Baur & Lucey (2010), who test gold's role in bull and bear markets. The authors

conclude that gold does indeed play a different role during bull markets than in a bear market, and they note that "there is no significant estimate regarding gold as a hedge or safe haven in bull markets, the estimates are highly significant in a bear market" (Baur & Lucey, 2010). As regards the DCC approach, McAleer (2019) argues that "any statements regarding the purported "statistical significance" of the estimated parameters are meaningless". Hence, the correlation coefficients retrieved by means of the DCC approach lack any statistical significance. Nevertheless, the dynamic conditional correlation model is a widely used method in the field of quantitative finance since Engle's analytical development in 2002 and I therefore chose it as a secondary statistical approach.

To specifically investigate the aforementioned anticipation effect of an imminent market crash among investors depicts an interesting extension to this research. The hypothesis that investors and fund managers are able to foresee unfavorable markets and that a flight to safety in the form of a spill-over from stocks to gold in the days before could be tested. Furthermore, the inclusion of the CNNMoney "fear & greed index" serving as an alternative proxy for global uncertainty would provide further interesting insights. Gold mining stocks, other precious metals such as platinum or silver or certain crypto currencies such as Bitcoin or Ethereum could be included in the analysis to examine their potential to diversify global equities. An extensive analysis of gold's diversification potential for bonds would serve as another viable extension. However, Baur & Lucey (2010) conclude that "gold is generally not a safe haven for bonds in any market". Last but not least, a portfolio analysis applying a pure buy-and-hold strategy together with different rebalancing methods would provide insights regarding gold's optimal portfolio weights. However, different portfolio optimizations, which also include the higher moments of the distribution, lead to unrealistically high weightings for gold. This is mainly explained by the asset's high annual mean return and its comparatively low standard deviation during the chosen periodicity and serves as the main reason why I have decided against a portfolio analysis.

5 Concluding remarks

By applying a two-model approach; (i) a linear regression- and (ii) a GARCH-DCC(*1,1*) model I examine gold's diversification potential for a broad cross-section of developed and emerging equity markets from the perspective of both foreign and domestic investors. Two main hypotheses are tested: first, whether gold serves as a hedge (i.e. its average diversification potential) for specific markets and second, whether gold exhibits safe haven characteristics. The later examines if buying gold protects investors' wealth in times of adverse markets, i.e. when diversification and portfolio protection is most needed.

I find compelling evidence that gold serves as a hedge for the USA (i.e. for all investors) as well as for India, Korea, and Taiwan from the perspective of domestic investors. This finding is further supported by the dynamic time-varying correlations, which exhibit a negative average correlation for these markets. Other than for the U.S. market, gold is no hedge for any of the markets from the perspective of foreign investors. However, the two models combined indicate a weak hedging potential for Hungarian, Malaysian, and Russian domestic investors. While the two approaches show slightly different insights regarding gold's safe haven potential for the chosen markets, I find strong evidence that these benefits increase as equity returns deteriorate, a finding confirmed by preceding research. This implies that gold's safe haven properties are strongest for shocks lying in the 1% quantile and confirms Baur & McDermott's (2010) observation, "that investors react to short-lived and extreme shocks by seeking out the safe haven of gold". Nonetheless, various countries remain for which gold offers no or only weak benefits as a safe haven for both domestic and foreign investors. Some of these markets exhibit positive and statistically significant coefficient estimates or positive dynamic correlations even for the 1% quantile for both currency samples. This partially contradicts the finding of Baur & Lucey (2010) who generally argue that "gold is a safe haven for stocks" or the observation of Baur & McDermott (2010) concluding that gold classifies as a safe haven for most developed countries. This difference is mainly due to the larger sample size of developed markets and the fact that this study is based on equity and gold returns in U.S. dollar and in domestic currency.

As regards emerging markets, both econometric models display a strong co-movement between gold and the respective MSCI indices for U.S. dollar data. Consequently, gold does neither classify as a hedge nor as a safe haven for foreign emerging markets investors, an observation that aligns with previous findings for a larger set of emerging markets. One possible explanation for this difference between the two markets is the fact that participants in emerging markets react differently to shocks than in its developed counterparts. They often move their funds to developed markets instead of seeking temporary safety in gold. However, with equity and gold returns denominated in the national currency, I achieve heterogeneous results which indicate that gold acts as a hedge and/ or safe haven for numerous emerging markets. An important finding that proves that from the perspective of domestic investors, gold is an effective diversifier for some emerging markets.

I find somewhat mixed results for countries with significant (gold) mining interest. While Australian, Peruvian, and South African stocks show a high and statistically significant co-movement with gold, other major gold producers such as Canada, China, Mexico, or Russia yield lower or even negative correlation coefficients. This can most likely be explained by the fact that companies involved in gold production or gold trading account for only a fraction of the index composition and therefore have much less weight.

Concerning periods of high volatility, proxied by the q% upper quantiles of the VIX, I conclude that for some markets, gold not only offers for some markets advantages as a safe haven on individual days with falling stock prices, but also proves to be effective for certain periods of increased volatility. While gold continues to offer certain advantages as a safe haven for numerous markets in the 90% and 95% quantile, this characteristic crumbles dramatically in times when volatility reaches its peak, i.e. in the 99% quantile. With the latter observation I provide evidence that gold is not considered a safe haven asset in times of enormous uncertainty and that investors rather increase their position in cash or risk-free bonds. While the linear model strongly supports this observation, the DCC approach provides less clear evidence in this regard. This deviation is most likely due to the model specification, which models the univariate volatilities.

Conclusively, unlike the BCOM or the Japanese yen, I find that gold inherits the potential to reduce financial losses when it is most needed in numerous markets, whether developed or emerging. However, a distinction must be made between foreign and domestic investors, as the diversification potential varies greatly between the two, a discrepancy which is largely due to the currency effect. Last but not least, I find that commodities exhibit a high co-movement with global equities and therefore are not an effective substitute for gold in terms of diversification. The Japanese yen offers foreign investors hedging and safe haven benefits in various markets. However, unlike gold, this effect mostly disappears in times of extreme negative returns, i.e. when diversification is most needed among investors.

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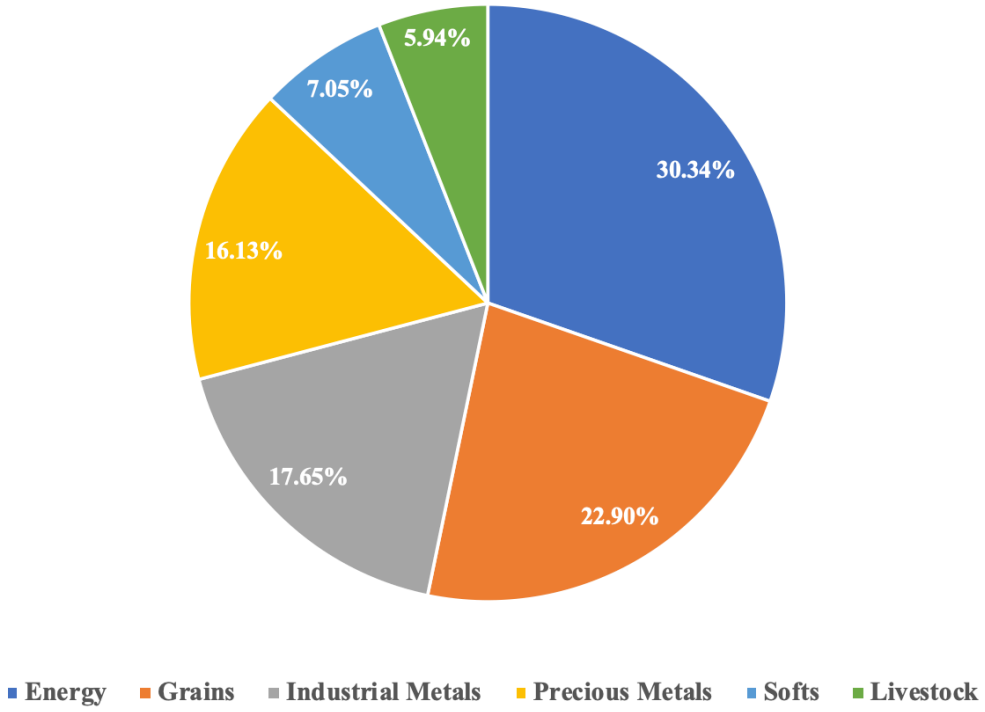
II Appendix

1. Bloomberg Commodity Index constituents and weights in 2019



Note: BCOM Index constituents and weights as of 2019 (Bloomberg, 2018)

2. Full overview summary statistics

Index	Mean	Max.	Min.	Std. Dev.	Skew.	Kurt.
COMEX Gold	0.098	0.086	-0.098	0.011	-0.265	5.905
JPY/USD	0.002	0.169	-0.163	0.007	0.529	112.959
BCOM	-0.004	0.056	-0.064	0.01	-0.241	2.977
Developed Markets (01.08.2000 – 31.07.2020)						
Australia						
r_{s_USD}	0.085	0.088	-0.159	0.015	-0.882	10.065
$r_{s\_Domestic}$	0.063	0.078	-0.165	0.013	-0.917	12.237
$r_{g\_Domestic}$	0.061	0.112	-0.104	0.011	0.236	11.796
Austria						
r_{s_USD}	0.02	0.134	-0.167	0.018	-0.396	8.803
$r_{s\_Domestic}$	0.01	0.12	-0.159	0.016	-0.45	8.47
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Belgium						
r_{s_USD}	0.019	0.107	-0.182	0.015	-0.853	11.728
$r_{s\_Domestic}$	0.009	0.107	-0.175	0.014	-0.857	12.436
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Canada						
r_{s_USD}	0.055	0.122	-0.142	0.014	-0.976	14.366
$r_{s\_Domestic}$	0.044	0.12	-0.131	0.012	-0.8	17.182
$r_{g\_Domestic}$	0.067	0.088	-0.086	0.011	0.013	5.977
Denmark						
r_{s_USD}	0.101	0.107	-0.135	0.014	-0.382	7.331
$r_{s\_Domestic}$	0.088	0.089	-0.115	0.013	-0.39	5.308
$r_{g\_Domestic}$	0.051	0.074	-0.092	0.01	-0.142	6.56
Finland						
r_{s_USD}	0.006	0.159	-0.201	0.02	-0.254	6.984
$r_{s\_Domestic}$	-0.009	0.154	-0.213	0.019	-0.32	7.702
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
France						
r_{s_USD}	0.023	0.12	-0.149	0.015	-0.259	7.918
$r_{s\_Domestic}$	0.011	0.101	-0.142	0.015	-0.285	6.553
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Germany						
r_{s_USD}	0.033	0.115	-0.15	0.016	-0.252	6.684
$r_{s\_Domestic}$	0.019	0.099	-0.144	0.015	-0.282	5.527
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Hong Kong						
r_{s_USD}	0.068	0.104	-0.124	0.013	-0.265	7.051
$r_{s\_Domestic}$	0.06	0.104	-0.124	0.013	-0.275	7.117
$r_{g\_Domestic}$	0.08	0.087	-0.098	0.011	-0.279	6.006

Ireland						
r_{s_USD}	-0.007	0.136	-0.189	0.018	-0.757	10.127
$r_{s\_Domestic}$	-0.019	0.127	-0.176	0.017	-0.633	9.255
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Israel						
r_{s_USD}	0.022	0.098	-0.116	0.013	-0.487	6.882
$r_{s\_Domestic}$	0.016	0.084	-0.107	0.012	-0.541	7.248
$r_{g\_Domestic}$	0.06	0.095	-0.093	0.011	-0.075	5.833
Italy						
r_{s_USD}	-0.007	0.125	-0.205	0.017	-0.607	11.038
$r_{s\_Domestic}$	-0.015	0.117	-0.198	0.016	-0.64	10.513
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Japan						
r_{s_USD}	0.029	0.114	-0.095	0.013	-0.181	4.642
$r_{s\_Domestic}$	0.016	0.117	-0.097	0.014	-0.272	5.747
$r_{g\_Domestic}$	0.069	0.075	-0.115	0.011	-0.462	7.298
Netherlands						
r_{s_USD}	0.044	0.105	-0.12	0.015	-0.307	7.373
$r_{s\_Domestic}$	0.032	0.09	-0.113	0.014	-0.302	5.892
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
New Zealand						
r_{s_USD}	0.11	0.102	-0.1	0.013	-0.408	5.206
$r_{s\_Domestic}$	0.079	0.097	-0.123	0.012	-0.379	6.521
$r_{g\_Domestic}$	0.046	0.091	-0.079	0.011	0.291	6.784
Norway						
r_{s_USD}	0.053	0.153	-0.142	0.018	-0.537	7.875
$r_{s\_Domestic}$	0.052	0.121	-0.11	0.016	-0.409	6.647
$r_{g\_Domestic}$	0.057	0.082	-0.09	0.011	-0.121	6.205
Portugal						
r_{s_USD}	-0.007	0.129	-0.138	0.014	-0.308	8.659
$r_{s\_Domestic}$	-0.02	0.128	-0.131	0.013	-0.312	8.759
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Singapore						
r_{s_USD}	0.057	0.085	-0.098	0.013	-0.248	5.84
$r_{s\_Domestic}$	0.04	0.072	-0.093	0.012	-0.208	5.769
$r_{g\_Domestic}$	0.052	0.08	-0.097	0.01	-0.191	6.852
Spain						
r_{s_USD}	0.018	0.16	-0.172	0.017	-0.292	9.434
$r_{s\_Domestic}$	0.007	0.158	-0.165	0.016	-0.22	8.504
$r_{g\_Domestic}$	0.048	0.073	-0.092	0.01	-0.158	6.445
Sweden						
r_{s_USD}	0.035	0.14	-0.148	0.018	-0.115	5.73
$r_{s\_Domestic}$	0.031	0.107	-0.125	0.016	-0.159	4.497
$r_{g\_Domestic}$	0.051	0.083	-0.087	0.011	-0.102	5.864
Switzerland						
r_{s_USD}	0.064	0.097	-0.113	0.012	-0.247	7.019
$r_{s\_Domestic}$	0.031	0.097	-0.149	0.012	-0.682	10.342
$r_{g\_Domestic}$	0.033	0.069	-0.147	0.01	-0.755	13.457

UK						
r_{s_USD}	0.032	0.122	-0.141	0.014	-0.409	11.591
$r_{s\_Domestic}$	0.034	0.095	-0.122	0.012	-0.345	8.714
$r_{g\_Domestic}$	0.06	0.13	-0.094	0.011	0.133	8.937
USA						
r_{s_USD}	0.07	0.11	-0.129	0.012	-0.402	11.943
$r_{s\_Domestic}$	0.07	0.11	-0.129	0.012	-0.402	11.943
$r_{g\_Domestic}$	0.098	0.086	-0.098	0.011	-0.265	5.905
Emerging Markets (01.01.2001 – 31.07.2020)						
Argentina						
r_{s_USD}	0.062	0.163	-0.511	0.027	-2.493	41.64
$r_{s\_Domestic}$	0.226	0.322	-0.369	0.027	-1.337	27.504
$r_{g\_Domestic}$	0.325	0.463	-0.106	0.016	6.693	162.651
Brazil						
r_{s_USD}	0.059	0.166	-0.194	0.022	-0.511	8.882
$r_{s\_Domestic}$	0.129	0.18	-0.199	0.018	-0.418	10.887
$r_{g\_Domestic}$	0.099	0.121	-0.103	0.014	-0.022	5.73
Chile						
r_{s_USD}	0.049	0.164	-0.167	0.014	-0.661	16.0623
$r_{s\_Domestic}$	0.07	0.133	-0.15	0.012	-0.624	16.383
$r_{g\_Domestic}$	0.07	0.096	-0.091	0.012	0.033	4.927
China						
r_{s_USD}	0.102	0.14	-0.128	0.017	-0.119	6.396
$r_{s\_Domestic}$	0.088	0.14	-0.127	0.017	-0.122	6.535
$r_{g\_Domestic}$	0.072	0.085	-0.099	0.011	-0.311	6.075
Colombia						
r_{s_USD}	0.158	0.17	-0.219	0.017	-0.877	20.74
$r_{s\_Domestic}$	0.191	0.166	-0.205	0.014	-0.511	23.061
$r_{g\_Domestic}$	0.074	0.116	-0.1	0.012	0.018	6.339
Czech Republic						
r_{s_USD}	0.079	0.197	-0.167	0.016	-0.364	13.817
$r_{s\_Domestic}$	0.067	0.16	-0.152	0.015	-0.399	11.823
$r_{g\_Domestic}$	0.024	0.086	-0.095	0.011	-0.099	6.51
Greece						
r_{s_USD}	-0.131	0.172	-0.251	0.024	-0.541	9.476
$r_{s\_Domestic}$	-0.145	0.171	-0.24	0.023	-0.548	9.73
$r_{g\_Domestic}$	0.063	0.073	-0.092	0.01	-0.169	6.484
Hungary						
r_{s_USD}	0.073	0.203	-0.203	0.021	-0.21	9.462
$r_{s\_Domestic}$	0.075	0.169	-0.163	0.018	-0.255	8.657
$r_{g\_Domestic}$	0.068	0.088	-0.093	0.012	0.217	6.599

India						
r_{s_USD}	0.09	0.195	-0.155	0.016	-0.385	10.678
$r_{s\_Domestic}$	0.117	0.159	-0.143	0.014	-0.383	10.765
$r_{g\_Domestic}$	0.081	0.076	-0.098	0.011	-0.209	5.311
Korea						
r_{s_USD}	0.131	0.25	-0.207	0.018	-0.158	14.48
$r_{s\_Domestic}$	0.096	0.135	-0.123	0.015	-0.258	5.821
$r_{g\_Domestic}$	0.057	0.086	-0.136	0.012	-0.406	9.715
Malaysia						
r_{s_USD}	0.088	0.072	-0.113	0.01	-0.528	8.732
$r_{s\_Domestic}$	0.098	0.076	-0.102	0.008	-0.77	12.839
$r_{g\_Domestic}$	0.07	0.086	-0.099	0.011	-0.206	5.193
Mexico						
r_{s_USD}	0.063	0.152	-0.112	0.016	0.016	7.114
$r_{s\_Domestic}$	0.108	0.123	-0.111	0.014	-0.188	6.41
$r_{g\_Domestic}$	0.103	0.097	-0.099	0.013	0.153	7.067
Peru						
r_{s_USD}	0.165	0.124	-0.165	0.018	-0.604	8.024
$r_{s\_Domestic}$	0.146	0.117	-0.154	0.017	-0.577	7.607
$r_{g\_Domestic}$	0.082	0.086	-0.096	0.011	-0.245	5.267
Philippines						
r_{s_USD}	0.082	0.158	-0.145	0.015	-0.512	10.91
$r_{s\_Domestic}$	0.073	0.198	-0.145	0.014	-0.082	14.806
$r_{g\_Domestic}$	0.084	0.082	-0.151	0.011	-0.707	11.426
Poland						
r_{s_USD}	0.028	0.142	-0.176	0.019	-0.384	6.42
$r_{s\_Domestic}$	0.025	0.108	-0.156	0.016	-0.43	6.245
$r_{g\_Domestic}$	0.057	0.093	-0.094	0.012	0.198	7.514
Russia						
r_{s_USD}	0.091	0.24	-0.256	0.022	-0.484	13.524
$r_{s\_Domestic}$	0.151	0.234	-0.245	0.02	-0.451	16.239
$r_{g\_Domestic}$	0.122	0.112	-0.128	0.013	-0.093	7.593
South Africa						
r_{s_USD}	0.071	0.124	-0.136	0.018	-0.394	4.495
$r_{s\_Domestic}$	0.117	0.082	-0.205	0.015	-0.642	8.96
$r_{g\_Domestic}$	0.068	0.161	-0.111	0.014	0.328	9.032
Taiwan						
r_{s_USD}	0.092	0.082	-0.072	0.014	-0.102	2.963
$r_{s\_Domestic}$	0.068	0.069	-0.076	0.014	-0.136	3.12
$r_{g\_Domestic}$	0.07	0.086	-0.099	0.011	-0.224	5.858

Thailand						
r_{s_USD}	0.095	0.105	-0.181	0.015	-0.687	10.391
$r_{s\_Domestic}$	0.112	0.135	-0.18	0.017	-0.346	14.317
$r_{g\_Domestic}$	0.061	0.129	-0.118	0.014	0.253	19.067

Note: The table presents the summary statistics of the different MSCI indices and diversifiers (COMEX Gold, BCOM, and Japanese yen) daily returns denominated both in USD and domestic currency. The following abbreviations are used: r_s refers to stock returns and r_g to gold returns. The difference in the periodicity between the developed and emerging markets portfolio is due to the fact that the launch date of the MSCI emerging markets indices was only in January 2001 and therefore no backtesting was performed.

3. Linear regression model results

I) MSCI developed markets – BCOM

Panel A					Panel B				
MSCI Developed Markets – in USD					**MSCI Developed Markets – in Domestic Currency**				
	BCOM - Daily Frequency					BCOM - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Australia	0.185***	0.230***	0.242***	0.263***	Australia	0.098***	0.120***	0.135***	0.139***
Austria	0.181***	0.222***	0.234***	0.260***	Austria	0.156***	0.167***	0.192***	0.226***
Belgium	0.179***	0.220***	0.226***	0.219***	Belgium	0.182***	0.194***	0.195***	0.172***
Canada	0.353***	0.344***	0.328***	0.314***	Canada	0.242***	0.218***	0.196***	0.153***
Denmark	0.180***	0.246***	0.251***	0.241***	Denmark	0.187***	0.245***	0.246***	0.219***
Finland	0.118***	0.085***	0.067***	0.054***	Finland	0.126***	0.096***	0.093***	0.079***
France	0.206***	0.253***	0.266***	0.243***	France	0.205***	0.226***	0.247***	0.213***
Germany	0.185***	0.217***	0.229***	0.212***	Germany	0.191***	0.219***	0.199***	0.150***
Hong Kong	0.117***	0.125***	0.150***	0.169***	Hong Kong	0.112***	0.131***	0.148***	0.180***
Ireland	0.147***	0.203***	0.176***	0.169***	Ireland	0.141***	0.163***	0.150***	0.118***
Israel	0.097***	0.084***	0.092***	0.084***	Israel	0.066***	0.075***	0.074***	0.083***
Italy	0.169***	0.201***	0.207***	0.194***	Italy	0.157***	0.161***	0.150***	0.129***
Japan	0.082***	0.089***	0.098***	0.095***	Japan	0.184***	0.213***	0.221***	0.215***
Netherlands	0.204***	0.243***	0.252***	0.243***	Netherlands	0.215***	0.234***	0.246***	0.192***
New Zealand	0.144***	0.204***	0.230***	0.266***	New Zealand	0.135***	0.185***	0.182***	0.255***
Norway	0.227***	0.271***	0.284***	0.298***	Norway	0.154***	0.176***	0.186***	0.169***
Portugal	0.189***	0.204***	0.201***	0.228***	Portugal	0.170***	0.171***	0.182***	0.207***
Singapore	0.186***	0.222***	0.236***	0.301***	Singapore	0.117***	0.141***	0.173***	0.215***
Spain	0.160***	0.193***	0.202***	0.222***	Spain	0.145***	0.136***	0.151***	0.126***
Sweden	0.165***	0.195***	0.207***	0.204***	Sweden	0.121***	0.135***	0.125***	0.072**
Switzerland	0.235***	0.285***	0.312***	0.288***	Switzerland	0.345***	0.424***	0.475***	0.542***
United Kingdom	0.265***	0.306***	0.311***	0.299***	United Kingdom	0.265***	0.258***	0.250***	0.280***
USA	0.193***	0.253***	0.284***	0.273***	USA	0.193***	0.253***	0.284***	0.273***

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

Note: The table presents the estimated regression coefficients for BCOM's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that the broad commodity index is a (strong) hedge for given market. Non-positive and (statistically significant) estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that the BCOM index serves as a (strong) safe haven for the respective market.

II) MSCI emerging markets – BCOM

Panel A					Panel B				
Emerging Markets – in USD					**Emerging Markets – in Domestic Currency**				
	BCOM - Daily Frequency					BCOM - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**		**Hedge**	**0.05**	**0.025**	**0.01**
Argentina	0.069***	0.050***	0.045	0.023**	Argentina	0.181***	-0.131***	0.008***	-0.201***
Brazil	0.140***	0.132***	0.133	0.133***	Brazil	0.091***	0.113***	0.110***	0.103***
Chile	0.191***	0.222***	0.236	0.249***	Chile	0.098***	0.134***	0.124***	0.123***
China	0.102***	0.111***	0.112	0.123***	China	0.090***	0.107***	0.112***	0.116***
Colombia	0.171***	0.201***	0.196	0.184***	Colombia	0.070***	0.046***	0.029	0.018
Czech Republic	0.157***	0.216***	0.223	0.212***	Czech Republic	0.138***	0.184***	0.184***	0.207***
Greece	0.065***	0.084***	0.072	0.053***	Greece	0.049***	0.064***	0.062***	0.043***
Hungary	0.126***	0.163***	0.174	0.190***	Hungary	0.064***	0.075***	0.069***	0.117***
India	0.105***	0.138***	0.136	0.135***	India	0.027***	0.069***	0.059***	0.094***
Korea	0.090***	0.104***	0.116	0.122***	Korea	0.016***	0.030*	0.050**	0.045*
Malaysia	0.151***	0.180***	0.185	0.123***	Malaysia	0.031*	0.059**	0.045	0.057***
Mexico	0.180***	0.222***	0.223	0.222***	Mexico	0.135***	0.166***	0.148***	0.128**
Peru	0.221***	0.247***	0.241	0.254***	Peru	0.199***	0.215***	0.210***	0.231***
Philippines	0.058***	0.081***	0.109	0.145***	Philippines	0.036***	0.067***	0.082***	0.114***
Poland	0.156***	0.181***	0.196	0.179***	Poland	0.091***	0.118***	0.103***	0.175***
Russia	0.137***	0.113***	0.093	0.070***	Russia	0.067***	0.047***	0.036**	0.011
South Africa	0.172***	0.221***	0.236	0.245***	South Africa	0.186***	0.207***	0.205***	0.252***
Taiwan	0.095***	0.157***	0.163	0.164***	Taiwan	0.049***	0.103***	0.112***	0.112***
Thailand	0.101***	0.122***	0.112	0.114***	Thailand	0.077***	0.118***	0.130***	0.139***

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

Note: The table presents the estimated regression coefficients for BCOM's role as a hedge and/ or safe haven asset based on daily data. The results in Panel A (USD) provide insights from the perspective of foreign investors and those in Panel B (domestic currency) from the view of domestic investors. Negative and (statistically significant) values in the hedge column indicate that the broad commodity index is a (strong) hedge for given market. Non-positive and (statistically significant) estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that the BCOM index serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

III) MSCI developed and emerging markets – Japanese yen

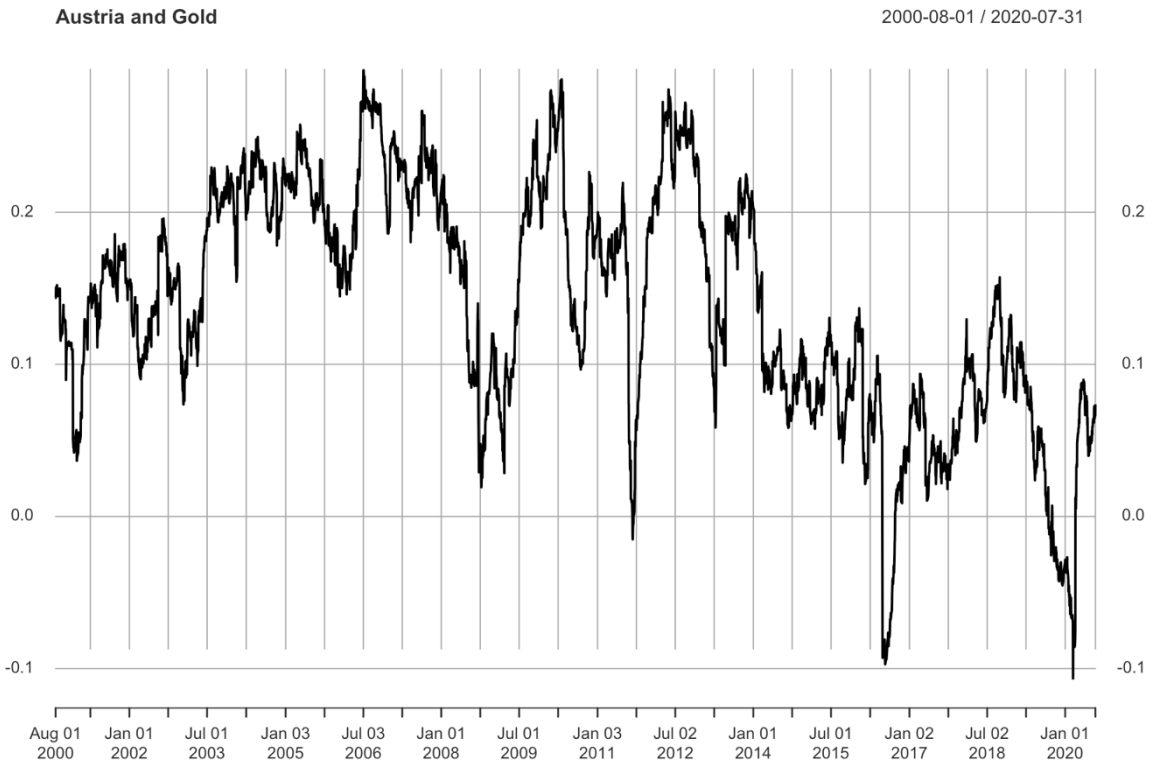
Developed Markets – in USD	Japanese Yen - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**
Australia	0.009	0.018	0.032**	0.053***
Austria	0.002	-0.028***	-0.011	0.005
Belgium	-0.002	-0.026**	-0.019	0.015
Canada	-0.004	-0.008	-0.009	0.000
Denmark	0.020***	0.020*	0.052***	0.073***
Finland	-0.006	0.006	0.022**	0.036***
France	-0.006	-0.020*	-0.002	0.040**
Germany	-0.007	-0.007	-0.001	0.042**
Hong Kong	-0.022***	-0.001	0.021	0.041*
Ireland	0.002	-0.014	0.001	0.006
Israel	-0.005	-0.003	0.004	0.022
Italy	0.001	-0.007	-0.010	0.030**
Japan	0.038***	0.048***	0.039**	0.037*
Netherlands	-0.006	-0.026**	-0.012	0.024
New Zealand	0.015**	0.000	0.009	0.021
Norway	0.003	-0.001	0.021	0.083***
Portugal	0.019***	0.002	0.008	0.016
Singapore	0.004	0.021*	0.031**	0.089***
Spain	-0.004	-0.014	-0.001	0.021
Sweden	-0.006	-0.001	0.007	0.054***
Switzerland	0.016**	0.001	0.016	0.069***
United Kingdom	-0.017**	-0.039***	-0.020	-0.029*
USA	-0.033***	-0.058***	-0.030**	0.000

Emerging Markets – in USD	Japanese Yen - Daily Frequency			
	Hedge	**0.05**	**0.025**	**0.01**
Argentina	-0.003	-0.002	0.003	0.006
Brazil	-0.006	-0.018**	-0.014	-0.025**
Chile	-0.009*	-0.019*	-0.010	-0.008
China	-0.011**	0.012	0.012	0.026
Colombia	0.006	-0.003	0.004	0.000
Czech Republic	0.024***	0.018*	0.029**	0.073***
Greece	0.008**	-0.004	0.001	0.010
Hungary	0.006	-0.006	-0.012	0.004
India	-0.006	-0.001	-0.006	-0.011
Korea	0.002	0.010	0.001	0.009
Malaysia	0.000	0.025	0.042**	0.028
Mexico	-0.018***	-0.026***	-0.025**	-0.029**
Peru	0.004	-0.012	-0.003	-0.013
Philippines	0.000	-0.004	-0.006	0.001
Poland	0.005	-0.013	-0.018	-0.030**
Russia	-0.009**	-0.010	0.003	0.012
South Africa	0.014***	0.010	0.013	0.017
Taiwan	-0.001	0.005	0.013	0.045**
Thailand	0.019***	0.023**	0.008	0.012

***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 level, respectively

Note: The table presents the estimated regression coefficients for the yen's role as a hedge and/ or safe haven asset based on daily data. Negative and (statistically significant) values in the hedge column indicate that the yen is a (strong) hedge for given market. Non-positive and (statistically significant) estimates in extreme market conditions (i.e. quantile columns 0.10, 0.025, or 0.01) imply that the yen serves as a (strong) safe haven for the respective market. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients. The light green shaded fields are simply for visualization purposes highlighting the non-positive regression coefficients.

4. Dynamic time-varying correlations for USD return data




Belgium and Gold
2000-08-01 / 2020-07-31
0.3
0.2
0.1
0.0
-0.1
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020

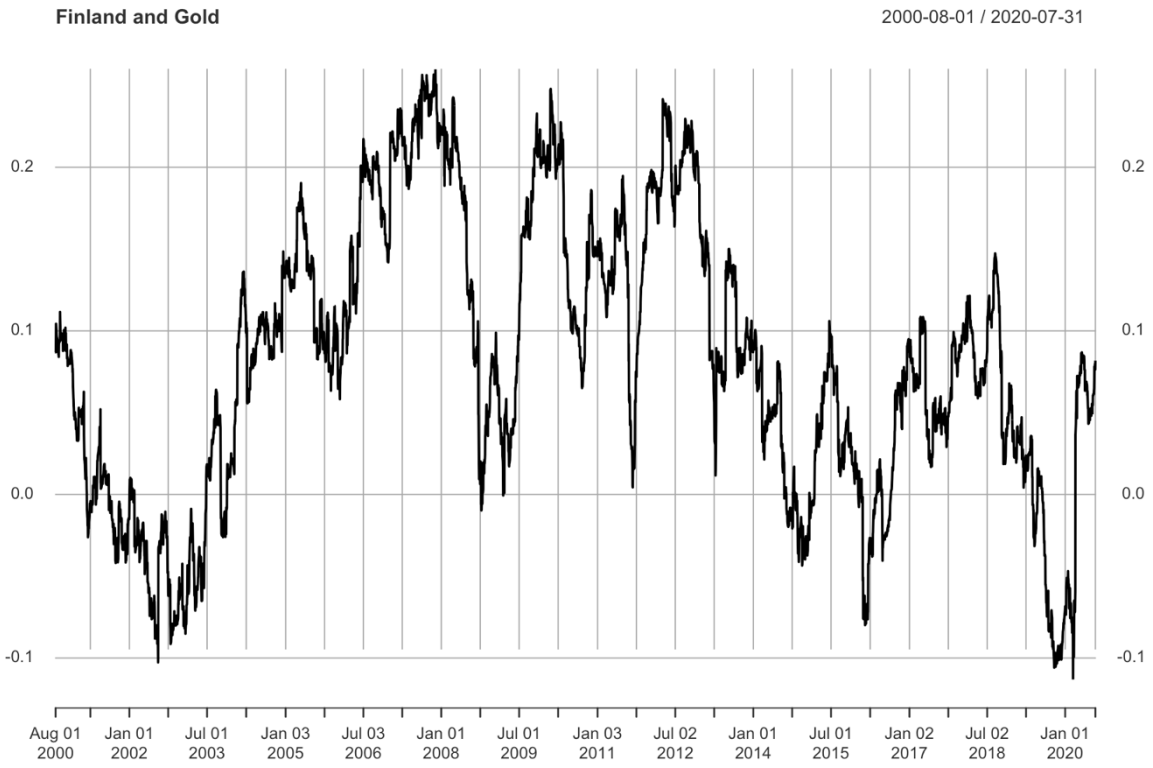

Canada and Gold
2000-08-01 / 2020-07-31
0.4
0.3
0.2
0.1
0.0
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


Switzerland and Gold
2000-08-01 / 2020-07-31
0.3
0.2
0.1
0.0
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


Germany and Gold
2000-08-01 / 2020-07-31
0.3
0.2
0.1
0.0
-0.1
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


Denmark and Gold
2000-08-01 / 2020-07-31
0.3
0.2
0.1
0.0
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


Spain and Gold
2000-08-01 / 2020-07-31
0.3
0.2
0.1
0.0
-0.1
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


Finland and Gold
2000-08-01 / 2020-07-31
0.2
0.1
0.0
-0.1
Aug 01 2000
Jan 01 2002
Jul 01 2003
Jan 03 2005
Jul 03 2006
Jan 01 2008
Jul 01 2009
Jan 03 2011
Jul 02 2012
Jan 01 2014
Jul 01 2015
Jan 02 2017
Jul 02 2018
Jan 01 2020


France and Gold
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Hong Kong and Gold
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Ireland and Gold
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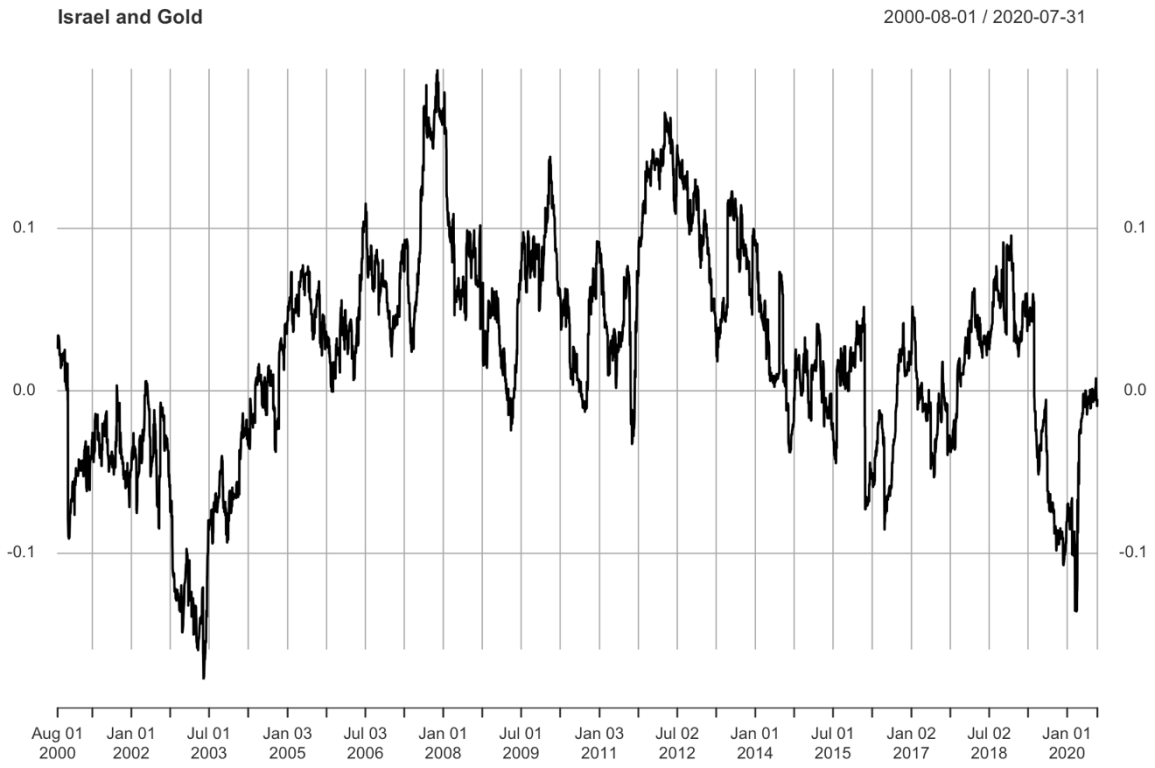
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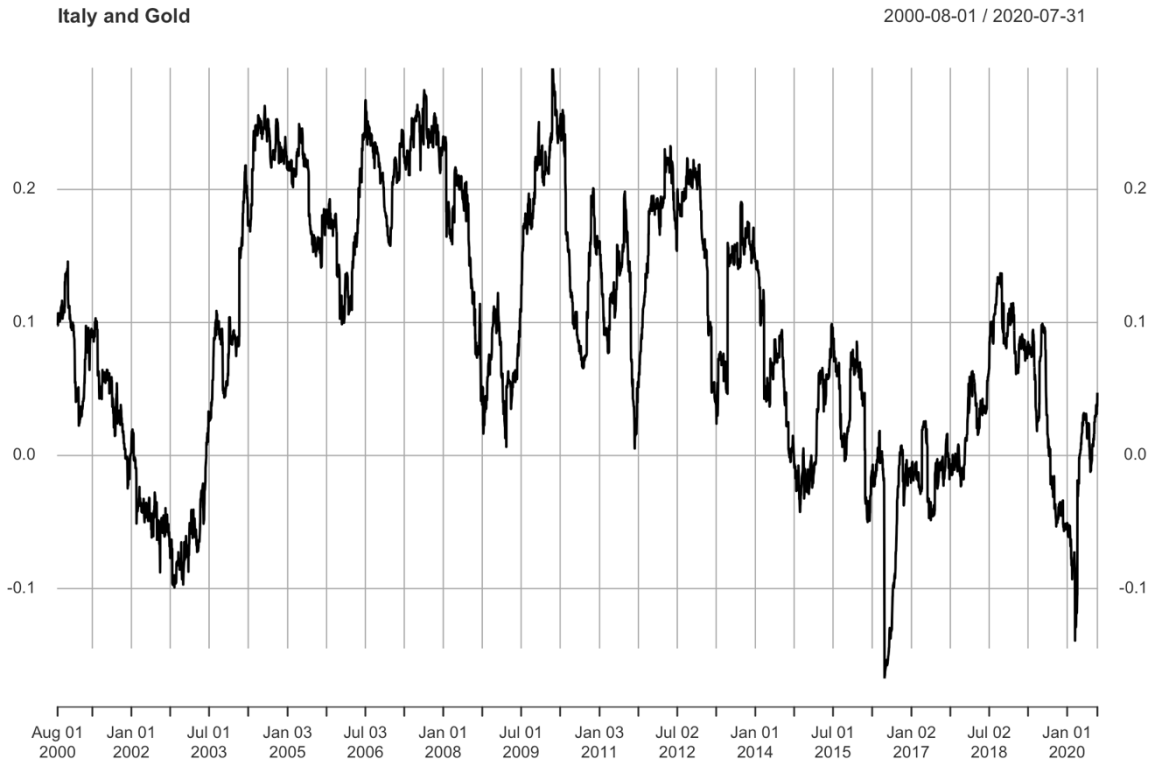
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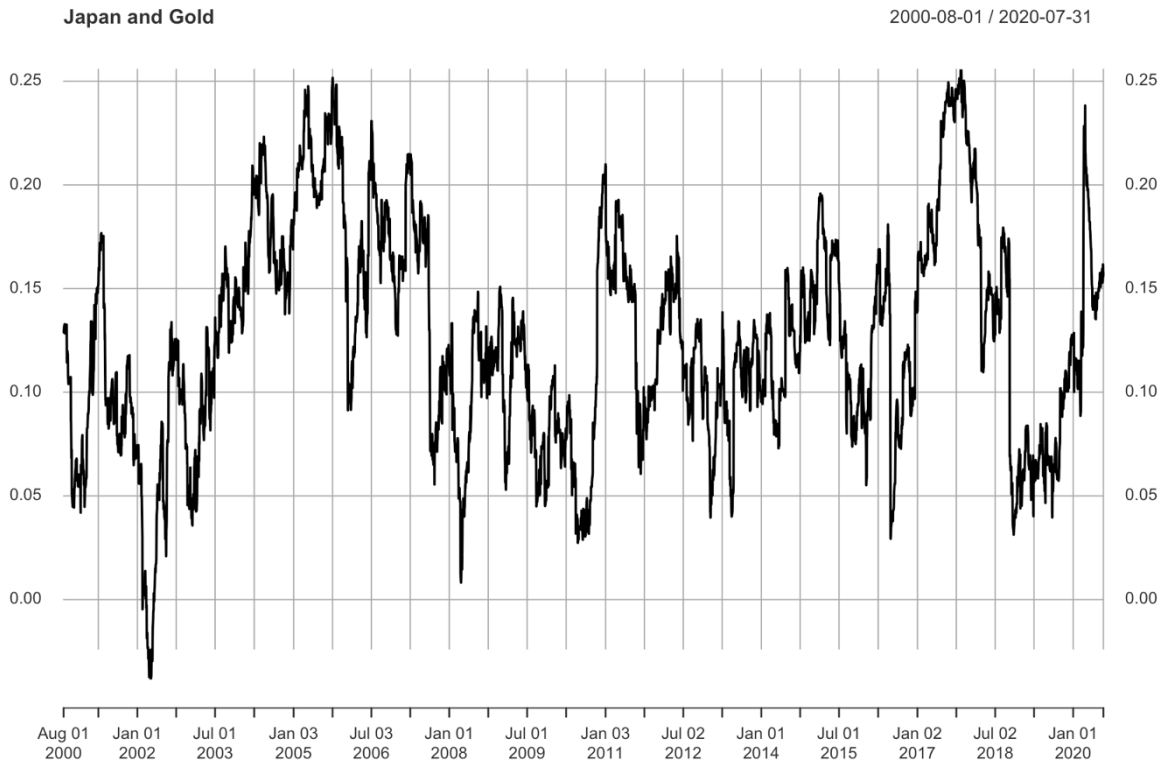
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Netherlands and Gold
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Norway and Gold
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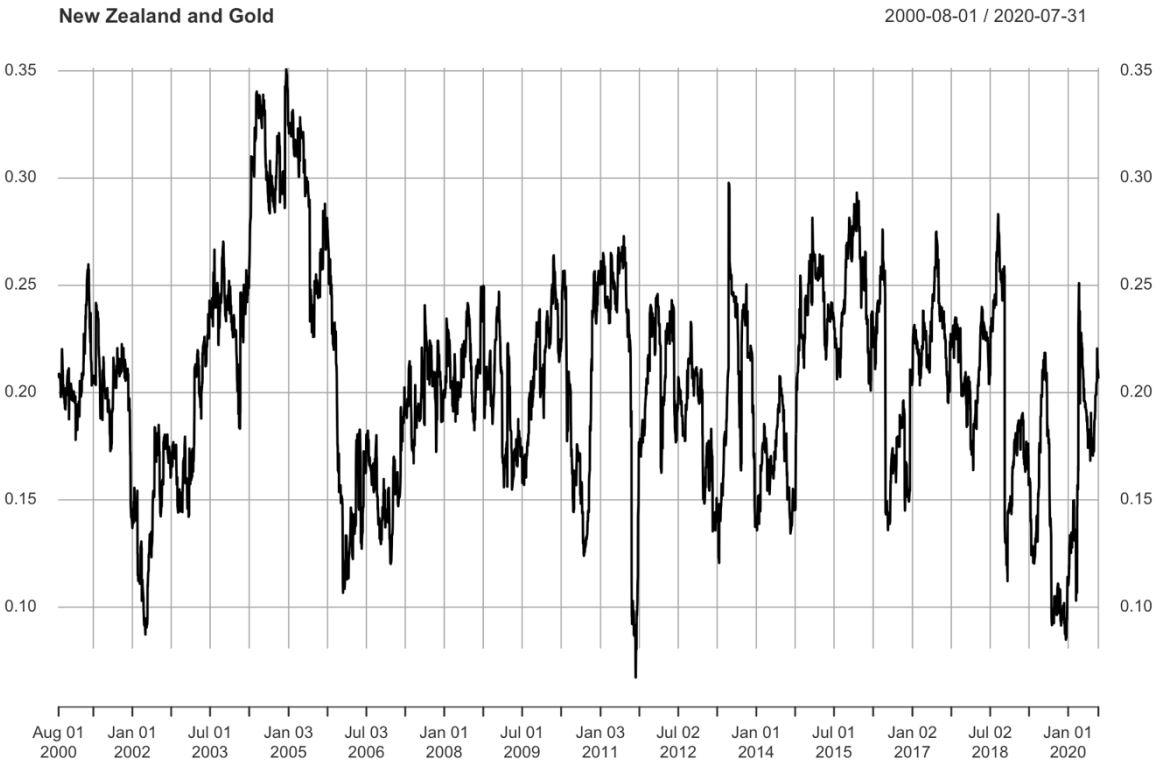
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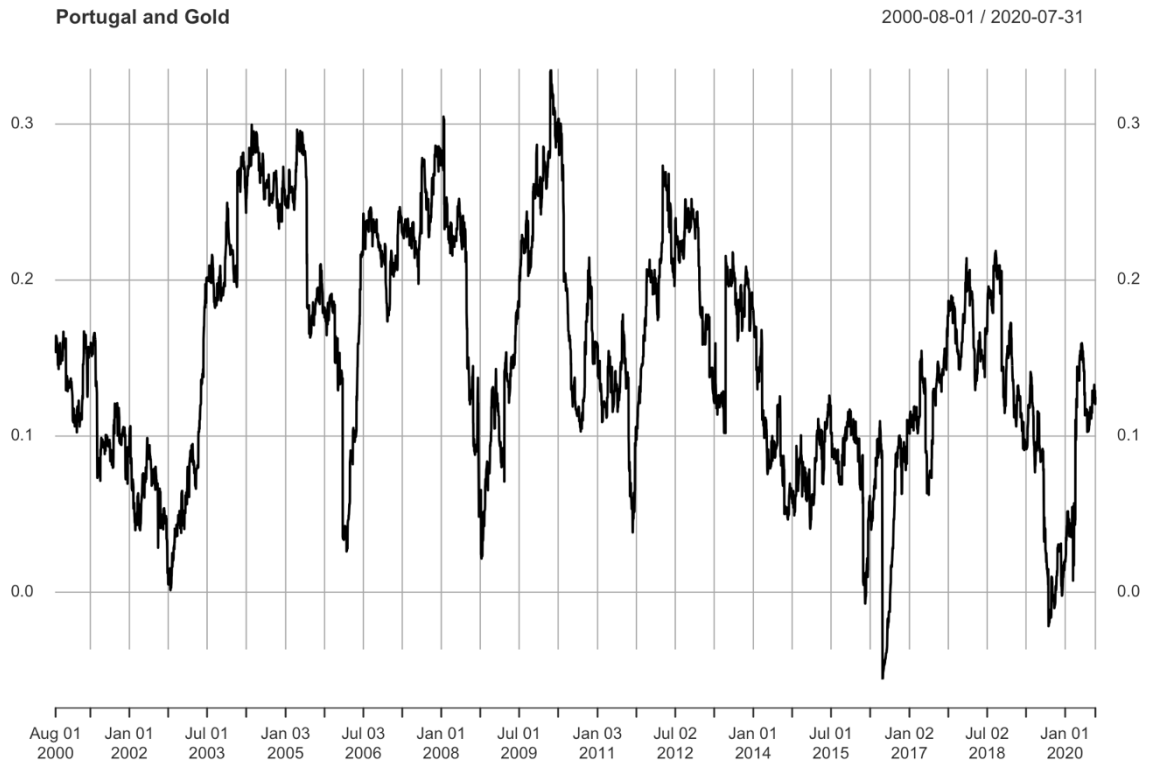
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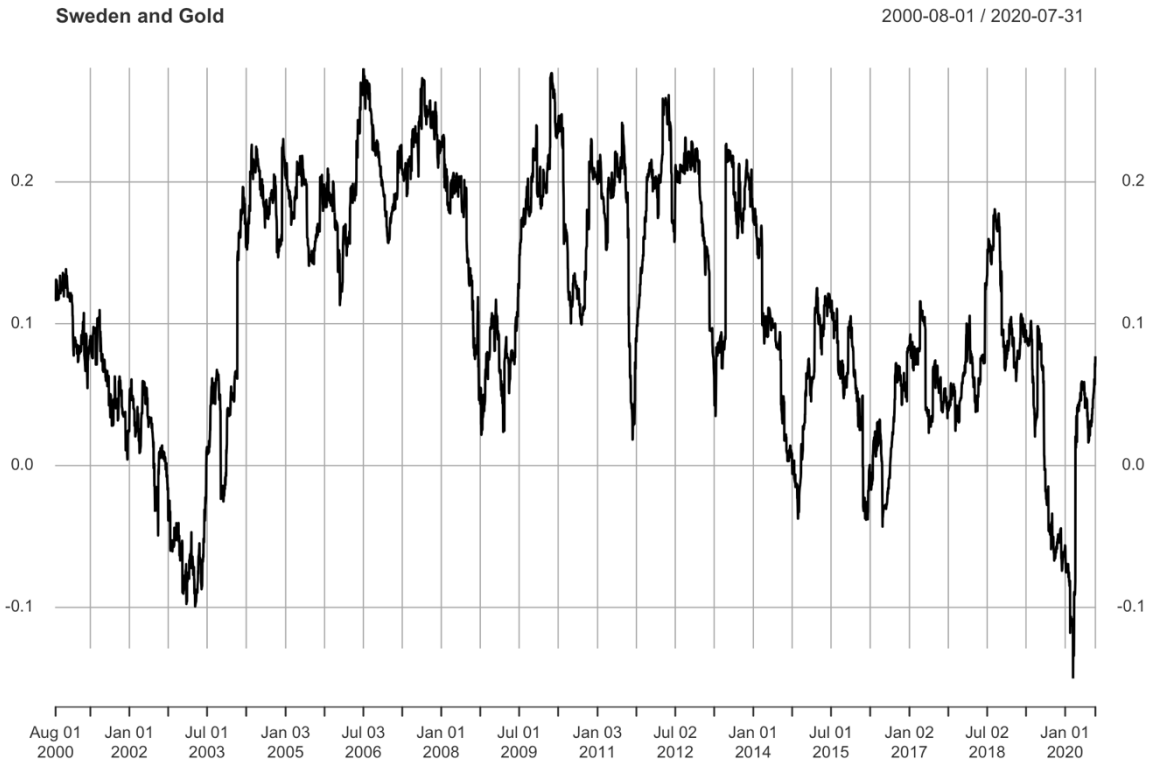
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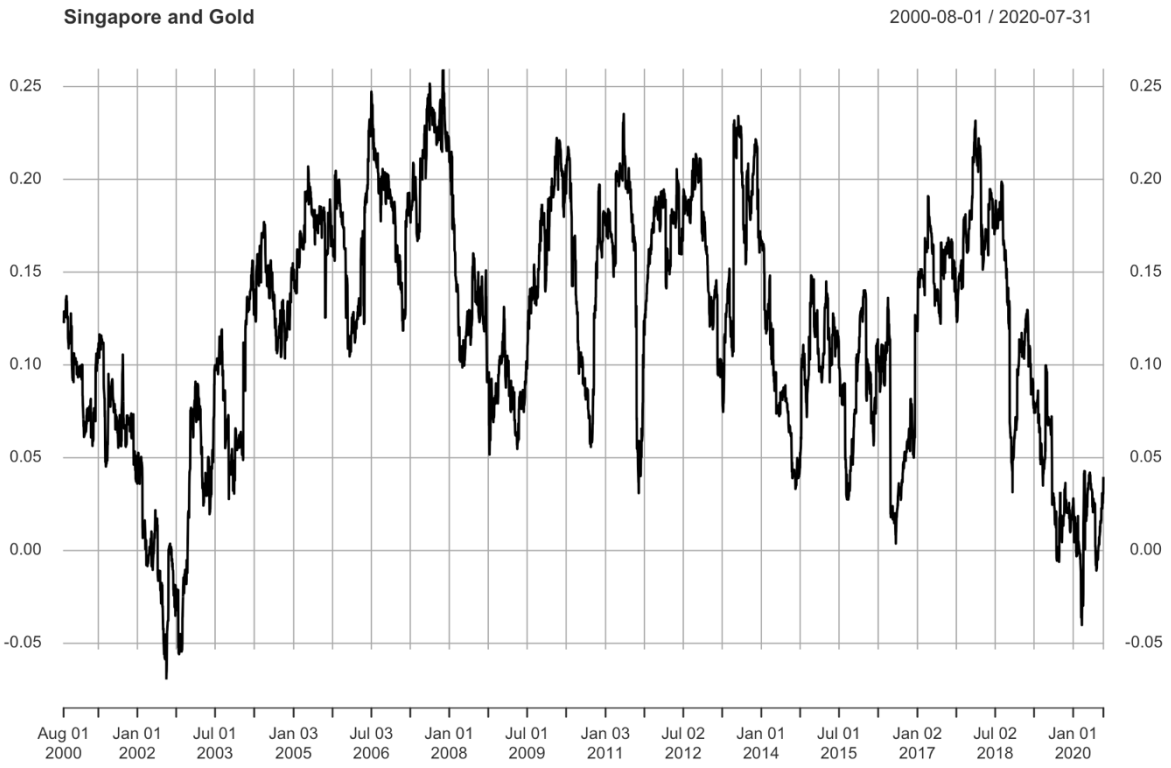
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United Kingdom and Gold
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USA and Gold
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Argentina and Gold
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Brazil and Gold
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Chile and Gold
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China and Gold
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Colombia and Gold
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Czech Republic and Gold
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Greece and Gold
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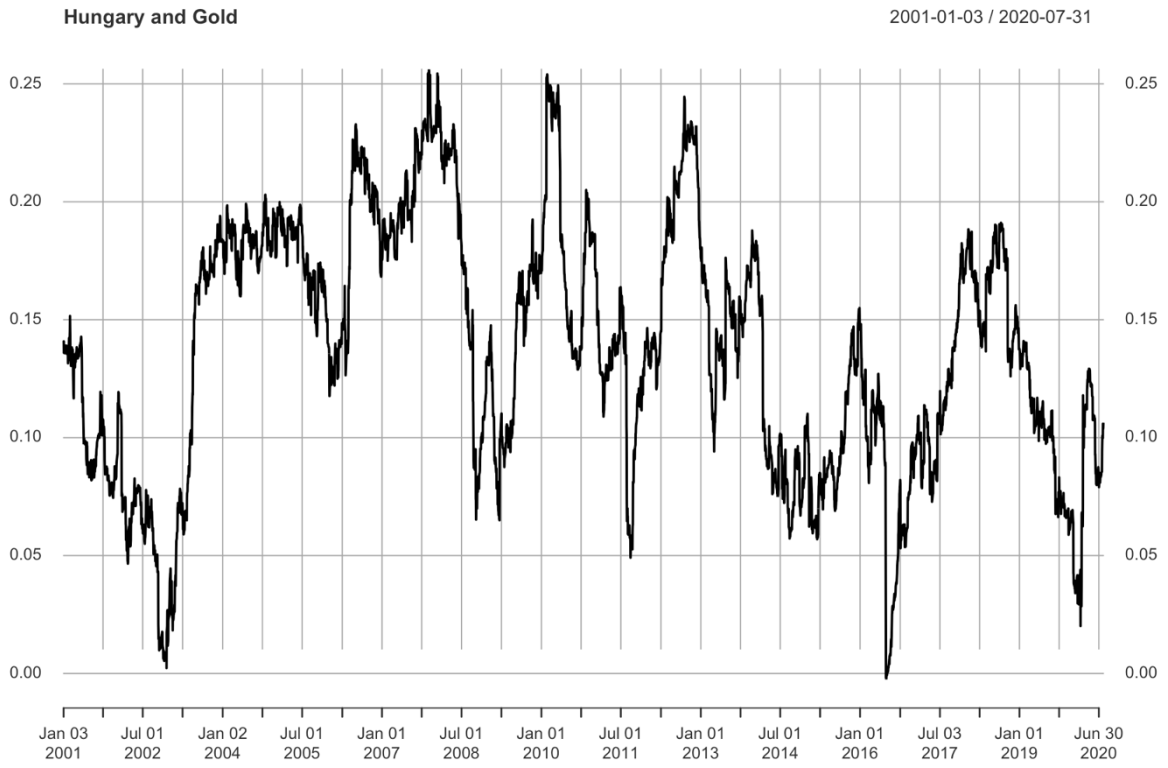
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India and Gold
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Korea and Gold
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Malaysia and Gold
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Mexico and Gold
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Peru and Gold
2001-01-03 / 2020-07-31
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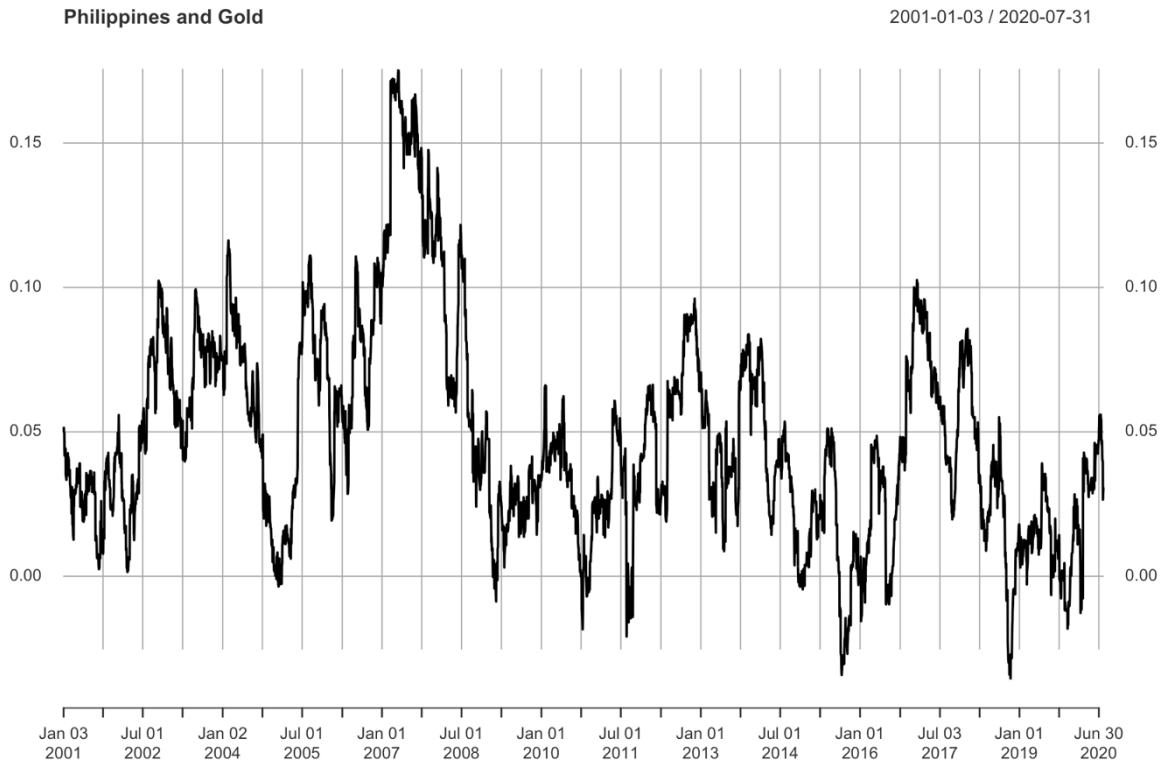
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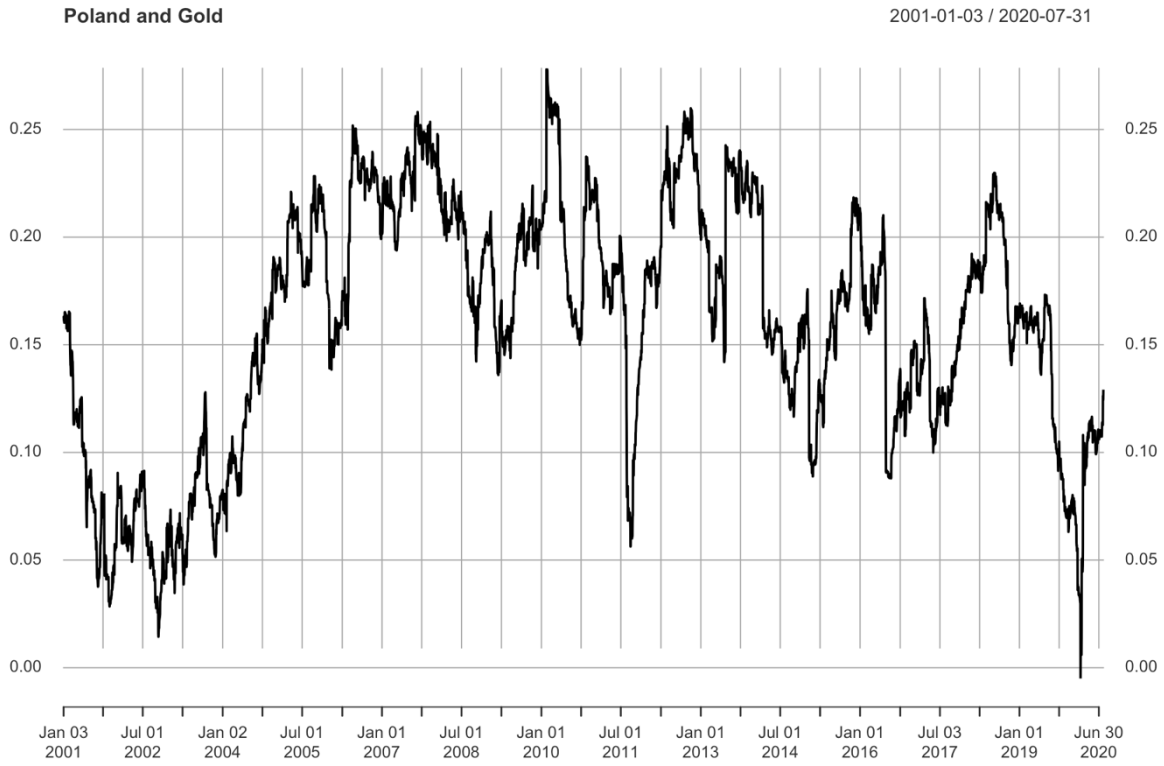
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Russia and Gold
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South Africa and Gold
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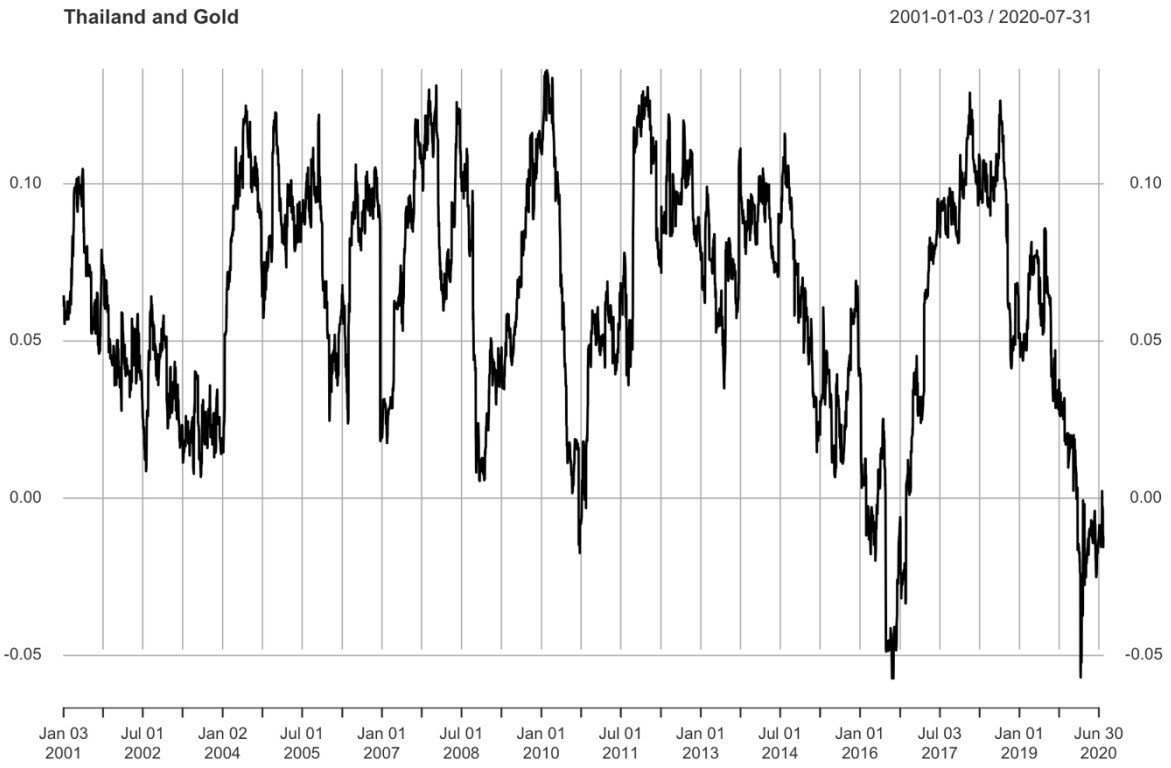
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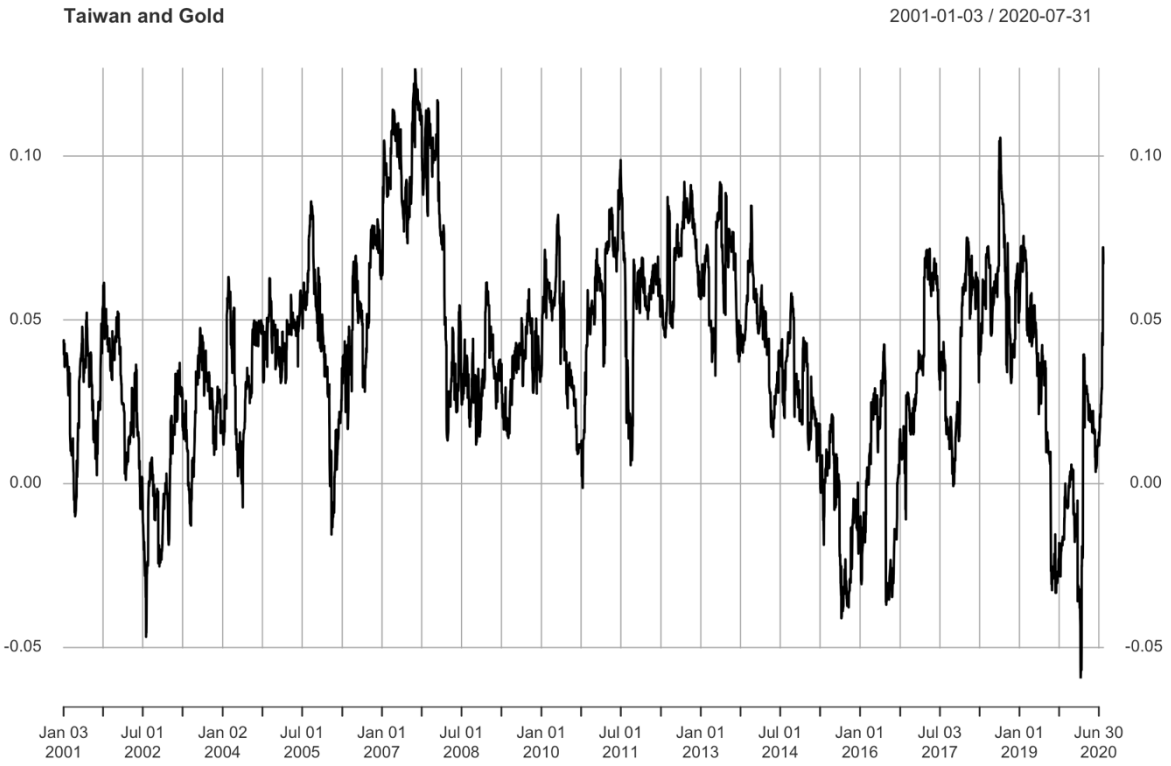
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