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Understanding Investor Behaviour; Explanatory Factors of Gold Safe Haven Heterogeneity

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Abstract

In this research, the connection between the returns of gold and stock markets in times of financial turmoil is scrutinized. Using quantile regression, gold is found to be a safe haven for monetary value in multiple, yet not all, countries. The heterogeneity in the safe haven property of gold is examined in greater detail and explanatory factors are proposed. Making use of country-specific fixed effects regression, this paper finds the degree of development of a country, the volatility of the stock market and the relative importance of gold production in the economy to be explanatory factors of gold safe haven heterogeneity. Financial openness does not seem to have explanatory power. Not all presented results, however, prove to be robust. Moreover, this study advocates for a further quest for underlying fundamental variables of this phenomenon.

Keywords: Safe Haven, Gold, Financial Markets, Heterogeneity

1 Introduction

On the 15th of September in the year 2008, investment bank Lehman Brothers filed for bankruptcy. This so called black swan event has been widely adopted to illustrate the development of the United States subprime mortgage crisis into a global financial crisis (Baba and Packer, 2009). On that particular date, the price of gold heavily rose to the point of 775 U.S. Dollar per troy ounce. During the three following financially turbulent years, the price per troy ounce of gold increased to $1782. This spectacular 130% increase occurred simultaneous with a mere 4.5% increase in the recovering Dow Jones stock market index.

These extraordinary developments have sparked a renewed academic interest in the price of the precious metal. More specifically, the evident display of a negative relationship between gold returns and stock market returns on some of the financially most disastrous days of the twenty-first century caught the eye of various researchers. Most notable, Baur and Lucey (2010) have presented early evidence of this negative relationship between gold and stock prices during times of financial distress. In further research, this effect has been found in most, yet not all, nations (Baur and McDermott, 2010; Gürgün and Ünalmış, 2014). This characteristic has been named the safe haven property of gold. This property will be examined in greater detail.

1.1 Safe Havens

The noun haven has a twofold definition. First of all, the word haven can be interpreted as a small port. Secondly, one could describe a haven as a general place of safety (Walter, 2008). Although these definitions seem particularly distinct from one another, their essence is comparable. A port is namely a place where boats seek shelter in times of stormy weather. Note that the terminology safe haven is in fact a tautology, as the adjective safe is implied by the word haven. To remain consistent with the relevant literature, the safe haven terminology is nonetheless adopted throughout this paper. In the context of financial markets, safe havens provide protection of monetary value in times of financial distress. Due to a larger degree of integration between modern financial markets, which decreases the benefits of international diversification, finding a safe haven asset has become of increasing importance (Agénor, 2001). Later on, a more formal testable definition of a safe haven will be discussed. Certain physical features of gold make this asset particularly suitable as a safe haven. These characteristics will be elaborated on.

1.2 Characteristics of Gold

The element gold has some unique physical features, which sets it apart from other financial assets. These characteristics are indissolubly linked to gold and therefore make gold a suitable safe haven. First of all, gold carries no risk of default. The intrinsic value of gold, which is ensured by demand for jewelry, industrial and dental application, differentiates the asset from sovereign bonds. Although sovereign bonds historically have been a quite safe asset, developments in the last decade have put pressure on this feature (De Santis, 2012). Moreover, the supply of gold is not subject at the whim of central banks or governments. This relative simplicity creates a transparent market for gold, which is comprehensible to the average investor. This in contrast to highly complex financial assets, such as collateralized debt obligations (Crotty, 2009). Therefore, the simplicity embedded in the market for gold could create a psychological impression of safety during times of great uncertainty. The market for gold will be discussed in greater detail in Section 2.1

Aforementioned features are nevertheless not exclusive to gold. Other precious metals also carry no risk of default and have a relative simple market structure. The distinct characteristic of gold over these other assets is the historical tie of gold with money. Gold has been used in the creation of coins since around the year 550 before Christ (Watson and Coeur, 1967). In most countries, gold was used as currency well before the introduction of money as we know today. Even when money in the form of monetary base M_0 was introduced, gold has often been used as an asset exchangeable for money at a fixed rate. This gold standard has largely been abolished since the breakdown of the Bretton Woods system, which occurred little over four decades ago (Bordo, 1993). This period is relatively short compared to the term in which gold was explicitly linked to our monetary base, which creates a historical trust in this specific asset.

> *"Get gold, humanely if you can, but at all hazards, get gold" - King Ferdinand of Spain, 1511 (Rosen, 1975)*

1.3 Relevance

In this paper, I scrutinize heterogeneity in the safe haven property of gold. First of all, prior developed techniques to measuring the safe haven feature of gold are executed for a unique set of countries. Secondly, econometric techniques are used in a quest to find explanatory variables of differences between countries in the mere existence and magnitude of the safe haven effect of gold. Multiple variables with significant explanatory power are presented. I thereby aim to address a void in the literature of this young field of research and provide a point of departure for further inquiry. No other analysis of gold safe haven heterogeneity is known by the author to date.

In addition to a contribution in academia, this paper hopes to provide practical applications. The presented results could function as a foundation for portfolio analysis, showing the value of gold as a diversifier in an investment portfolio in different countries. Moreover, understanding causes of investor behaviour during times of financial hardship is of the utmost importance to central banks and could therefore have considerable policy implications. This study attempts to contribute to this purpose.

To do so, a formal definition of safe havens will be presented in the Theoretical Framework. Furthermore, relevant literature will be discussed and used to derive the hypotheses. In section 3, the constructed databases will be introduced. After discussing the relevant econometric analysis for this research in section 4, results will be presented in section 5. In section 6, the most notable results will be discussed and exploited to draw conclusions on.

2 Theoretical Framework

In this section, relevant background information will be introduced. Moreover, the hypotheses tested in this research are deduced, formalized and operationalized.

In the aftermath of the largest financial crisis since the turn of the century, a strong increase in the price of gold unfolded itself. This fact was glazed upon by Baur and Lucey (2010). In their research, they introduce a formal test of gold as a safe haven against the stock market. Their operationalization of the safe haven property has since been widely adopted in relevant literature.

Throughout this paper, I employ the same definition and describe a safe haven as an asset that is either negatively correlated or uncorrelated to the stock market in times of financial distress (Baur and Lucey, 2010). Finding a nonpositive relationship with the stock market creates safety for investors and therefore provides a place of shelter for monetary value. An asset which is on average negatively correlated with the stock market is said to be a hedge.

Using their safe haven definition, Baur and Lucey (2010) show that gold indeed functions as a safe haven under extreme negative market conditions in the United States, the United Kingdom and Germany. Due to the introduction of a simple method to test safe haven properties, their paper paved the way to further research. The safe haven branch of research distinguishes itself from flight to quality literature, since the latter usually examines sovereign bonds.

Baur and Lucey's work gave rise to a further inquiry about the safe haven effect of gold, performed by Baur and McDermott. Baur and McDermott introduce a distinction between a weak and a strong safe haven. They define a weak safe haven as an asset with a correlation that does not significantly differ from zero with the stock market in times of financial turmoil. Strong safe havens are formalized as assets that display a negative correlation with the stock market during periods of financial distress (Baur and McDermott, 2010). Baur and McDermott show heterogeneity in the safe haven property of gold amongst countries. Their results indicate safe haven properties in France, Germany, Italy, the United Kingdom and the United States. On the contrary, they find no evidence of the safe haven property of gold in Australia, Brazil, Canada, China, India, Japan, Russia and Switzerland (Baur and McDermott, 2010).

Gürgün and Ünalmış (2014) adopt the methodology of Baur and McDermott (2010) and investigate the safe haven property of gold in developing countries. Out of the 28 countries considered in their research, Gürgün and Ünalmış present evidence of a strong safe haven for six countries and find weak safe haven properties in nine others. Significant positive correlations are found for the other thirteen countries (Gürgün and Ünalmış, 2014). Beckmann, Berger and Czudaj make use of a different econometric approach. Their research also finds large cross-sectional differences, indicating robustness in the heterogeneity characteristic of the safe haven property (Beckmann et al., 2015). In order to address and explain this variation, one must first understand the structure of the market for gold.

2.1 Supply and Demand of Gold

In the year 1980, Glenn Seaborg, Nobel Prize winner in Chemistry, discovered a way to convert the element bismuth into gold. The practical implications of Seaborg's resolution to an ancient alchemy puzzle were, nevertheless, limited. The costs to produce one ounce of gold would amount to more than one quadrillion dollar (Aleklett et al., 1981). The fact that converting base metals into gold is not a feasible method of production, is an important driver of the supply of gold. On a yearly basis, over 200.000 kilograms of the precious metal are extracted from mines. An estimate of the amount of gold above the surface is 190 million kilograms. About 54 million kilograms of gold is believed to still be below grounds (WorldGoldCouncil, 2018). A combination of the finite amount of the precious metal and long lead times to mine give rise to an inelastic supply of gold.

The demand for gold consists of numerous components. Notably, gold is used in the production of jewelry. Moreover, a large amount of gold is required for industrial and dental applications. A third category of demand for the precious metal originates from investors and central banks. Gold is often used as a financial asset, due to its unique physical characteristic, as discussed in Section 1.2. Considering the relative inelasticity of the supply of gold, fluctuations in demand have a direct effect on the price of gold. This causes the price of gold to be quite volatile, as depicted below:

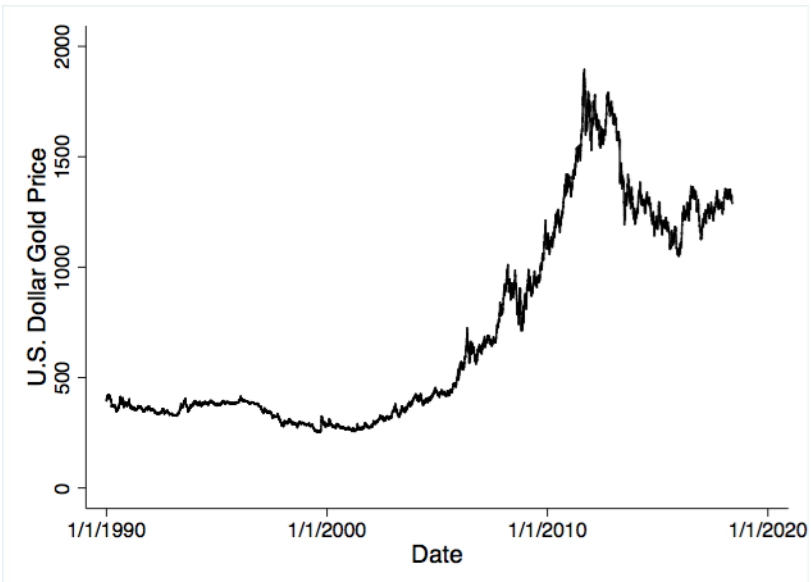

Figure 1: The development of the price of gold expressed in U.S. Dollars

One could argue that the first two components of demand, related to the consumption of gold, are strongly procyclical. Due to the aforementioned safe haven properties of gold, demand for gold as a financial asset would be expected to be countercyclical. A discussion about the fashion in which the aggregated demand for gold follows the business cycle should therefore entail identifying a dominant factor. There is, however, no reason to believe this dominant factor is the same component over the business cycle as a whole. As most stocks, and therefore stock markets, follow a procyclical pattern, we can relate the components of aggregate demand for gold to the stock market. We express the aggregate demand for gold below:

$$\underset{(+/-)}{G_D} = \underset{(+)}{J_D} + \underset{(+)}{I_D} + \underset{(-)}{F_D}$$

Where G_D resembles the aggregate demand for gold, J_D denotes the demand for gold used in jewelry, I_D shows the demand for gold for industrial application and F_D indicates the demand for gold as a financial asset. The signs between parentheses denote the expected correlation between the demand for this component and stock market returns.

One could expect the financial demand for gold to be more exposed to daily fluctuations compared to the demand for gold for consumption purposes. As financial markets typically take less time to adjust compared to the goods market, a logical dominant factor in times of extreme financial uncertainty would therefore be gold as a financial asset (Boivin et al., 2009). It is important to note that one would expect a certain level of asymmetry in this behaviour of the demand for gold. When the stock market experiences exceptionally high positive returns, the gold price is not expected to plummet. This is due to the fact that the safe properties of gold do not become *undesirable* in times of financial euphoria, but only less desirable. The dominant factor in these times is harder to identify. This creates a varying correlation between stock market returns and gold returns over the business cycle, as depicted in Figure 2.

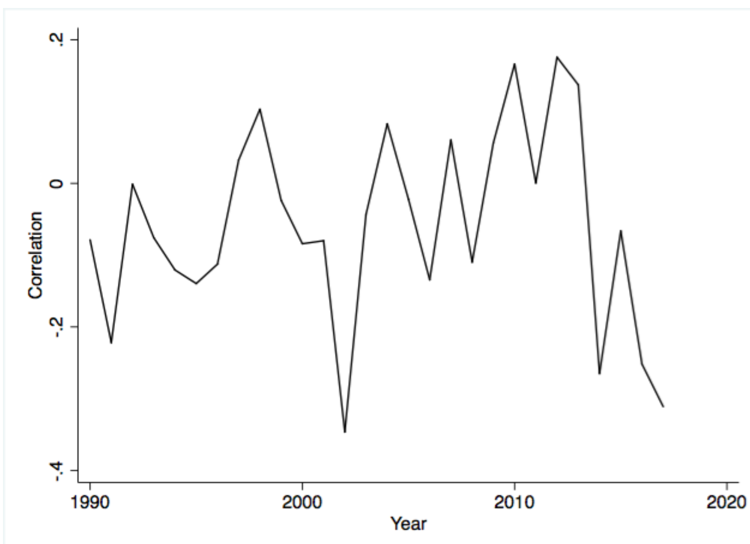

Figure 2: The development of the correlation between the Dow Jones stock market index and the gold price expressed in U.S. Dollar.

One could argue that changes in gold demand sparked by a fall in the stock market index of developing countries with a small economy would have a negligible effect on the overall price of gold. A safe haven effect of gold for investors from these countries can nonetheless still be expected, due to the fact that gold is priced in U.S. Dollars. Via a depreciation of the domestic currency, caused by capital outflows in times of financial turbulence, the asset gold would still prove to be a wise diversifier for domestic investors.

2.2 Safe Haven Heterogeneity

Although differences between countries in their respective gold safe haven properties are presented by multiple researchers, only few comments have been made on the occurrence of this phenomenon. Most researchers in this field view explanatory factors of this heterogeneity as beyond the scope of their research. In this paper, we formulate and investigate multiple potential explanatory variables.

We begin by inspecting the most apparent factor. As mentioned earlier, a safe haven mitigates financial uncertainty. The call for a safe haven asset has intensified due to a stronger integration of international stock markets, which has decreased the possibilities for effective international diversification. The nonpositive correlation between the stock market and the safe haven asset could, however, cease to exist when these markets itself are integrated. When a country is a large producer of gold, one would expect a positive correlation between the price of gold and the earnings of their firms, which in its turn are positively linked to stock market value (Dow and Gorton, 1997). A stock market which is significantly influenced by gold producing firms would thus be expected to be positively correlated to the price of gold. This notion is shared by Gürgün and Ünalmıs, who formulate the expectancy of a positive correlation between stock and equity returns in major gold producing countries during times of financial hardship (Gürgün and Ünalmış, 2014). They, nonetheless, find mixed results for the largest gold producers. In doing so, Gürgün and Ünalmış ignore the relative importance of gold production to the country. In this paper, I propose a more structural approach and compute the relative importance of gold production within a nation. This enables formal tests of the discussed expectation, which brings us to the first hypothesis:

> H_1*: A higher relative importance of gold production has a negative effect on this country's safe haven property of gold.*

The relative importance of gold production is measured by a countries total gold production as a fraction of total gross domestic product. The safe haven property of a country is operationalized by calculating the correlation between gold returns and stock market returns in times of financial turmoil, where a lower correlation represents a larger safe haven property. This exact methodology will be discussed in more detail in Section 4.

A different probable explanatory variable was proposed, yet not formally tested, by Baur and McDermott (2010). While making a qualitive assessment of their results, they point out that the safe haven property is most evident in developed countries. In an attempt to clarify investor behaviour, they reason that severe losses suffered in developing and emerging nations do not induce investors to switch their capital from emerging stock markets to gold. They argue a more likely response would be to switch funds to developed stock or bond markets. Financial turmoil in the stock markets of emerging countries are here assumed not to cause immense investor distress. On the contrary, falling developed stock markets are presumed to cause great financial hardship. This will create a larger desire for a safe haven asset. This belief is formulated in the second hypothesis:

> *H_2: A higher degree of development of a country has a positive effect on this country's safe haven property of gold.*

In this paper, I do not engage in the important discussion on development indicators and limit myself with gross domestic product per capita to the most widely used indicator (Wilson et al., 2007). The safe haven property per country is calculated as aforementioned.

In their research, Beckmann, Berger and Czudaj claim that capital flow openness could be held responsible for the variety across countries in their results. They, however, view an explicit assessment of this factor to be beyond the scope of their research (Beckmann et al., 2015). Dee, Li and Zheng (2013) also propose imperfect capital mobility as an explanation for the lack of the safe haven property of gold in China, as presented in their study. The rationale behind financial openness as an influence on the gold safe haven property of a country is twofold. First of all, a lower degree of capital mobility creates a lower integration with international stock markets. A negative shock in this imperfect capital market would be more contained and hence not cause global uncertainty. Secondly, the sheer impossibility to switch capital between markets induced by capital controls would prevent the gold safe haven phenomenon to occur. Vice versa, a larger degree of financial openness would give rise to a stronger safe haven property of gold. This allows us to deduce the third hypothesis:

> *H_3: A higher degree of financial openness of a country has a positive effect on this country's safe haven property of gold.*

Financial openness is a quite broad term and therefore fairly difficult to quantify. A combination of multiple capital flow restriction indices, an exchange rate regime index and stock market liquidity variables will be made via Principal Component Analysis. This will be discussed in more detail in Section 3 and Section 4. The definition of the safe haven property of gold is in line with descriptions provided earlier.

In a paper published two years after their study on international evidence of gold as a safe haven, Baur and McDermott scrutinize the raison d'être of the safe haven property of gold. They do so by contrasting gold with U.S. government bonds. In their paper, they elucidate the connection between the gold price and uncertainty in a more detailed, psychological, fashion. Gold is mostly purchased under extreme uncertainty, especially when investors receive ambiguous signals. Sovereign bonds are more popular in times of extreme yet unambiguous market signals (Baur and McDermott, 2012). The intuition behind their result is that investors will seek out a destination that is as little as possible integrated with international capital markets under great uncertainty. Moreover, the uncertainty causes them to invest in an asset with an intrinsic value and no risk of default. Capital markets that carry a larger degree of uncertainty are therefore expected to have stronger safe haven properties. This brings us to the fourth, and last, hypothesis:

> H_4*: A higher degree of uncertainty in the stock market of a country has a positive effect on this country's safe haven property of gold.*

The uncertainty of a stock market will be calculated as the yearly volatility of the relevant stock market index.

3 Data

In order to both demonstrate and explain gold safe haven heterogeneity, two datasets will be used. The first database allows us to generate correlations between stock market indices and the price of gold, which will be examined later in this research. To find the relevant correlations, data consisting of stock market indices and gold prices for various countries is used. A total number of 25 countries are considered in this research. In order to evaluate the second hypothesis, both developed and developing countries are embodied in this sample. The United States, the United Kingdom, Spain, Republic of Korea, Portugal, the Netherlands, Japan, Italy, Ireland, Greece, Germany, France, Canada, Belgium, Austria and Australia are included as developed countries. Emerging and developing nations China, India, Indonesia, Russia, Saudi-Arabia, South Africa, Thailand, Turkey and the United Arab Emirates were also selected due to the role gold plays in their economy, as either large consumers or producers of gold. This helps in evaluating the first hypothesis. For all mentioned countries, daily gold prices per troy ounce quoted in their domestic currency over the period 1995 to 2015 are obtained from the World Gold Council. Per country, one stock market index is selected based on prominence of the index and availability of data. Daily stock index data is obtained from Bloomberg. All stock data is quoted in domestic currencies. A comprehensive overview of all used stock market indices can be found in Appendix A.

A logarithmic transformation is applied to all financial time series. Daily returns are calculated by taking the first difference of the logarithms of both the stock market indices and gold prices. All resulting time series are tested for stationarity with a Dickey-Fuller unit root test and display stationarity. Exemplary results for the Dow Jones stock market index are depicted in Appendix B. Due to the stationarity property of all time series, no further transformations are performed. As shown in Figure 1, the gold price in U.S. Dollars has heavily increased since the year 2000, peaking at times of falling stock markets. Correlations between the stock market indices and gold prices in the domestic currency for the five percent most disastrous trading days in terms of stock market returns are calculated on a yearly basis, for all countries. The threshold of five percent is decided upon after considering the trade-off between keeping a sufficient large sample and using only the days with the greatest financial turmoil. An elaboration of this methodology will be provided in Section 4. The calculated correlations are stored in a second database. This panel data set, consisting of gold safe haven coefficients for 25 countries and 21 years, functions as the operationalization of safe haven heterogeneity. Summary statistics of this variable are presented in Table 1 and Table 2:

Table 1: Descriptive statistics of the safe haven coefficients of considered countries.

Country	Mean	Min	Max	SD
Australia	-0.217	-2.161	1.186	0.756
Austria	0.089	-0.190	0.468	0.089
Belgium	0.173	-1.189	1.561	0.610
Canada	0.245	-1.089	3.165	1.047
China	0.112	-0.680	0.548	0.285
France	0.258	-0.963	1.331	0.623
Germany	0.198	-0.719	1.414	0.640
Greece	0.076	-0.484	1.421	0.473
India	-0.029	-0.340	0.416	0.146
Indonesia	-0.090	-0.330	0.076	0.109
Ireland	0.063	-0.315	0.503	0.224
Italy	0.008	-0.449	0.629	0.268
Japan	0.282	-0.278	1.230	0.380
Netherlands	0.055	-0.245	0.342	0.171
Portugal	0.038	-0.356	0.397	0.223
Republic of Korea	0.038	-0.118	0.417	0.124
Russia	-0.056	-1.010	0.438	0.287
Saudi-Arabia	0.054	-0.515	0.799	0.384
South Africa	-0.060	-0.249	0.103	0.092
Spain	0.051	-0.415	0.531	0.286
Thailand	-0.022	-0.183	0.175	0.088
Turkey	-1.771	-4.300	0.390	1.599
United Arab Emirates	-0.049	-0.338	0.297	0.180
United Kingdom	0.117	-0.430	0.664	0.348
United States	-0.017	-3.240	3.536	1.186

A lower coefficient indicates a lower correlation between the stock and the gold market and therefore indicates a stronger safe haven property.

Table 2: Descriptive statistics of the safe haven coefficients per period of three years.

Period	'95 - '97	'98 - '00	'01 - '03	'04 - '06	'07 - '09	'10 - '12	'13 - '15
Average Coefficient	0.140	0.201	-0.203	0.182	-0.189	-0.179	-0.047

As presented in Table 1 and Table 2, safe haven coefficients vary over both time and country. All countries have displayed both positive and negative correlations. The average correlations seem to have become lower since the turn of the century. This is in line with the rising degree of international stock market integration, which is expected to increase the need for safe haven assets.

To test the formulated hypotheses, the second database is extended with additional variables. In order to evaluate differences between developed and emerging countries, data on gross domestic product per capita is included. This data is obtained from the World Bank and expressed in thousands of current U.S. Dollars. We find complete data for all 25 countries and 21 years. In the year 2015, Ireland had the largest GDP per capita. The least developed country included in the sample, as stated by this indicator, is India.

The relative importance of gold to an economy is computed manually. The mine production of gold in kilograms per country is retrieved from the Mineral Yearbook, published by the U.S. Geological Survey National Minerals Information Center. Dividing this amount by the total gross domestic product of the country expressed in millions, as obtained from the World Bank, gives us the relative importance of gold production. Countries that do not produce gold automatically receive the value zero. In 2015, this was the case for ten countries. The countries with the largest importance of gold in their economy are respectively South Africa, Australia and Indonesia.

Stock market volatility is calculated as a measure of uncertainty. This is executed by estimating a volatility model on all stock market returns time series. As time-varying volatility and volatility clustering often occurs in financial time series, a GARCH [1,1] model is considered the most suitable for this purpose (Bollerslev, 1986; Zhuang and Chan, 2004). Daily volatility per stock market index is computed and annualized by multiplying the average daily volatility with $\sqrt{252}$, where 252 represents a standard number of trading days per year.

Financial openness is the most complex concept used in testing the hypotheses. This variable is operationalized by performing a Principal Component Analysis on various variables which are expected to be related to financial openness. A further discussion of this methodology is provided in Section 4. Considered variables can be divided into two broad categories. First of all, the mere possibility to transfer funds between international markets is certainly a strong indication of capital flow mobility. An attempt to capture this capital flow openness is made by using four variables. The first two variables, capital inflow restriction index and capital outflow restriction index, are measures of capital controls. These are found in the dataset of capital control measures, developed by Fernandez et al. (2016). Another proxy of capital flow openness employed in this research is the exchange rate classification, as characterized by Ilzetzki et al. (2017). This classification is manually augmented to have a currency union qualify as the most integrated category with world markets. The second largest integration is given by freely floating exchange rates. Fixed exchange rates are taken as an indication of lower integration with world markets and therefore receive a lower score. The fourth variable of capital flow openness is the capital account openness index, better known as the Chinn-Ito index and calculated by quantifying restrictions on financial transactions as reported in the Annual Report on Exchange Arrangements and Exchange Restrictions, published by the International Monetary Fund (Chinn and Ito, 2008). An overlap in information between variables will be omitted by dimension reduction, executed by the Principal Component Analysis.

The other variables used in resembling financial openness are measures of stock market size. Relatively large and liquid stock markets indicate a larger importance of the stock market and most likely a more developed, international, stock market. Including these factors has been suggested by Beckmann et al. (2015). The first included factor in operationalizing stock market development is the turnover ratio. This variable, which expresses the value of traded shares as a fraction of market capitalization, shows the liquidity of the stock market. The other two variables mirror stock market size more closely. The market capitalization as a percentage of GDP shows the product of total shares outstanding and the price of these shares as a fraction of gross domestic product. Stocks traded as a share of total gross domestic product shows the size of stock market transactions per year. All three variables of stock market development are obtained from the World Bank.

All aforementioned variables are summarized in a table in Appendix A, where a comprehensive overview of all variables, their source and descriptive statistics can be found.

4 Methodology

The analysis performed in this research consists of two parts. First of all, the relationship between the price of gold and the price of stocks will be examined in a more formal fashion. Secondly, the focus is shifted to heterogeneity in the safe haven properties of gold amongst countries. Aforementioned possible explanatory variables will be introduced in the models specified in this section.

4.1 Addressing Safe Haven Heterogeneity

In order to obtain a deeper understanding of the interdependence of the stock market and the market for gold, Granger causality tests on the stock and gold returns will be executed for all countries. Testing for Granger causality will provide information concerning the usefulness of one time series in predicting the other. This is done by examining the effect of prior values of a variable on the current or future values of another (Granger, 1980). For all nations, vector autoregression models are estimated in order to identify interdependencies between their stock market returns and their gold returns. Lag selection for these vector autoregression models is performed by calculating the Akaike information criterion. The number of lags included in the model is determined by selecting the number of lags with the lowest criterion, with a minimum of one, in order to allow for Granger causality tests. The estimated vector autoregressive models can be formalized as:

$$StockReturns_i = \alpha_{i,1} + \sum_{j=1}^{n} \phi_{i,j} StockReturns_{t-j} + \sum_{k=1}^{m} \phi_{i,k} GoldReturns_{t-k} + \varepsilon_{i,1}$$

$$GoldReturns_i = \alpha_{i,2} + \sum_{k=1}^{m} \phi_{i,k} GoldReturns_{t-k} + \sum_{j=1}^{n} \phi_{i,j} StockReturns_{t-j} + \varepsilon_{i,2}$$

(1.0)

Where i denotes the identifier of the country, j denotes the lag of stock returns, k resembles the lag of gold returns and n and m denote the total number of lags of stock and gold returns respectively, as determined by the rule of thumb discussed above. The pairwise Granger causality test formally tests the significance of $\phi_{i,k}$ in the first model and $\phi_{i,j}$ in the second model against zero. Rejecting the null hypothesis gives rise to the conclusion of a Granger causation of the variable on the other variable. This information will be used to provide a deeper understanding of the average relationship between stock and gold returns.

To test the safe haven property of gold in times of financial distress, the rest of this research will focus on the relationship between the returns of gold and stocks during financial turmoil. Using three definitions of financial distress creates robustness of the results generated. Therefore, the correlation between stock market returns and gold returns for the 10%, 5% and 1% worst trading days are investigated. By using quantile regression, all other trading days are expunged from the estimated coefficients. In line with methodology suggested by Baur and Lucey (2010), an ordinary least squares regression model is estimated with interaction terms between the stock returns and a dummy indicating whether the observation belongs to one of the quantiles mentioned earlier. The simple model is specified as following:

$$GoldReturns_i = \alpha + \beta_{1,i} StockReturns_i + \beta_{2,i} StockReturns_i * D_{q10} + \beta_{3,i} StockReturns_i * D_{q5} + \beta_{4,i} StockReturns_i * D_{q1} + \varepsilon_i$$

(1.1)

Where i denotes the country, α is a constant and β's are the estimated coefficients. All D variables are dummies which take the value of one when the observation belongs to the specified quantile and zero otherwise. The model specified above calculates the safe haven property of gold in the country under different definitions of financial turmoil. Gold is said to be a hedge against the stock market if β_1 is smaller than zero. Evidence of a strong (weak) safe haven property is found if the sum of β_1 and all relevant coefficients is negative (zero). For example, using the strictest definition of extreme market conditions, the sum of coefficients β_1 to β_4 is tested against zero. This is due to the fact that β_1 indicates the average correlation between gold and stock returns and β_2, β_3 and β_4 indicate the difference in effects for the relevant quantiles.

After estimating Model 1.1, a test for heteroskedasticity is performed. Storing the residuals of the model and regressing them on dependent variable gold returns, significant coefficients are obtained for all countries. This implies a large degree of heteroskedasticity. An example of the results of this test are presented in Appendix B. Moreover, all time series display significant autocorrelations. These concerns will be addressed with by using Newey-West heteroskedasticity and autocorrelation robust standard errors (Newey and West, 1987). Although it is very likely that Model 1.1 suffers from endogeneity, no further assessment of this will be made. This is due to the fact that this research has no interest in explaining gold prices, but merely in finding the correlation between stock returns and gold returns. Relatively low values of R^2 therefore do not create a problem to this purpose.

4.2 Explanatory Factors of Safe Haven Heterogeneity

In order to test safe haven heterogeneity in different countries and periods of time, a second database is constructed. This panel dataset contains the safe haven coefficients of all 25 countries for 21 years. These coefficients are generated by estimating quantile regressions similar to methodology mentioned previously, now limiting the observations to one specific year. These models operationalize financial turmoil as the five percent worst trading days of the year. Five percent is selected as a threshold because using a one percent lowest returns criterion would leave too few observations for adequate statistical inference. On the contrary, the ten percent most unfavorable trading days would leave too many observations that do not qualify as extreme negative market conditions. Model 1.2 can be formulated as following:

$$GoldReturns_{i,t} = \alpha + \beta_{1,i,t} StockReturns_{i,t} + \beta_{2,i,t} StockReturns_{i,t} * D_{q5,t} + \varepsilon_{i,t} \tag{1.2}$$

Where t denotes the specific year and all other characters are similar to Model 1.1. Generated coefficients, the sum of β_1 and β_2, are stored in the second dataset and will be used as the dependent variable in further analysis. To receive data on our independent variables stock market volatility, stock market size and capital flow openness, further calculations are necessary. Stock market volatility is generated by estimating a generalized autoregressive conditionally heteroskedastic (GARCH) model. As volatility often clusters in financial time series, and therefore could be dependent on prior variance, the variance of stock market returns is modelled as a function of a lagged errors and lagged volatility (Cont, 2007). One error and one variance lag are included in the GARCH [1,1] model. Daily volatilities are modelled as:

$$\sigma_t^2 = \alpha_0 + \phi_1 \sigma_{t-1}^2 + \alpha_1 \varepsilon_{t-1}^2$$

(1.3)

Daily volatilities are converted to yearly volatilities to fit the panel dataset by taking the average of the daily volatilities within one calendar year. This average is annualized by multiplying with $\sqrt{252}$, as 252 is a broadly used average number of trading days in stock markets.

To investigate the effect of stock market size and capital flow openness on the safe haven property of gold, these variables must first be operationalized. To prevent including redundant predictors in the estimated models, which could lead to difficulties with statistical inference, dimension reduction is necessary. By performing a principal component analysis on the variables discussed in Section 3, an attempt is made to retain a large amount of variance while capturing this in as few variables as possible. Principal component analysis makes transformations on these financial openness variables in order to have the largest degree of variance in the data captured by the first factor. This is done by ranking components based on their eigenvalues, where the factor with the largest eigenvalue captures the largest amount of variance (Abdi and Williams, 2010). The factor loadings of the components show the correlations between the original variables and the generated components.

Prior to this principal component analysis, the adequacy of our variables for this type of analysis is investigated. By obtaining a Kaiser-Meyer-Olkin measure, which calculates the degree to which variables are predicted by the other considered variables, one can address the question whether variables are correlated strongly enough to perform Principal Component Analysis. The results of this test are presented in Table 3.

Table 3: Kaiser-Meyer-Olkin test indicating the degree to which the variable is predicted by the other variables

Variable	KMO
Turnover Ratio	0.2605
Market Cap. as % GDP	0.1798
Stocks Traded as % GDP	0.3227
Inflow Restriction Index	0.6554
Outflow Restriction Index	0.6905
Capital Account Openness	0.7492
Aug. Exchange Rate Class.	0.6726
Overall	0.5243

The statistic, which takes the value 0.52, indicates the analysis is an acceptable technique for these purposes (Kaiser, 1974). Results of the consecutively executed principal component analysis can be found in Table 4.

Table 4: Correlations between the first two components and the considered variables.

Variable	Capital Flow Openness	Stock Market Size	Unexplained
Turnover Ratio	-0.0236	0.5548	0.4704
Market Cap. as % GDP	0.0038	0.3899	0.7391
Stocks Traded as % GDP	0.0604	0.7243	0.0894
Inflow Restriction Index	-0.5506	-0.0321	0.1131
Outflow Restriction Index	-0.5422	0.0292	0.1401
Capital Account Openness	0.5265	-0.0995	0.1736
Aug. Exchange Rate Class.	0.3486	0.0615	0.6387

The share unexplained of the original variables is shown. In total, 66.2% of all variance is explained by these components

The Kaiser rule, which states that all components with eigenvalues larger than one should be retained, is not followed. This is due to the fact that the factor loadings of the first two components maintain intuitive interpretation, where the first component resembles capital flow openness and the second component maps stock market size. Moreover, the first two components explain 66.2% of the variance within the examined variables, which is considered sufficient by the author. The first principal component will be referred to as capital flow openness from here on. The second component is named stock market size.

At last, we have arrived at a point where statistical explorations of gold safe haven heterogeneity are possible. Using the safe haven estimates, generated variables and other explanatory variables as mentioned prior, the resulting model allows for a formal test of our hypotheses.

$$SafeHavenCoefficient_{i,t} = \alpha + \beta_1 GoldpGDP_{i,t} + \beta_2 GDPpCapita_{i,t} + \beta_3 CapitalFlowOpenness_{i,t} + \beta_4 StockMarketSize_{i,t} + \beta_5 Volatility_{i,t} + \varepsilon_{i,t} \quad (1.4)$$

The dependent variable, gold safe haven coefficients, displays a large degree of autocorrelation, as shown by the Wooldrigde test. Moreover, the residuals of this model show a correlation with the dependent variable, which indicates heteroskedasticity. The results of these tests are presented in Appendix B. Once again, Newey-West standard errors are used to overcome these concerns (Newey and West, 1987). An important note to bear in mind is that a higher coefficient indicates a weaker safe haven property. That is, negative coefficients show a negative correlation between stock and gold returns and therefore provide a place of shelter in times of falling stock markets.

Furthermore, a Durbin-Wu-Hausman test is performed in order to examine possible endogeneity. First of all, the volatility variable is regressed on all other independent variables. The errors of this model are stored and included in model 1.4. The significant coefficient indicates endogeneity. This shows omitted variable bias in the original model, where the variables of interest are correlated with the error term (Nakamura and Nakamura, 1981). By adjusting model 1.4 to a fixed effects regression, the issue of time-invariant omitted variable bias is mitigated. This country fixed effects regression controls for influences which are constant over time by differencing model 1.4 with its respective average value per variable. The appropriateness of fixed effects is ascertained by executing a Hausman test, of which the results are presented in Appendix B. The final model is formalized as:

$$SafeHavenCoefficient_{i,t} - \overline{SafeHavenCoefficient_i} = \beta_1(GoldpGDP_{i,t} - \overline{GoldpGDP_i}) + \beta_2(GDPpCapita_{i,t} - \overline{GDPpCapita_i}) + \beta_3(CapitalFlowOpenness_{i,t} - \overline{CapitalFlowOpenness_i}) + \beta_4(StockMarketSize_{i,t} - \overline{StockMarketSize_i}) + \beta_5(Volatility_{i,t} - \overline{Volatility_i}) + (\varepsilon_{i,t} - \overline{\varepsilon_i}) \quad (1.5)$$

4.3 Robustness

The presented estimation technique of Model 1.5 requires a two-step process. First of all, safe haven coefficients are generated in Model 1.2. These coefficients are consecutively explained in a fixed effects regression. This two-step method could lead to problems with statistical inference caused by biased standard errors. Including the variables of interest in Model 1.2 would lead to a more efficient estimation of the proposed effects. All yearly macro-economic variables are duplicated for all trading days of the relevant year. After including a variable of interest of equation 1.5 in the model and applying fixed effects regression, the following model can be formulated:

$$GoldReturns_{i,t} - \overline{GoldReturns_t} = \beta_{1,t}(StockReturns_{i,t} - \overline{StockReturns_t}) + \beta_{2,t} * (StockReturns_{i,t} * D_{q5,t} - \overline{StockReturns_t * D_{q5,t}}) + \beta_{i,t}(StockReturns_{i,t} * X - \overline{StockReturns_t * X}) + \beta_{j,t}(StockReturns_{i,t} * D_{q5,t} * X - \overline{StockReturns_t * D_{q5,t} * X})$$

(1.6)

Where X denotes the vector of independent variables in Model 1.5 and i and j denote their respective β's. After considering these variables seperately in the model, all variables will be introduced in Model 1.6. Because the sum of β_1 and β_2 in Model 1.2 gave the safe haven coefficients, all β_i and β_j's indicate a change in the slope of the effect of stock returns during financial turmoil on gold returns. Testing β_i for all variables of interest against zero will indicate whether the variables have a positive effect on the hedge property of gold. All β_j coefficients show a change of the slope of the connection between gold and stock returns in times of great financial distress. The sum of β_i and β_j gives the total effect on the safe haven coefficient. The correction for fixed effects is again included to mitigate all time-invariant omitted variable bias.

5 Results

After executing the methodology discussed in the prior section, the main results of this paper have become evident. These will be discussed in order to gain a deeper understanding of the connection between the stock market and the gold market. Furthermore, introduced explanatory variables will be statistically tested in hope to enhance current knowledge on the safe haven property of gold. First of all, Granger causality tests display results that vary across countries. The results, as presented in Table 15 in Appendix C indicate that stock returns do indeed granger cause gold returns in United Kingdom, Canada, Indonesia, South Africa, France and Austria. On the contrary, gold is found to granger cause stock returns in the India, Saudi-Arabia, Indonesia, Republic of Korea, Russia, Australia, France, Italy and Spain. In all other considered countries, no granger causation is found, indicating that lagged values of gold (stock) returns do not predict stock (gold) returns. Although one would expect economies with a high relative importance of gold production to have a granger causation of the gold market on the stock market, this evidence does not support that claim. Moreover, no clear trend in differences in granger causation with regard to development can be identified. There is, however, large evidence of heterogeneity being present in the relation between the stock and gold market for various countries.

In order to investigate the role of gold as a safe haven asset in various countries, quantile regressions are executed. The results indicate that gold functions as a strong hedge in the

United States, Indonesia, Thailand, Republic of Korea, South Africa and Italy. That is, the returns of gold in these countries are on average negatively correlated with the returns of stocks. Gold is found to be a weak hedge in all other countries expect for Japan. A weak hedge is uncorrelated to the stock market. When inspecting the interdependencies of gold and stocks during financial turmoil, attention is turned to correlations in times of financial distress.

When using the 10% worst trading days in every nations stock market over a period of 21 years, evidence is found of a strong safe haven only for Turkey and Republic of Korea. All other countries, except Japan and China, can be characterized as weak safe havens under this definition. When only the 5% worst trading days are taken into account, and therefore a stricter definition of financial distress is used, more countries show strong safe haven characteristics of gold. Turkey, Thailand, Republic of Korea, South Africa, the Netherlands, Portugal and Ireland seem to be strong safe havens.

When making use of only the 1% most disastrous trading days over a period of 21 years, the picture is more evident. The United Kingdom, Saudi-Arabia, Indonesia, Thailand, Republic of Korea, Germany, France, Belgium and Italy present themselves as strong gold safe havens. Investors indeed seem to purchase gold when these, mostly developed, economies experience falling stock markets. Fifteen different countries are found to be weak safe havens. Only in Japan, the stock market is positively correlated with the gold market under extreme negative market conditions. In line with results found by Baur and McDermott (2010) and Gürgün and Ünalmış (2014), strong heterogeneity in the results is found. The full results are summarized in Table 5. Denoted coefficients are sums of the relevant β's, as discussed in Section 4.

Table 5: Hedge and Safe Haven coefficients for various countries in the period 1995 - 2015.

Country	Hedge	0.10	0.05	0.01
United States	-0.2568*	0.1197	-0.1238	-0.1070
Japan	0.1048*	0.1565*	0.1389*	0.2538*
United Kingdom	-0.0057	0.0257	0.0164	-0.2898*
Canada	-0.0182	-0.1479	-0.0072	-0.3658
India	-0.2098	0.0011	0.0378	-0.0379
China	0.0165	0.2042*	0.0190	-0.0368
Turkey	-0.0287	-0.8781*	-0.6401*	-0.0085
Saudi-Arabia	-0.0047	-0.0375	-0.0479	-0.0855*
Indonesia	-0.0321*	-0.0403	-0.0386	-0.2203*
United Arab Emirates	-0.0119	0.1184	-0.0530	0.0125
Thailand	-0.024*	-0.0317	-0.0571*	-0.0838*
Republic of Korea	-0.0527*	-0.0458*	-0.0652*	-0.0857*
Russia	0.0811*	0.0340	0.0119	0.0878
South Africa	-0.0867*	0.0144	-0.1428*	-0.0793
Australia	0.0447	0.0826	0.0508	-0.0703
Germany	-0.0129	-0.0252	-0.0195	-0.4810*
France	-0.0125	-0.0399	-0.0759	-0.4293*
The Netherlands	0.0022	0.0136	-0.0598*	-0.0839
Belgium	-0.0184	-0.0819	-0.0312	-0.6119*
Italy	-0.0607*	0.0031	-0.0401	-0.2919*
Spain	-0.0024	0.0347	-0.0417	-0.1458
Portugal	-0.0238	0.0888	-0.2079*	-0.0793
Greece	-0.0365	0.0229	0.0349	-0.0245
Austria	-0.0232	-0.0089	-0.0528	-0.1186
Ireland	-0.0140	0.0060	-0.1032*	-0.1695

Asterisks denote significance at the 5% level. Negative coefficients show gold is a strong hedge/safe haven. An insignificant coefficient shows gold as a weak hedge/safe haven.

Once again, heterogeneity in gold safe haven property per country has been found. By making use of quantile regression with a 5% financial turmoil definition, heterogeneity over time can also be inspected. After storing these estimates, fitting a GARCH model for volatility and performing a principal component analysis, it is possible to test explanatory factors of this heterogeneity. The fixed effects model 1.5 allows testing our hypotheses. The results of this model are presented in the following table:

Table 6: Fixed effects least squares regression for the influence of GDP per capita, capital flow openness, stock market size, stock market volatility and gold production as share of GDP on the safe haven coefficients per country per year.

Safe Haven Coefficient	Coefficient	P-value	95% Condifence Interval	
GDPpCapita	-0.0811	0.077*	-0.0172	0.0010
CapitalFlowOpenness	-0.0327	0.449	-0.1201	0.0549
StockMarketSize	0.0033	0.882	-0.0425	0.0491
StockMarketVolatility	-2213.1	0.000***	-0.0072	-0.3658
GoldpGDP	0.13854	0.048**	0.1578	0.2755
No. of observations		445		
R^2 Within		0.0218		
R^2 Between		0.6196		

One asterisk denotes significance at the 10% confidence level, two at the 5% level and three at the 1% level.

The R^2 between, indicating the amount of variance between different countries explained by the model, is quite high with 62%. The R^2 within is much lower, indicating only 2.2% of the fluctuations of safe haven coefficients over time within the same country are explained by the model. This poses no great concerns, as the safe haven coefficients are far more volatile than the macro-economic variables can be expected to be. This research is mainly concerned with differences amongst countries. As visible in the model presented above, countries with a larger relative importance of gold production in their economy display a more positive correlation between stock and gold returns during financial distress. The safe haven effect of gold, which indicates a negative relation between stock and gold returns under extreme negative market conditions, is therefore negatively influenced by the relative importance of gold in an economy. The first hypothesis is therefore accepted, a higher relative importance of gold production has a negative effect on this country's safe haven property of gold.

Furthermore, gross domestic product per capita seems to have a negative effect on the correlation between stock and gold returns when a 10% significance level is obtained. With 92.3% certainty, one could say that a larger degree of development has a positive effect on the safe haven property of gold. The second hypothesis is accepted, a higher degree of development of a country has a positive effect on this country's safe haven property of gold.

Financial openness is operationalized with the components stock market size, which is a factor of market capitalization and market liquidity, and capital flow openness. One would expect a higher degree of capital flow openness and stock market size to lead to more integrated markets, which give rise to a higher demand for safe assets, such as gold. Nevertheless, the individual items do not generate results that significantly deviate from zero. Moreover, the two components are jointly insignificant. This leads to a rejection of the third hypothesis. A higher degree of financial openness of a country does not have a positive effect on this country's safe haven property of gold.

Additionally, the degree of uncertainty in a specific year and country has a significant influence on the safe haven coefficient. As expected, a higher degree of stock market volatility has a negative impact on the correlation between stock and gold returns. This leads to a stronger safe haven effect of gold. The fourth hypothesis is accepted, a higher degree of uncertainty in the stock market of a country has a positive effect on this country's safe haven property of gold.

5.1 Check for robustness

Aforementioned Model 1.6 can be used to investigate the found effects in a more direct fashion. Because this model uses daily stock market volatilties, results are expected to differ. Moreover, yearly macro-economic variables such as GDP per capita are duplicated for all days within the specific year. The results of including all potential explanatory variables seperately in the model and all variables combined are presented in the following table:

Table 7: Results of estimating model 1.6 for all variables of interest seperately and combined.

	GoldReturns					
	GDP	Cap.F.O.	S.M.S.	Vol.	GoldpGDP	All
$StockRet.$	-0.047	-0.042*	-0.054*	-0.036*	-0.075*	-0.039
$StockRet. * D_{q5}$	-0.023	-0.023	-0.0277	-0.078*	-0.025	-0.037
$StockRet. * GDPpCapita$	-0.000					-0.002
$StockRet. * D_{q5} * GDPpCapita$	-0.000					-0.000
$StockRet. * CapitalFlowOpenness$		0.032*				0.052*
$StockRet. * D_{q5} * CapitalFlowOpenness$		0.015				0.014
$StockRet. * StockMarketSize$			0.000			-0.000
$StockRet. * D_{q5} * StockMarketSize$			0.000			0.000
$StockRet. * StockMarketVolatility$				137.14*		74.383
$StockRet. * D_{q5} * StockMarketVolatility$				22.298		58.256
$StockRet. * GoldpGDP$					0.251*	0.276*
$StockRet. * D_{q5} * GoldpGDP$					-0.043	-0.055
No. of observations	119.766	119.766	119.766	119.766	119.766	119.766
R^2 Between	0.0060	0.0068	0.0060	0.0071	0.0066	0.0089

Asterisks indicate significance at the 5% level.

An interesting first insight is the fact that all models considered in Table 7 indicate the existence of an aggregated safe haven property in the considered countries. When only the gross domestic product per capita is included, this variable is not found to have a significant influence on the difference in effect for the worst trading days of the past 21 years. This indicates that countries with a higher gross domestic product per capita do not have stronger safe haven properties, contrary to results presented earlier. The sign of the effect is nonetheless equal to the expected sign. The same effect is found in the complete model. A larger degree of capital flow openness has a positive effect on the correlation between stock and gold returns. This could be related to the functionings of the currency markets in these countries. Moreover, stock market size seems not to have a statistical significant influence on the safe haven coefficients. These results are in line with the conclusion drawn earlier, financial openness does not have a positive effect on the safe haven property of gold. Higher stock market volatility creates a weaker hedge property of gold when considered seperately. This result nevertheless ceases to exist once the complete model is specified. The statistical insignificant result is not in line with the result presented earlier. The explanatory variable gold per million of GDP shows a statistically significant positive effect. A larger relative importance of gold production in an economy does indeed create a stronger positive correlation between gold and stock returns. This creates a higher safe haven coefficient and therefore a weaker gold safe haven property. In line with the result presented earlier, a larger importance of gold creates a weaker safe haven property.

6 Discussion and Conclusion

In this research, the safe haven property of gold has been inspected for a unique set of countries, consisting of gold producers, developed countries and developing countries. Granger causality tests and hedge analysis performed in this research show a large variety in the relationship between gold and stock returns in general. The same heterogeneity is present in times of falling stock markets, which give rise to distress amongst investors. In line with relevant literature, no unambiguous answer to the question of gold as a safe haven for the domestic stock market can be given. Often, one needs to relax the assumption of a negative correlation for assets to form a safe haven, to find convincing evidence. These uncorrelated assets, which form weak safe havens, are nonetheless less suitable as diversifiers.

The variety in correlations between the returns of stocks and gold in times of financial turmoil sparks this papers interest in exploring explanatory variables. Over a period of 21 years and considering a set of 25 countries, the level op development of a country seems to enhance the safe haven effect. The reasoning behind this connection would be that the amount of distress caused by falling stock markets of developed countries is much larger than the financial hardship caused by negative market conditions in developing countries. Financial turmoil in developing countries would most likely shift an investor's portfolio to stocks or bonds in more developed economies. Evidence of this fact is found in the discussed model. Robustness of this result is, however, not shown. Moreover, countries that are large producers of gold would be expected to have a relatively strong dependency of the stock market on the price of gold. The integration between these markets would lead to a more positive correlation between these assets. By operationalizing gold production relative to the size of a country's gross domestic product, a unique way of quantifying this factor is introduced. The relative importance of gold production in an economy indeed positively influences the correlation between stock and gold returns in times of financial hardship. Therefore, economies that are heavily reliant on gold production tend to have a weaker safe haven effect of gold in the domestic stock market. This result is confirmed by the test for robustness.

Capital flow mobility and stock market size, the components capturing financial openness, were expected to have an enhancing effect on the safe haven property of gold. The sheer possibility to transfer funds out of the stock market and into the gold market was voiced as a possible factor that could pave the way for the safe haven effect. Moreover, liquid and developed capital markets were expected to have a stronger integration with international stock markets. Negative shocks in the stock markets would therefore lead to greater global uncertainty. No evidence of these reasonings is found in this paper. A possible explanation for this could be that countries with a lower financial openness are more likely to have instable currencies. Although their domestic economy might not be large enough to have a significant influence on the world gold price, a heavy depreciation of their currency in these times of financial distress could still increase gold returns from the perspective of a domestic investor.

A last considered explanatory factor of the safe haven property is stock market volatility. In countries with large uncertainty and ambiguous signals, investors will desire a quite certain asset. The specific characteristics of gold provide this certainty. Therefore, one would expect volatile markets to experience stronger safe haven effects. Strong statistical evidence of this connection is found in the presented model. Volatile markets do indeed seem to give rise to a search for a place of shelter for investor capital. No further proof of this result is found in the check for robustness.

All in all, multiple explanatory variables have been presented and tested for statistical significance. Three variables have been pointed out to have significant influence on the safe haven effect. These can function as a start for further research into the gold safe haven effect or investor behaviour in times of financial distress in general. Due to differences in the results prestented by the check for robustness, a methodological discussion needs to be had. Identifying the conditions necessary to have gold function as a hedge in times of negative market circumstances could prove to be very useful in portfolio analysis. Moreover, grasping a deeper understanding of investor behaviour in these specific situations would help in macro-economic policy making.

6.1 Limitations

An important limitation of this research is the operationalization of the safe haven coefficients. In order to make use of fixed effects to mitigate time-invariant omitted variable bias and to assess changes over time, yearly coefficients per country are stored. When estimating these coefficients per year, a difficult trade-off arises. First of all, one would like to have a sufficient amount of observations per calculated coefficient in order to ensure reliable estimates, independent of outliers. The nature of these coefficients is however that they attempt to capture effects specific to extreme market conditions. Qualifying ten percent of all trading days during one year as acute financial hardship would misrepresent extreme conditions. Keeping only one percent of all trading days would lead to statistical conclusions based on three or less observations. With the five percent most distressful trading days per year as a rule of thumb, an attempt to minimalize this complication is made.

Another limitation of this research is the fact that explanatory variables are tested in quite an ad-hoc fashion. If one aims to find stronger evidence of causation of the explanatory variables introduced in this paper, a model specific to this factor should be estimated. This model would entail variable of interest specific control variables. Moreover, the variable of interest should meet the conditional independence criterium. Because this paper serves as a quest for explanatory variables within this new field of research, a best practices approach with country specific fixed effects is taken. This approach controls for time-invariant omitted variable bias. A critical attitude could nonetheless still be taken against time-variant omitted variable bias.

6.2 Recommendations

Although this paper formally considers the possible explanations mentioned in the most prominent literature in this field of study, not much thought by other researchers has gone into explanatory factors of golds safe haven heterogeneity. This research aims to spark further exploration of determinants of the safe haven effect of gold. Points of departure for this inquiry could be the exchange rate of a country. Due to the fact that not all countries will be of large enough economic size to significantly influence the world gold price, which is quoted in dollars, changes in the exchange rate of a currency could be crucial to the gold safe haven effect. Instability of a currency relative to the dollar would therefore be an important factor. Moreover, the exchange rate system could be of the utmost importance. Fixed exchange rates could mitigate the gold safe haven effect. These were also integrated in the considered financial openness variable but should receive further attention. Furthermore, this paper and prior research show heterogeneity in the function of gold as either a hedge or safe haven. As long as no conclusive answer can be given to the question of explanatory factors of safe haven heterogeneity, portfolio analysis should distinguish between stock markets when determining whether gold is a suitable diversifier. Gold could prove to be a very strong hedge against the stock market in a certain country, while possibly being useless to these purposes if a portfolio consists of stocks from a different country. All in all, the quest for financial safety must continue.

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Appendix A

In Appendix A, relevant information about the data used in this research is provided. First of all, the set of considered stock market indices for all countries are provided. Secondly, descriptive statistics of all considered variables are shown.

Table 8: Considered stock market indices per country.

Country	Stock Market Index
Australia	All Ordinaries
Austria	Austrian Traded Index (ATX)
Belgium	BEL 20 Index
Canada	S&P/TSX Composite Index
China	Shanghai Stock Exchange Composite Index
France	Cotation Assistée en Continu (CAC40)
Germany	Deutscher Aktienindex (DAX)
Greece	ATHEX Composite Price Index
India	Bombay Stock Exchange Sensitive Index
Indonesia	Jakarta Stock Exchange Composite Index (JCI)
Ireland	Irish Stock Exchange Overall Index
Italy	FTSI Milano Indice di Borsa (FTSI MIB)
Japan	Nihon Keizai Shimbun (Nikkei) 225
Netherlands	Amsterdam Exchange Index (AEX)
Portugal	Portuguese Stock Index 20 (PSI-20)
Republic of Korea	Korea Stock Price Index (KOSPI)
Russia	MOEX Russia Index
Saudi-Arabia	Tadawul All Share Index (TASI)
South Africa	FTSE/JSE All Share Index
Spain	Índice Bursátil Español 35 (IBEX 35)
Thailand	Stock Exchange of Thailand Index (SET)
Turkey	Borsa İstanbul 100 (BİST 100)
United Arab Emirates	Abu Dhabi Securities Market General Index
United Kingdom	Financial Times Stock Exchange Index (FTSE 100)
United States	Dow Jones Industrial Average

Table 9: Considered variables with source and descriptive statistics.

Variable	Source	Mean	Min	Max	SD
Gold Prices	World Gold Council		Various		
Stock Prices	Bloomberg		Various		
Safe Haven Coefficient	Computed	-0.0177	-4.3001	3.5360	0.6763
Stock Market Volatility	Computed	0.0001	1.98E-06	0.0034	0.0002
Gold per Dollar GDP	N.M.I.C.	0.077	0	2.251	0.251
GDP per Capita	Worldbank	24.209	3.701	67.709	16.693
Outflow Restriction Index	Fernandez et al. (2016)	0.3173	0	1	0.3470
Inflow Restriction Index	Fernandez et al. (2016)	0.2803	0	1	0.3148
Aug. Exchange Rate Class.	Ilzetzki et al. (2017)	11.378	2	16	4.5110
Capital Account Openness	Chinn and Ito (2008)	1.3419	-1.9036	2.3744	1.3938
Capital Flow Openness	Computed	9.63E-11	-1.7992	4.3610	1.7089
Turnover Ratio	Worldbank	87.790	5.2381	694.43	72.065
Market Cap. as % GDP	Worldbank	71.910	1.191	276.95	47.000
Stocks Traded as % GDP	Worldbank	59.244	2.4538	372.260	56.549
Stock Market Size	Computed	3.52E-10	-1.8901	7.1265	1.3097

Appendix B

In Appendix B, formal tests for stationarity, autocorrelation and heteroskedasticity are summarized. The United States is used as an example, but other time series display similar results.

Dickey-Fuller test for unit root

H_0: *Dow Jones stock market returns display unit root*

H_A: *Dow Jones stock market returns display no unit root*

Number of observations: 5398

Table 10: Test of the Dow Jones stock market returns for stationarity.

	Statistic	1% Critical Value	MacKinnon P-value
Z(t)	**-80.781**	-3.960	0.0000

OLS Regression for heteroskedasticity

Table 11: OLS Regression of the US dollar gold price on the residuals of Model 1.1

USDollarGoldPrice	Coefficient	P-value
Residuals	**1.00**	0.000

Wooldridge test for autocorrelation in panel data

H_0: *No first order autocorrelation*

H_A: *First order autocorrelation*

Table 12: Wooldridge test for first order autocorrelation in safe haven coefficients

Safe Haven Coefficients	Statistic	P-value
F-statistic	11.695	0.0022

OLS Regression for heteroskedasticity

Table 13: OLS regression of the gold safe haven coefficients on the residuals of Model 1.4

Safe Haven Coefficients	Coefficient	P-value
Residuals	**1.00**	0.000

Hausman test

Table 14: Hausman test for fixed or random effects in panel data for Model 1.5.

X^2	P-value
18.451	0.0024

Significant estimate shows fixed effects is the appropiate option.

Appendix C

Table 15: Granger causality test results.

Variable	Caused by	χ^2	P-value
USDollarGoldReturn	USDollarStockReturn	1.4257	0.232
USDollarStockReturn	USDollarGoldReturn	0.9805	0.322
JapaneseYenGoldReturn	JapaneseYenStockReturn	1.0438	0.307
JapaneseYenStockReturn	JapanseYenGoldReturn	3.7643	0.052
UKPoundSterlingGoldReturn	UKPoundSterlingStockReturn	4.4696	0.035*
UKPoundSterlingStockReturn	UKPoundSterlingGoldReturn	1.0530	0.305
CanadianDollarGoldReturn	CanadianDollarStockReturn	5.3954	0.020*
CanadianDollarStockReturn	CanadianDollarGoldReturn	1.5975	0.206
IndianRupeeGoldReturn	IndianRupeeStockReturn	1.8857	0.390
IndianRupeeStockReturn	IndianRupeeGoldReturn	8.2021	0.017*
ChineseRembiniGoldReturn	ChineseRembiniStockReturn	2.1282	0.345
ChineseRembiniStockReturn	ChineseRembiniGoldReturn	0.4274	0.808
TurkishLiraGoldReturn	TurkishLiraStockReturn	6.5686	0.161
TurkishLiraStockReturn	TurkishLiraGoldReturn	5.6743	0.225
SaudiRiyalGoldReturn	SaudiRiyalStockReturn	1.0678	0.301
SaudiRiyalStockReturn	SaudiRiyalGoldReturn	6.2025	0.013*
IndonesianRupiahGoldReturn	IndonesianRupiahStockReturn	24.309	0.000*
IndonesianRupiahStockReturn	IndonesianRupiahGoldReturn	29.065	0.000*
UAEDirhamGoldReturn	UAEDirhamStockReturn	2.0430	0.153
UAEDirhamStockReturn	UAEDirhamGoldReturn	0.2823	0.595
ThaiBahtGoldReturn	ThaiBahtStockReturn	4.0162	0.260
ThaiBahtStockReturn	ThaiBahtGoldReturn	1.4668	0.690
KoreanWonGoldReturn	KoreanWonStockReturn	8.3554	0.079
KoreanWonStockReturn	KoreanWonGoldReturn	16.719	0.002*
RussianRubleGoldReturn	RussianRubleStockReturn	8.8403	0.065
RussianRubleStockReturn	RussianRubleGoldReturn	103.02	0.000*
SouthAfricanRandGoldReturn	SouthAfricanRandStockReturn	7.8925	0.048*
SouthAfricanRandStockReturn	SouthAfricanRandGoldReturn	2.4121	0.491
AustralianDollarGoldReturn	AustralianDollarStockReturn	0.2875	0.595
AustralianDollarStockReturn	AustralianDollarGoldReturn	5.3394	0.021*
EurGoldReturn	GermanyStockReturn	4.0004	0.261
GermanyStockReturn	EuroGoldReturn	2.0259	0.567
EuroGoldReturn	FranceStockReturn	9.7199	0.008*
FranceStockReturn	EuroGoldReturn	7.3070	0.026*
EuroGoldReturn	NetherlandsStockReturn	6.4766	0.091
NetherlandsStockReturn	EuroGoldReturn	5.6957	0.127
EuroGoldReturn	BelgiumStockReturn	5.2047	0.157
BelgiumStockReturn	EuroGoldReturn	6.4505	0.092
EuroGoldReturn	ItalyStockReturn	2.6035	0.107
ItalyStockReturn	EuroGoldReturn	12.131	0.000*
EuroGoldReturn	SpainStockReturn	5.7330	0.125
SpainStockReturn	EuroGoldReturn	8.9938	0.029*
EuroGoldReturn	PortugalStockReturn	3.5002	0.061
PortugalStockReturn	EuroGoldReturn	2.1215	0.145
EuroGoldReturn	GreeceStockReturn	2.5575	0.276
GreeceStockReturn	EuroGoldReturn	2.6749	0.263
EuroGoldReturn	AustriaStockReturn	7.1259	0.028*
AustriaStockReturn	EuroGoldReturn	1.9698	0.373
EuroGoldReturn	IrishStockReturn	0.1174	0.943
IrishStockReturn	EuroGoldReturn	5.5147	0.063

An asterisk denotes significance at the 5% significance level.