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Impact of Dynamic Asset Allocation in Safe Haven Portfolios:
Performance Analysis During Financial Crises and Beyond

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Abstract

The purpose of this thesis was to review and extend the current knowledge on safe haven portfolios. Three objectives were pursued, the first was to incorporate current trends in safe haven assets, the second dealt with the dating of crises periods and the abilities of an investor to predict and time the buying and selling of safe haven assets, the third objective was to dynamize the allocation of assets within the safe haven portfolio based on the characteristics of a given crisis. The conclusions include several findings, one is that the demand for individual safe haven assets does not only vary throughout time but also reflects economic realities. Another is that the addition of further, less popular, assets has proved to be beneficial even in the context of safe haven portfolios. Next the timing methods were compared, a descriptive ex-post timing outclassed even a very optimistic forecasting model based on the Gebert indicator, leading to the conclusion that the use of such descriptive methods makes sense only under very strong assumption, which usually cannot be fulfilled in reality. Another noticeable difference was that the portfolios with comparably worse timing generally made use of more assets with more balanced weights. Lastly a dynamized asset allocation has also led to better performance, which highlights that even safe haven assets perform differently based on the economic situation and mainly the policies and steps taken by regulators, central banks, or governments. Together the results of this thesis hint that although a moderate amount of protection against market downfall can be achieved by following generalized solutions an investor could largely benefit from obtaining more information on the current economic realities and current trends.

Abstract (in German)

Ziel dieser Arbeit war die Überprüfung und Erweiterung des aktuellen Wissensstandes über Safe-Haven-Portfolios. Es wurden drei Ziele verfolgt: das erste war die Berücksichtigung aktueller Trends in Safe-Havens, beim zweiten ging es um die Datierung von Krisenperioden und die Fähigkeit eines Investors, diese zu prognostizieren, um den Kauf und Verkauf von Safe-Havens rechtzeitig zu bestimmen, das dritte Ziel war die Dynamisierung der Portfolios von Safe-Havens in Abhängigkeit von den Merkmalen einer bestimmten Krise. Die Schlussfolgerungen umfassen mehrere Erkenntnisse: Eine davon ist, dass die Nachfrage nach einzelnen Safe-Havens nicht nur im Laufe der Zeit schwankt, sondern auch die wirtschaftlichen Verhältnisse widerspiegelt. Eine andere ist, dass sich die Aufnahme weiterer, weniger beliebter Vermögenswerte auch im Rahmen von Safe-Haven-Portfolios als vorteilhaft erwiesen hat. Als nächstes wurden die Timing-Methoden verglichen, wobei ein deskriptives Ex-post-Timing ein sogar sehr optimistisches Prognosemodell auf der Grundlage des Gebert-Indikators weit übertraf, was zu der Schlussfolgerung führt, dass die Verwendung solcher deskriptiven Methoden nur unter sehr starken Annahmen sinnvoll ist, die in der Realität meist nicht erfüllt werden können. Ein weiterer bemerkenswerter Unterschied war, dass die Portfolios mit vergleichsweise schlechterem Timing im Allgemeinen mehrere Anlagevermögen mit ausgewogenerer Gewichtung enthielten. Schließlich führte auch eine dynamisierte Vermögensallokation zu einer besseren Leistung, was hervorhebt, dass selbst Safe-Havens je nach Wirtschaftslage und vor allem je nach den von Regulierungsbehörden, Zentralbanken oder Regierungen unternommenen Politiken und Maßnahmen unterschiedlich leistungsfähig sind. Insgesamt deuten die Ergebnisse dieser Arbeit darauf hin, dass ein Investor, auch durch Befolgung allgemeiner Lösungen, einen moderaten Schutz gegen Marktrückgänge erreichen kann, allerdings in hohem Maße davon profitieren könnte, wenn er mehr Informationen über die aktuellen wirtschaftlichen Bedingungen und Trends erlangen würde.

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1. Introduction

Humans have an innate aversion to losses and a primal instinct to safeguard wealth. This psychological underpinning propels investors to explore avenues that offer protection and stability, particularly in times of economic uncertainty and market volatility (Kahneman & Tversky, 1979; Shefrin & Statman, 1985; Barberis et al., 2001). Thus, it is perhaps in line with our innate human nature turn to safe haven assets, which are negatively correlated (uncorrelated) with other assets or portfolios in their strong (weak) form, but in certain periods only, e.g. in times of financial crisis (otherwise this would be a hedge) (Baur & McDermott, 2010). Investors tend to seek out safe haven en masse to protect themselves from financial losses in times of market turmoil (Habib & Stracca, 2015) as their preferences change towards those assets that carry less risk, but are of higher liquidity, this behaviour is referred to as “flights to quality” and “flights to liquidity” (Beber et al., 2009), for example US Treasury Bonds can serve to both preferences.

But these must not just be fixed-income assets. Gold, even though riskier when compared to fixed-income assets, and in its physical form less liquid than for example short term US Treasury bonds, is still widely considered to be a safe haven asset (Baur & McDermott, 2016). Thus, safe haven assets can be volatile and still be of high quality, but they shall not carry systematic risk (McCown & Zimmerman, 2006), this would be measured as the CAPM's beta of 0 (Sharpe, 1964; Lintner, 1965).

Similarly, to gold, currencies are also unproductive, a return is only achieved through change in market value, but they are the most liquid asset (Ciner, et al., 2013). Liquidity, the second and more sought-after property (Beber et al., 2009) provides flexibility, as a safety cushion usable for unexpected spending. On the contrary if one was to hold illiquid assets and forced to sell them, this could result in high transaction costs, and thus unfavourable selling prices (even more so in times of financial crises). Therefore, the possibility of sudden spending needs motivates investors to hold highly liquid assets (Rösch & Kaserer, 2014).

As already visible from the elaboration above the presented safe haven assets, bonds, gold, currencies have many similarities, but also notable differences. In fact, their developments

can be different over time, and therefore it was beneficial to create safe haven portfolios, which diversified risk and increased the reliability of safe haven returns during crisis (Wendlberger, 2019).

In his thesis Wendlberger suggested potential extensions of the presented analysis, amongst them an analysis of recent trends that could result in the introduction of further/new assets or disinvestment from old ones. Since some time has already passed and we have faced the consequences of the COVID 19 pandemic, which affected many economies, worsened their conditions and may have been the trigger of severe recession or even depression (Li et al., 2022), a discussion about safe haven assets emerged in papers such as the ones from Ji et al., 2020; Akhtaruzzaman et al., 2021; Disli et al., 2021 and Hasan et al., 2021. This development naturally creates the space for our first research question:

How did the exposure to the economic consequences of the COVID 19 pandemic change the trends in safe haven assets?

Another potential extension is a more sophisticated portfolio analysis, which shall include varying portfolio weights that depend on the characteristics of the crisis (timeframe, severity). Connected to this, one thing that has not been mentioned but might be worth exploring is the timing of buying (and maybe even selling) of individual asset, or the whole portfolio. Wendlberger (2019) compiled three portfolios, but even the one that can be considered as the most realistic is bought precisely at the start of a crisis and sold at the exact end. It could be argued that this is a quite naïve assumption and seems to result in quite high returns. For example, if a cautious investor thinks about changing the structure of his portfolio due to the potential losses he could face during a crisis, he would probably rather buy the safe haven assets sooner than later (before the crisis). Thus, we can formulate two further research questions:

How does the performance of safe haven portfolios vary when considering dynamic asset allocation based on the type and development of a financial crises?

and

What is the impact of realistic timing expectations of the initial investment on composition and performance of safe haven portfolios?

2. Literature Review

2.1 Excuse into Crises

As already mentioned above safe haven assets are particularly interesting at times of crises, when they showcase their differences against the rest of the asset pool. Thus, if one wants to understand safe haven assets, he must be familiar with the concepts of crises.

Financial crises are multidimensional events that can be hardly characterized by a single indicator, they share commonalities but come in various forms. Usually, they are accompanied with significant changes in asset prices and credit volume, severe disruptions in financial intermediation and supply of external financing, large-scale balance sheet problems and large-scale government support (Claessens & Kose, 2014).

Although crises are already a well-known phenomenon, they manage to keep an element of surprise and unpredictability since the relationship between the different crisis types and thus also their nature and origins change dramatically over time.

2.1.1 Causes and Explanation of Financial Crises

Although some of the driving factors such as macroeconomic imbalances, internal or external shocks of crises have been agreed upon in literature definite identification of the exact deeper causes has not been achieved. It is perhaps so since financial crises can also stem from “irrational” factors as sudden banks runs, emergence of asset busts, credit crunches, and fire sales, limits to arbitrage, spillovers and contagion in between financial markets (Claessens & Kose, 2014). This idea of “irrational” factors sometimes also called “animal spirits”, behind the cause of crises was indeed thoroughly discussed in significant literature contributions (Keynes, 1930; Minsky, 1975; Kindleberger, 1976).

Often a similar sequence of events surrounds financial crises, first there usually comes an asset and credit boom that eventually turn into busts. Sharp increases in asset prices are sometimes also called bubbles, these are parts of asset price movement, which are not explainable based on what we call fundamentals (Garber, 2000). Bubbles are often followed by crashes. Some of these are widely recognized, for instance the Dutch Tulip Mania 1634–37, the

French Mississippi Bubble 1719–20, and the South Sea Bubble in the United Kingdom 1720 (Kindleberger, 1986; Garber, 2000). These episodes are characterized by rapid and substantial increases in certain asset prices over a short period, often followed by abrupt corrections.

Such busts can be set off by minor shocks, whether in fundamental values or market sentiment. Information asymmetries can magnify the impact of minor disturbances into market freezes, initiating adverse feedback loops, characterized by rapid declines and downward spiral effects in asset prices (Claessens & Kose, 2014). For example, a fire sale can be started by a drop in prices as decline in asset values of financial institutions can lead to problems with attracting of short-term financing. These abrupt halts can result in the mentioned spiral effect of compelled sales and asset liquidations, resulting in additional price declines (Claessens & Kose, 2014).

Flight to quality, for example the preferences of investors to hold certain debt claims, can further intensify financial turmoil (Gorton, 2008).

In normal conditions, debt claims are considered "low information intensive" since the risk of default is remote. However, during financial turmoil when risks escalate, these claims become "high information intensive." Investors evaluate default risks, emphasizing safety, as a result they gravitate towards high-quality assets, such as government bonds, and steer clear of lower-quality debt claims, this shift in preference contributes to the drops in prices of the latter types of debt claims (Gorton and Ordonez, 2012). Another phenomenon that characteristically precedes crises is a rapid increase in credit, a build-up of leverage, increased risk-taking and rising asset prices. This pattern of significant credit growth is then followed by a bust in the credit markets and sharp corrections in asset prices (Claessens & Kose, 2014).

2.1.2 Types of Financial Crises

Financial crises come in diverse shapes and forms, the formal definitions are heavily shaped by the theories attempting to explain them. Historically crises have been divided into banking crises, debt (or also fiscal) crises, currency crises and sudden stop (or capital account or balance of payments) crises but also their combinations (Bordo & Meissner, 2006; Reinhart & Rogoff, 2009; Claessens & Kose, 2014).

Currency Crises

This type of crises occurs when a currency faces a speculative attack, leading to either devaluation, sharp depreciation, or response from authorities that involves significant use of international reserves, or substantial increases in interest rates, or capital controls (Claessens & Kose, 2014). Here three slightly different crisis phenomena were described by three generations of models.

The first generation of models describe a sudden speculative attack on a fixed or pegged currency when rational investors foresee a government's excessive deficits financed with central bank credit (Krugman, 1979; Flood & Garber, 1984). These authors describe how the investors want to achieve a collapse of the chosen currency by holding the currency for as long as they consider the exchange rate regime to remain stable, but once they expect the end of the end of the peg they divest in a fast and in large amounts, which should trigger a run that depletes the central bank's foreign currency reserves or liquid assets and cause the collapse.

The second-generation models show the role of multiple equilibria that can lead to currency crises once uncertainties about a government's commitment to its exchange rate peg arise (Obstfeld, 1986). Here self-fulfilling prophecies are introduced, and investors attack the currency simply because they expect other investors to do the same (Eichengreen, Rose, & Wyplosz, 1995; Flood & Marion, 1997).

Third-generation models investigate how currency crises can be initiated by rapid balance sheet deterioration connected with the fluctuations in asset prices, including exchange rates. These models reveal that even economies with seemingly small macroeconomic imbalances (before the currency crisis) can have substantial vulnerabilities in the financial and corporate sectors leading to balance sheet mismatches and thus the crises itself (Claessens & Kose, 2014). For instance, large foreign currency-denominated debts held by local banks can contribute to not only currency, but also banking crises (Chang & Velasco, 2000). Currency crises can also be caused by vulnerabilities created by the willingness of government to bail out failing banks, banks are willing to overborrow because of the availability of these government subsidies a weak point in the system (McKinnon & Pill, 1996; Krugman, 1999; Corsetti, Pesenti, & Roubini, 1998).

But it could also be argued that self-fulfilling panics can affect financial intermediaries and prompt asset liquidation, thus confirming the panic and leading to a currency crisis (Radelet & Sachs, 1998).

Sudden Stop Crises

Sudden stops result from disruptions in the supply of external financing. These are either explained by international factors (international interest rates or spreads on risky assets) (Calvo, Izquierdo, & Mejía, 2004). Or frictions (in cases when companies must take out loans to pay for inputs such as wages, materials, or foreign inputs), here the rising external financing premiums together with a decline in credit reduce aggregate demand and causes a decline in output, alternatively, due to collateral constraints in lending a debt-deflation spiral can be triggered (Calvo & Reinhart, 2000). This may cause reductions in credit, prices, and the quantity of collateral assets, also leading to an output decline. Financial distress and bankruptcies create negative externalities, cautious banks reduce new lending, causing a further credit decline which further contributes to a potential recession (Calvo, 2000).

Even small shocks (to the world interest rate, productivity, or imported input prices) can lead sudden stops when amplification mechanisms magnify their impact (Fisher, 1933; Mendoza, 2010; Korinek, 2011).

Debt Crises

A situation when a country is not able or willing to pay off its foreign debt obligations is referred to as a foreign debt crisis. In the absence of a proper enforcement mechanism, either intertemporal or intratemporal sanctions are employed to coerce the borrowing country to pay off its debt (Eaton & Gersovitz, 1981). However, all aspects of defaults on foreign debt are still not fully explained in current academic literature (Panizza, Sturzenegger, & Zettelmeyer, 2009).

A domestic debt crisis occurs when a country cannot repay domestic fiscal obligations, this can either be an explicit default, or be tackled by inflating or otherwise debasing currency, or other forms of financial repression (Reinhart, Kirkegaard, & Sbrancia, 2011). Following inflation or debasement, it often takes a considerable amount of time to restore public confidence, which

significantly raises the fiscal costs of stabilizing inflation, resulting in adverse economic consequences, including currency crashes (Reinhart & Rogoff, 2009).

Distinguishing deeper causes from the proximate ones is challenging. The causes are often tied to financial integration, political economy, and institutional environments. Debt crises frequently encompass sudden stops, currency crises, or banking crises (or a combination), complicating the identification of the primary cause (Claessens & Kose, 2014).

Banking Crises

Historically (before deposit insurance, or interventions of monetary authorities, or lender of last resort) banking crises were results of events such as 1. panic attempts to convert deposits into currency by the public at large or 2. a stock market crash leading to fear of unavailability of loans at any price.

This has sometimes resulted in consequences on real economy through reduction of money supply (Friedman & Schwartz, 1963) and/or deterioration of financial intermediation (Bernanke, 1983). In fear of illiquidity banks resorted to desperate actions such as fire sales impacting asset markets, or refusal of upholding institutional arrangements (interruption of bank lending) leading to a systemic collapse (Mitchener & Richardson, 2014).

Amongst many others Schularick & Taylor (2012) and Brunnermeier & Oehmke (2013) presented the view that bank credit-driven asset price booms proceed systemic banking crises. But the crises could also start in companies like shadow banks or other ones outside of the traditional banking sector, a failure in one of these can also cause a significant shock that develops into a banking panic (Rockoff, 2014).

Financial crises can have international or even global dimensions, five global financial crises were identified: 1890-91, 1914, 1929-30, 1980-81, and 2007-08, here cross-border claims and struggling banks or counterparties triggered liquidity and insolvency problems across borders in multiple countries (Bordo & Landon-Lane, 2012). Related to this interest rate shocks for example from Bank of England in 1890 and the Federal Reserve in 1929 and in 1980–81, or other financial centers can (in-)directly start or magnify financial stress abroad, especially in emerging countries (Kaminsky & Vega-García, 2016).

Banking panics were severely spread in advanced countries during the 19th century before monetary authorities adopted the role of lenders of last resort (Schwartz, 1987). Further, the introduction of deposit insurance and other government guarantees marked a shift in the nature of banking crises, transitioning from panics to crises predominantly resolved through fiscal rescues, establishing a direct link between the banking system and the public sector balance sheet (Bordo & Meissner, 2016). As these authors state this did not only create the potential for substantial fiscal imbalances and even defaults, but also introduced the risk of moral hazard (banks might enlarge their balance sheets and take on more risk, anticipating bailouts), which can increase the strain on government finances even further.

This marks a substantial paradigm shift as deficits financed with an expansion in the monetary base and/or fiscal policies, increase likelihood of inflation, currency crises, or sovereign default. This is different from the situation before 1930s, back then the risky nature of borrowing led to sovereign defaults regularly and unavoidably, as the lent funds were often used to build infrastructure, fund wars, or cover revenue gaps, which led to a maturity mismatch as it had no immediate growth effects or revenue payoffs (Claessens & Kose, 2014). Sovereign defaults frequently occurred due to sudden stops in capital flows for this reason (Bordo, 2006).

2.1.3 Identification and dating of crises

When it comes to crises identification and dating classification uncertainty still remains to be a key issue. As crises definitions differ amongst leading authors, discrepancies also arise in the causes, timing and ultimately impact of crises (Bordo & Meissner, 2016).

Currency crises are relatively easy to identify as they involve large changes in exchange rates, and related inflation crises (Claessens & Kose, 2014). The identification can be done using specific threshold values. Reinhart and Rogoff (2009) set a threshold of over 15% annual depreciation for currency crises and 20% for inflation crises. Frankel & Rose (1996) define a currency crisis as a cumulative 25% depreciation over 12 months, with a 10-percentage-point greater decline than the preceding 12 months. A measurement challenge emerges when there is no substantial currency adjustment despite pressures or attacks. Monetary policy can mitigate exchange rate pressures, therefore Eichengreen, Rose, & Wyplosz (1995) started using not only

actual exchange rate changes, but also interest rates and changes in international reserves to document periods of crises.

Objective classification is also possible with sudden stops. Calvo, Izquierdo, & Mejía (2004) define sudden stops as instances where output collapses and significant reversals in capital flows occur concurrently. In their later work this is refined, now a decline in annual changes in capital flows must exceed two standard deviations at any time and the starting and ending points must be at least one standard deviation below the capital flows relative to their mean (Calvo, Izquierdo, & Mejía, 2008). Various cutoff benchmarks are implemented in different studies, sometimes these include requirements on output declines, but generally the resulting periods are quite (Claessens & Kose, 2014).

External sovereign debt crises must contain the default on payments and therefore the identification of the starting dates is generally straightforward. Usually, information from international financial institutions such as rating agencies can be used, for instance the change of classification of the incriminated and related debt vehicles can be utilized for dating of periods of crises (Bordo & Meissner, 2016), but also other information can be used, for example sovereign bond spreads can indicate the likelihood of default (Edwards, 1984). Determining the end is more challenging. Sometimes a specific credit rating is needed, other studies date it based on when countries once again manage access to private financial markets (IMF, 2005; 2011).

Identifying domestic debt crises poses more challenges. With low availability of data on domestic public and surfacing of unrecorded debt obligations being the main issues (Bordo & Meissner, 2016). Despite these challenges, Abbas et al. (2011) have constructed historical series on domestic debt. Reinhart & Rogoff (2009) have also done so whilst even including considerations on differences in outright direct defaults, periods of hyper or high inflation, punitive taxation of interest payments, forced interest rate adjustments, or principal adjustments or conversions, gold clause abrogation, debasing of currency, and forms of financial repression.

Banking crises can pose a bigger challenge. Qualitative approaches have to be employed, using combinations of events such as runs on several banks, mergers, forced closures, government takeovers of multiple financial institutions, or the extension of government

assistance to one or more financial institutions are usually considered, the fiscal cost of resolving these can be used as another metric (Bordo & Meissner, 2016). Identifying the end of a banking crisis is also problematic, partly because its effects can persist for long periods of time. Again, Reinhart & Rogoff (2009) serve as an example, the start is marked by a closure, merger, or takeover, or substantial public assistance to a significant financial institution (or more of them) be it after a bank run or not. Acknowledged drawbacks of this approach include the absence of precise end dates, and possible late or early start dates.

Common features in many crises (asset price and credit booms, busts, and crunches) can also be used for classification. For instance, the classical business cycle approach is used by Claessens, Kose, & Terrones (2012), they identify peaks and dips in the levels of real asset prices and categorize them as booms, busts, or crunches if they are in the top and bottom quartiles. Mendoza & Terrones, 2008 use large deviations from trend in real credit growth and the credit-to-GDP ratio to classify credit booms. Another approach is used by Gourinchas, Valdes, & Landerretche (2001), who set a limit on the number of episodes to classify rather than thresholds and do so based on absolute and relative deviations from trend from the credit-to-GDP ratio. Habib & Stracca (2015) have used the MSCI World Index and the VIX index together. They identify crises as the intersection of months with the largest increase in the VIX index (last decile of changes) and largest decrease in the MSCI World Index (first decile of returns).

2.2 Safe Haven Assets

As already explained in the introduction safe haven assets are sought after in times of crises because they protect investors from financial losses (Habib & Stracca, 2015). They should be uncorrelated (or negatively correlated) with other assets during crises (Baur & McDermott, 2010), in other words they shall not carry systematic risk (McCown & Zimmerman, 2006) and essentially have the CAPM's beta near 0 (Sharpe, 1964; Lintner, 1965). Other than less risk, investors also seek high liquidity (Beber et al., 2009), which provides flexibility and is a safety cushion for unforeseeable spending needs (Rösch & Kaserer, 2014).

The rest of this chapter will elaborate upon assets that are widely considered to fulfil these criteria.

2.2.1 Commodities

Following the aforementioned differentiation between hedges and safe haven assets of Baur & McDermott (2010), certain energy commodities like crude oil and some metals such as silver can be classified as hedges, while gold, can be considered as safe haven. However, the ongoing debate on this classification remains to be settled.

After the implementation of the Commodity Futures Modernization Act of 2000, there was a substantial influx of investment capital in commodity markets, this has been since labelled as "commodity financialization" (Tang & Xiong, 2012; Algieri & Leccadito, 2017), which has established commodities as a new investment trend. Notably, portfolio managers sought after commodities for their weak/negative correlations with conventional assets, positive co-movement with inflation, plus comparable to equities commodities now had the capability to provide a risk-adjusted return (Gorton & Rouwenhorst, 2006). Unfortunately, increased prices were not the only result of the rising demand for many commodities, return volatility grew as well, but perhaps most interestingly heightened correlations between different commodities diminished the hedging and diversification potential of commodity markets (Gromb & Vayanos, 2010; Daskalaki & Skiadopoulos, 2011; Silvennoinen & Thorp, 2013; Adams & Glück, 2015).

It is important to note that commodities exhibit sensitivity to not only fundamental demand factors, but also the fundamental supply factors. Gas and cereal prices may be influenced by weather conditions, others, for example crude oil are sensitive to geopolitical instabilities and macro-financial variables, events as mining strikes and industrial demands might influence the price of Industrial metals (Ali et al., 2020).

This implies that different commodities have different relationships with equity markets, idiosyncratic conditions may be more determining for individual commodities than to the impact of aggregate demand on the overall commodity markets (Ali et al., 2020). For example, the development and price determinants of precious metals do not only differ from other commodities but also from each other. For instance, gold's demand is primarily driven by its use in jewellery (43%) and its role as a monetary asset (36%), while silver and platinum prices are mainly

influenced by industrial use, constituting over 50% of their total demand (Batten et al., 2010; Batten et al., 2015).

Past research typically did not give enough attention to many individual commodities rather the performance of a broader spectrum of commodities is usually represented by aggregate commodity indices to represent overall market performance this is the case for example in Baur and McDermott (2016) and Raza et al. (2018). However, each commodity has distinct characteristics influencing its ability to mitigate stock market downside risks, for instance, compared to energy and agricultural commodities metals demonstrate a more robust capacity to hedge against equity market risk (Ali et al., 2020). Moreover, even commodities within the same category, such as precious metals like gold and silver, exhibit different potentials in mitigating stock market risks (Lucey and Li, 2015).

Because of this Ali et al. (2020) examined the specific roles of individual commodities in relation to movements on various equity markets, searching for the asset with the highest safe haven potential and quite expectedly concluded that out of all analysed commodities gold was the best performing asset across the most of the examined equity markets. Other precious metals and crude oil have also been considered as safe haven assets but did not perform nearly as well. This reinforces the findings of studies such as Baur & McDermott (2010) and emphasizes the prime position of gold.

In line with this, Gold will be the only commodity that shall be further elaborated upon in the later parts of the commodities subsection of this chapter.

Gold

While the work of Baur & McDermott (2010) has been used above to cement gold as a primary example of a safe haven asset, amongst other reasons this study emphasizes gold's intrinsic value, gained because of its multiple applications in jewelry, electronics, dentistry, medicine, aerospace, and (historically) currency, this paper also shows that gold has limits and is not a universal safe haven asset. The findings show that the safe haven properties are upheld in the US, Switzerland and the EU but also that these are not found in markets like Australia, BRIC, Canada and Japan. Baur & McDermott (2010) are also warning that gold should not be utilized

as safe haven only at all times, as under extremely high uncertainty gold is found to be moving together with the stock markets.

In their later work Baur & McDermott (2016) have also found that safe haven properties of gold only increase in times of extremely negative shocks since the correlation of stock and gold returns gets even more negative. However, they observed that the safe haven effect tends to diminish after 10 to 15 days. They explained this pattern through behavioural analysis, suggesting that the lack of information is the cause behind the hurried purchases of gold made by countless investors and subsequently, once they comprehend the crisis developments the sale of gold starts.

The relationship between gold and the US stock market, this time represented by the S&P 500 index, has also been examined by Flavin et al. (2014) and the same conclusion has been achieved, due to its negative correlation gold qualifies as a safe haven asset. This notion is also supported by Beckmann et al. (2015), where findings across 18 countries observed within the study demonstrated that gold predominantly serves as either a safe haven or a hedge. Additional evidence for gold's safe haven status and even superiority during against the US bonds during the observed period based on its performance was found in McCown & Zimmerman (2006), in their study gold has not only been a zero-beta asset, but also had returns higher than the bonds. Moreover, Baur & McDermott (2016) show that gold provides security against inflation, default and currency risks as it is not dependent from counterparties and markets.

Sakemoto (2018) focused more on gold's safe haven characteristics when safeguarding against currency fluctuations and discovered that gold does indeed provide advantages for investors employing varying (G10⁸) currency portfolio strategies. However, he also found that the increasing popularity of gold among investors has led to a decline in gold's safe haven properties since 2000. Ciner et al. (2013) also came to the conclusion that increasing usage and popularity of gold led to diminished safe haven attributes against equities.

⁸ "Group of ten" - refers to the group of countries that have agreed to participate in the General Arrangements to Borrow (GAB), a supplementary borrowing arrangement that can be invoked if the IMF's resources are estimated to be below a member's needs. These include Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom and United States.

The safe haven properties of gold may be diminished by rising demand for gold due to several factors. According to the "cross-market rebalancing effect" (Kodres & Pritsker, 2002) the losses in equities or other assets may force investors to sell gold to rebalance their portfolios. Similarly, the "wealth effect" (Kyle & Xiong, 2001) prompts investors seeking to reduce risk exposure in all assets after losses in one and thus influencing gold allocations. Investors in need of cash might fall victim to the "liquidity shock effect" (Brunnermeier & Pedersen, 2009) and sell assets across various markets not only in the one where the losses have occurred. And finally, the "disposition effect" (Tversky & Kahneman, 1974) leads investors to retain losing assets and sell those maintaining value. Baur and Glover (2012) suggest that if gold becomes a mainstream asset the above-named effects may pressure gold prices downward after equity market downturns.

But there are also other psychological or behavioural aspects that influence the price development of gold. Gold's position of a preferred asset during financial crises may well be due to its associations with wealth and luxury and its historical role as a means of payment and store of value (Baur & McDermott, 2016). Investors might be swayed by the positive image and tangibility of gold, fostering trust in turbulent financial times. Baur & McDermott (2016) also explain that compared to fixed income assets physical gold ownership involves higher storage costs and thus is (from a rational perspective) more risky and less liquid than for example US Treasury bonds.

However, once investors find themselves under stress (during an economic crisis), they may overlook high storage costs or other drawbacks of gold. Research by Lighthall & Mather (2012) indicates that stressed investors tend to downplay the significance of negative information and assign greater value to positive information. Consequently, investors might neglect costs and risks associated with gold, and prioritize the positives, such as its historical performance.

Stressful situations may prompt impulsive decision-making, limiting the evaluation of available alternatives (Keinan, 1987). And combined with the "local thinking" model, where decisions under stress rely on readily available information, gold may be the first choice of many investors searching for a safe haven asset as it simply comes to mind fastest out of all (Gennaioli

& Shleifer, 2010). These biased behaviors could create a self-fulfilling prophecy, with investors buying gold based on its past performance in crises, potentially driving up demand and validating its safe haven status (Baur & McDermott, 2016).

2.2.2 Currencies

Alongside their research on gold Baur & McDermott (2016) have also analysed other potential safe haven assets and discovered additional evidence that attributes this status to the Swiss Franc and the US Dollar. They observed that the US Dollar exhibits stronger safe haven properties in response to the S&P 500 index catering more to US investors, whilst the Swiss Franc reacts more robustly to shocks in the MSCI World index, which could mean that Swiss Franc is sought after by global investors. Moreover, Baele et al. (2018) looked at the “flights-to-safety” and were able to observe the appreciation of the Swiss Franc, US Dollar, and Japanese Yen during these events.

Similarly, to gold currencies are also unproductive (returns are only generated through changes in market value) and yet even more liquid (Ciner, et al., 2013). There is however a large difference in short term effects of political events such as elections, trade negotiations, or sanctions on currency prices.

Despite such political interventions, certain currencies seem to retain their safe haven properties. Habib & Stracca (2015) identified the US as the preferred destination for foreign investors during crises as investors predominantly turn to US Treasuries, resulting in an appreciation of the US Dollar. The situation in Switzerland and Japan is also similar although demand for their securities does not experience a parallel increase, their currencies are appreciating during crises.

In this context it might be interesting to look at Campbell et al. (2010), who have found an increase in Euro’s safe haven properties when observing the interdependence of stock markets and currencies. Further research on this topic by the likes of Bernoth et al. (2012) or De Santis (2014) led to similar results, here German bonds are even considered to be safe haven. This can lead to interesting parallels with the work of McCauley & McGuire (2009). The results of their research hint that the US Dollar is in fact a safe haven currency (also) because of the increased

demand for US Treasuries by foreign investors through crises periods. Thus, it might be that the foreign demand for German bonds could be the cause behind the value of Euro. But altogether not so many papers analyse the safe haven properties of the Euro. One of the few exceptions is Rinaldo & Söderlind (2010), yet their definition of (weak) safe havens also includes assets that are non-correlated with the equity market. This can be put into contrast with Hossfeld & MacDonald (2015) who consider an asset as a safe haven only if it is “significantly negatively related to global stock market returns” and have therefore found no significant evidence in support of the Euro.

The previously named safe haven currencies, the US Dollar, Japanese Yen, Swiss Franc, but also the Euro exhibit an effect of carry funding on exchange rates, which has been proven in multiple studies (as for example, Brunnermeier et al., 2008; Rinaldo & Söderlind, 2010; Lustig et al., 2011; Hossfeld & MacDonald, 2015). A funding currency is a currency borrowed at a lower interest rate to invest in higher-yielding assets denominated in another currency. This strategy, known as a carry trade, involves taking advantage of interest rate differentials between currencies. During market crises, investors tend to reverse these positions, selling higher-yielding assets and repurchasing the funding currency. This unwinding of carry trades increases demand for the funding currency and lower demand for the target currency. Thus, leading to depreciation of the target currency and appreciation of the funding currency (Hossfeld & MacDonald, 2015).

In line with this Menkhoff et al. (2012) find that global exchange rate volatility⁸ is a key explanatory factor for returns from carry trade strategies. In a low to moderate volatility higher yield currencies exhibit good performance, but in times of increased volatility they may lead to large losses. This study contributed to the expanding body of knowledge (such as for instance Brunnermeier et al., 2008; Lustig et al., 2011) studying the connection linking global risk aversion with profitability of carry trade strategies and addresses the importance of fundamentals in formulating carry trade strategies as also done in for example Jorda & Taylor, 2009.

However, the typical patterns in safe haven effects have been at least partially disrupted by the 2008 financial crisis (Kohler, 2010), here the role of some of the above-named currencies

⁸ Global exchange rate volatility is the aggregated volatility of all observed currency pairs in Menkhoff et al. (2012)

as safe havens has been challenged. Certainly, specific factors played a role and must be named. One of them being the support of US Dollar exchange rate from US Dollar shortages (driven by net long US Dollar exposure funded by European banks) and (write-downs of US Dollar assets that resulted in) "over hedged" US Dollar positions (McCauley & McGuire, 2009). The impact of market-wide liquidity risk on exchange rate movements has also been econometrically proven by Hui et al. (2010).

In line with Kohler (2010) Habib & Stracca (2012) confirmed that the link between interest rate spread and safe haven status can only be found during the great financial crisis. Their study also hints that currency excess returns during a crisis can be explained by behavioural aspects such as self-fulfilling prophecies and not only economic fundamentals.

2.2.3 Government Debt

Unlike gold or currencies, government bonds offer returns in form of scheduled interest payments and repayments of the principal, or they can be resold on secondary markets instead of being carried to maturity. Theoretically the first are considered to be safe unless the issuer defaults and should be unaffected by market shocks or other information. However, the resale value on the secondary market is riskier and can be influenced by new information and market dynamics. Usually, bond prices are most sensitive to expected interest and inflation rates. Rising interest rates make fixed coupon payments less attractive, and expectations of increasing inflation decrease real returns. Additionally, the bond price is under the influence of the credit worthiness of the issuer (reflected in credit rating). A decline in credit rating often leads to lower secondary market price.

In the research of Andersson et al. (2008) price dynamics of government-issued bonds (prime examples include 10-year US bonds, German federal bonds, and the UK Gilts) showed a generally positive correlation with the stock market. However, this correlation is not the same during periods of low inflation expectations or high investor uncertainty, in fact it tends to invert itself quite quickly. Making government bonds great candidates for safe haven status. These findings were also supported by Baele et al. (2018), who developed a model that distinguishes normal periods from "flights-to-safety" periods using an analysis of the correlation between 10-

year government bonds and stocks. By doing so they have managed to separate safety-seeking periods when both the demand for US Treasury bonds and investor stress (measured by the VIX index) increase.

The US government bonds might be perhaps the most preferred and also most studied fixed income asset and also the bond with the biggest recognition as safe haven. Extreme safety and liquidity of US government bonds have been identified to be the primary reasons why many investors regard US Treasuries as a safe haven (Krishnamurthy & Vissing-Jorgensen, 2012). During market tumult, parallels between money and US debt have been observed by Krishnamurthy & Vissing-Jorgensen (2012), leading them to think that investor's view US Treasuries as a "convenience asset" in these times. A further supporting fact is the countercyclical behaviour of US bonds found by many authors such as Chan et al., 2011; Flavin et al., 2014; Habib & Stracca, 2015 and Baur & McDermott, 2016. Ciner et al. (2013) suggests that also bonds issued by the United Kingdom exhibit good performance in times of extreme declines in the equity market. In their paper they do not only find that US bonds but also the UK government bonds can be used as safe haven assets, since their returns have both negative correlations with the equity markets. Furthermore, they have observed a positive correlation between the UK Gilts and gold (its safe haven attributes have already been mentioned above).

During crises also the liquidity preferences of investors need to be satisfied, for example the US government bonds are a frequent target of "flights-to-safety". A study that shows this phenomenon is the paper from Longstaff (2004), who has made an analysis of US government bonds and bonds issued by the US government agency Refcorp. (these are guaranteed by the US government). Both of these bonds shall therefore carry the same risk as US Treasuries and differ only in their liquidity on secondary markets. In line with the underlying theory the price of 2-10 year Treasury bonds appreciates more during crises than the price of bonds issued by the Refcorp.

European investors also valued the liquidity provided by certain government bonds quite highly (Beber et al., 2009). Other than the UK Gilts the German federal government bonds have recently developed into a safe haven asset. This has been proven by many studies, for example

Bernoeth et al. (2012) have looked at fiscal characteristics, mainly government indebtedness, and their influence on the prices of bonds and came up with the conclusion that the status of German government bonds has changed during the financial crisis of 2008. Research on several 2- to 10-year European government bonds has also been conducted by De Santis (2014) with the same result regarding German bonds. The paper highlighted that both spreads and prices of German government-issued securities have been increasing faster relative to other comparable European sovereign bonds since 2008. One of the leading arguments on what might have caused this development has been their liquidity, which again contributes to the importance of liquidity for safe haven assets. Additional evidence of "safe haven flows" to German federal bonds has been provided by the later study of Ejsing et al. (2015), further cementing the safe haven status of these bonds.

Further studies suggest that modelling prices and yield spreads based on "hard facts" might not be sufficient and that perhaps other factors are at play. For instance, government indebtedness or other fiscal characteristics were studied by Bernoeth et al. (2012), these fiscal indicators were found to have a large influence, but it was also discovered that the investors' perceptions of bond values play a significant role. The authors then theorize that the safe haven flows towards German and US bonds might be attributed to the market crisis around 2009 led to heightened investor scrutiny of the loose fiscal policies. In a related study that considered determinants of government bond prices across 22 countries Poghosyan (2014)m attempted to model equilibria during times of crises, but his work did not seem to achieve the desired result and thus he concluded that government debt level, GDP, and inflation and similar "hard facts" proved to be insufficient to explain deviations from equilibrium in these specific time frames. Further interesting research regarding sentiment has been done by Balduzzi et al. (2001), this study states that government bond prices rise after countercyclical news but are adversely affected by procyclical ones. The emphasis is laid on the surprise effect, stemming from both the information and the unexpected nature of these news, which are key contributors to bond price volatility of US Treasury securities in this paper.

2.2.4 Recent developments, Cryptocurrencies and all other assets

As already mentioned, the COVID 19 pandemic affected many economies, worsened their conditions and may have been the trigger of severe recession or even depression (Li et al., 2022). Although one could argue that there is not enough time separation since the end of the pandemic, its economic consequences and today. Especially if we take into consideration the events that closely followed the pandemic as the War in Ukraine, the inflationary consequences of this conflict, the harm on international trade that this conflict has sparked, but also other military conflicts and problematic situations with presumably negative effects on the economy. It has to be said that estimating the influences of these events on the economy is very challenging and maybe even not fully possible until a recovery is made / a new “normal” state of the world is reached. Therefore, whilst reading the following part of the literature review the reader should keep in mind that there are still many areas, which have not been fully researched or phenomena that have not been fully explained yet. This is not to say that the presented conclusions of the papers that will be presented are incorrect or unreviewed, but even the authors of the papers that will be cited admit that sometimes deeper research is needed to tackle some issues in enough detail.

The COVID-19 has been considered a “once-in-a-century” pandemic (Gates, 2020). Arguably this has made the underlying forces behind the disruptions in the global financial system much more complex and harder to understand or predict. This combination of unprecedented problems has of course led not only to an increased demand for safe haven investments, but also to (academic) curiosity to find which assets and why have been safe haven (Ji et al., 2020). Above the role of gold, select currencies and bonds has been explained.

In recent times cryptocurrencies also come up in debates on safe haven assets. The most popular decentralised digital currency that is independent of central banks or governments, Bitcoin, launched by Nakamoto (2008) is also the most studied one. Results of research did vary before the pandemic as Bitcoin was considered to be a safe haven asset by what seems to be a majority, but not all. Bitcoin exhibits some safe haven properties, mainly it is uncorrelated with

other financial assets (Baur et al., 2019) and that it (but also Ethereum) can be used as a hedge against downside risk in equity investment (Bouri et al. 2020).

Preceding the pandemic Bitcoin was also analysed as a safe haven across assets, markets and timeframes. Bouri et al. (2017) examined the safe haven properties of Bitcoin for stock markets in the Asia Pacific area using dynamic conditional correlation approach and found evidence in support of its safe haven status. Bitcoin was also examined as safe haven for several currencies by Urquhart and Zhang (2019) and also this time with positive results. Shahzad et al. (2019) were analysing Bitcoin, gold and commodities as potential safe haven investments for stock market indices and found Bitcoin to be a weak safe haven for certain indices but this time the desired properties were found to be time sensitive. However not all are of the same opinion in favour of the use of Bitcoin as a safe haven (Klein et al., 2018; Smales, 2019).

Similarly, another safe haven gaining popularity in the recent years was the VIX index. It has been so perhaps since Hood & Malik (2013) have discovered that VIX had superior safe haven properties relative to gold in their observed period. The highly desirable characteristics of VIX have been since also highlighted in the works of Balcilar et al. (2020), Hasan et al (2021) and Shahzad et. al. (2022).

However, during the time of the COVID-19 pandemic these assets considered as safe havens have behaved at least partially differently as expected or as they have done before. Firstly, during this crisis the response of fiscal and monetary policy was quick and severe, it provided liquidity to financial markets, thus, investor confidence was restored faster than before (Akhtaruzzaman et al., 2021; Hasan et al., 2021). Akhtaruzzaman et al. (2021) showed this on gold, in the phase before the introduction of these policies gold performed relatively better than many other assets and confirmed its safe haven status, after the response from governments and central banks the demand for what were considered safe haven asset, remained high, but the one for risky assets increased as well. Leading to higher correlations of gold and other financial assets. The authors of this paper also warn that such policies can possibly lead to bubbles and ultimately new boom–bust cycles. The safe haven status of gold during the period of the initial part of the COVID-19 outbreak was also confirmed in Ji et al., (2020). Upon further

analysis Hasan et al. (2021) also found that gold and Bitcoin exhibit safe haven properties during severe market downturns during the COVID-19 pandemic. Ethereum has also exhibited similar characteristics as Bitcoin in this analysis, it had lower negative correlation during severe market downturns, but also a lower correlation during the whole studied period and can therefore be utilized for hedging activities. However, in the analysis of Hasan et al. (2021) currencies (other than Swiss Franc that is a weak safe haven) and commodities other than gold were neither safe havens or hedges. The paper from Mariana et al. (2021) also confirms short-term safe-haven characteristics of Bitcoin, but this analysis also concludes that Ethereum might be an even better safe haven asset during the selected timeframe, although it has a higher return volatility.

Perhaps the most important and reoccurring insight, which can be observed from the similarities and differences between individual studies, but also explicitly formulated by Akhtaruzzaman et al. (2021), Disli et al. (2021), and Hasan et al. (2021) is that the results are affected by the choice of the analysed timeframe even more than in other crises, possibly because of the fast reactions of governments and central banks.

This is also obvious in the so far omitted safe haven category, bonds. For example, Hasan et al. (2021) have considered US treasury bonds and concluded that these did not have safe haven characteristics during the COVID-19 pandemic. On the other hand, Choudhury et al. (2022) have also examined US government bonds, but also other ones that were named previously in this study, those of Germany and UK, and have come to the opposite conclusion. In fact, in their paper, they state that these bonds were better safe havens than gold during the observed timeframe.

3. Methodology

The theoretical base of knowledge formed above is a solid starting point for the research process in order to find the answers to the formulated research questions. As a next step the time periods that will be considered as crises must be determined. Wendlberger (2019) has used a method that has followed Habib & Stracca (2015) but modified it so that in his work two conditions had to be met to mark the beginning of a crisis period, firstly the VIX had to exceed the

value of 25, and secondly the MSCI World index had to exhibit negative returns. If these conditions were met again within a week, the whole week was added as a part of the crisis period. These thresholds are relaxed compared to the original ones, but as they have been transformed to absolute values of price or returns, they do not change when the studied timeframe is extended (or even shortened). Thus, the identification method of Habib & Stracca (2015) seems to be superior, as it can be used for any timeframe (assuming the time frame is large enough to contain both crises and periods with positive development). Therefore, in this paper crises periods will be marked as the intersection of months with the largest increase in the VIX index (last decile of changes) and largest decrease in the MSCI World Index (first decile of returns). Of course, comparisons will be made to illustrate the differences between this method and the method of Wendlberger. But this selected method is a purely descriptive one, it can only be used when dealing with past data and cannot be used predictively.

Therefore, a second method must be defined, here the Gebert-(Börsen)Indikator will be used. This indicator has been developed by Thomas Gebert and published in his book "Börsenindikatoren" together with Paul Hüsgen. This indicator comprised out of four partial indicators: interest rate-, inflation-, USD-EUR-exchange rate- and a seasonality-indicator, each taking on the number of 0 or 1, is a helpful tool when considering an investment into German stocks, especially the DAX stock index (Gebert & Hüsgen, 1997).

The interest rate indicator is equal to 1 if the ECB's last interest rate move was a reduction, if it was an increase 0 points are awarded. Similarly, if the eurozone inflation rate determined by Eurostat is below that of the same month of the previous year, this also means 1 point. On the other hand, an equal inflation rate or an increase in inflation in a twelve-month comparison is awarded 0 points (values published by Eurostat at the beginning of the month are only given as estimates and are only labelled as official values 14 days later, the inflation sub-indicator is therefore always included with a one-month delay). The third signal relates to the exchange rate development. If the US Dollar in Euros (formerly: Deutsche Mark) is quoted above its level of twelve months ago, this in turn results in 1 point, while an exchange rate that is the same or lower is rated as 0 points. The monthly values averaged by the Deutsche Bundesbank are used for this purpose (the Deutsche Bundesbank values represent the Euro value in US

Dollars and that the reciprocal value must be used for the sub-indicator). The seasonality indicator (also known as the Halloween indicator, because of the motto "Sell in May and go away and come back on St. Leger Day") is equal to 1 point from 1st November to 30th April (Gebert & Hüsken, 1997).

If the sum of the partial indicators is 3 or above it represents a buy signal for the investor, a value of 2 is a hold (or do not change the current state) signal, a value of 1 or below is a sell signal (Gebert & Hüsken, 1997). In our case the value of 1 or below would also be considered as a signal for investment into the safe haven assets.

This second method based on the Gebert indicator will be used to create and study realistic investment scenarios that could have been a result of an investment behaviour of an investor, who is familiar with and does indeed follow the strategy provided by the Gebert indicator. This shall model the situation in which an investor tries to adjust his current portfolio with an investment strategy based on an increased potential of an incoming crisis. These attempts are relatively "inexpensive" as the Gebert indicator is published and provides indicative information with minimal costs and thus an investor can use it with limited knowledge, or other inputs such as time to follow and understand the current economic trends. However, the first method can and shall be used as an idealistic reference, and for supporting analyses (in which the studied period shall overlap/fit the crisis period as close as possible).

Once the crisis periods are determined a potential pool of assets that could be included within the portfolio shall be selected. First for data availability reasons only quoted/listed assets will be included. To clearly describe the picking process, the selection of assets will be divided into four groups: commodities, currencies, government bonds and equities.

The first three groups have already been discussed above and from these groups the assets that are considered safe haven assets will also be selected based on the consensus present in literature. A reference pool consisting of both safe haven and non-safe haven assets in all of the three categories will be formed out of the most demanded or widely used assets in each category. For example, there is only a limited number of commonly traded commodities (68 commodities as of 18.9.2023) (IMF, 2023). Out of these some are naturally more popular and

widely traded, this observed on the data presented by the Futures Industry Association. For example, some of the most popular include WTI Crude Oil, Brent Crude Oil, Natural Gas, Soybeans, Corn, Gold, Copper, Silver (FDA, 2023). Both currencies (BIS 1, 2022) and government bonds (BIS 2, 2022) can also be categorized based on how much they are demanded. Furthermore, cryptocurrencies can also be divided using the same technique, the focus will only be on the two by far most traded coins, Bitcoin and Ethereum (Coinmarketcap, 2023) (stable coins have the same returns as the underlying and are less liquid, therefore they will not be included).

This leaves us with equities. Equities are not as thoroughly studied in the context of safe haven assets as the other groups (this is completely logical as there is a much larger number of equities than of the other assets and they are inherently riskier since debtholders are repaid first). Therefore, another method (as literature review would not be effective) must be used for the selection of equities. As already mentioned, there are two desired features of safe haven assets, these must be (highly) liquid and uncorrelated or negatively correlated with the initial (in this case) market portfolio. As there are tens of thousands of stocks in the world two heuristic criteria that will help to pre-select a narrowed down initial pool of equities (that shall be further analysed) will be used at this point. First in line with the liquidity feature of safe havens only mega cap and large cap stocks will be included. Second to further trim down the potential inclusions only stocks which are typically considered to have defensive characteristics and thus should be more likely to be uncorrelated or negatively correlated with the market will be analysed, this shall include healthcare, utilities, and consumer staples.

Now the fact that the reference pool is a set of assets that has already been classified as safe haven assets (or non-safe haven assets) can be used. This reference pool can be utilized as training (and testing) dataset for a Naïve Bayes classifier.

The Naive Bayes classifier belongs to the group of probability-based classifiers, in our case this rather simple probabilistic machine learning algorithm should identify potential safe haven stocks by making predictions (of a class y that will be either non-safe haven - 0 or safe haven - 1) based on the probabilities calculated using independent features observed for each of

the potential stocks. These features are organized into a matrix X , where each row represents an instance or observation, and each column represents a specific feature.

For each continuous feature x_i , the likelihood $P(X|y)$ is modelled using the Gaussian (normal) distribution. For a Gaussian distribution, the probability density function is given by:

$$P(X|y) = \prod_{i=1}^n P(x_i|y)$$

and the Gaussian probability density function for each feature x_i given class y is:

$$P(x_i|y) = \frac{1}{\sqrt{2\pi\sigma_{y,i}^2}} \exp\left(-\frac{(x_i - \mu_{y,i})^2}{2\sigma_{y,i}^2}\right)$$

where $\mu_{y,i}$ is the mean of feature x_i and $\sigma_{y,i}^2$ is the variance of feature for class y .

The prior probability $P(y)$ of each class also needs to be calculated is also calculated as:

$$P(y) = \frac{\text{Number of assets of class } y}{\text{Total number of assets}}$$

then the Bayes' theorem is used to predict the class label for the given stock:

$$P(y|X) = \frac{P(X|y) \times P(y)}{P(X)}$$

and finally, the class of the given asset is assigned to a class based on which class is the one with the highest posterior probability $P(y|X)$ (Tan et al., 2019).

Here features as volatility, or correlation of relative returns of these assets or market Beta of the assets could be used. Within this analysis the term relative return $R_{i,t}$ is used for the discrete daily change in the price of a selected asset i calculated as:

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

where $P_{i,t}$ is the price of the asset i on day t and $P_{i,t-1}$ is the price on the previous day.

Of course, the inclusion of particular features, selection of the best training and test size will be definitely determined with the help of classification reports and cross-validation. A

classification report includes metrics of Accuracy, Precision, the F1-score, also macro and weighted averages of these are included.

$$Accuracy = \frac{\text{Number of correctly classified instances}}{\text{Total number of instances}}$$

Accuracy can only be looked at from the perspective of the whole model, but the further performance indicators are always from the non-safe haven (0) or the safe haven (1) perspective.

$$Precision = \frac{\text{True positives}}{\text{True positives} + \text{False positives}}$$

$$Recall = \frac{\text{True positives}}{\text{True positives} + \text{False negatives}}$$

Precision denotes the proportion of true positive predictions among all positive predictions, while recall represents the proportion of true positives that were correctly identified.

$$F1 - score = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$

The F1-score, a harmonic mean of precision and recall, offers a balanced measure of the classifier's accuracy.

$$Macro\ Precision = \frac{\sum_{i=1}^n Precision_i}{n} \quad (n - \text{number of classes})$$

$$Weighted\ Precision = \frac{\sum_{i=1}^n Precision_i \times \text{Ture positives}_i}{\sum_{i=1}^n \text{True postives}_i} \quad (n - \text{number of classes})$$

The formulas above are analogous for Precision, Recall and F1-score. Macro average treats each class equally, the weighted average considers the class imbalance by giving more weight to classes with greater representation.

$$Cross - validation\ accuracy = \frac{1}{k} \sum_{i=1}^k Accuracy_i \quad (k - \text{number of folds in the cross - validation})$$

The cross-validation accuracy scores, offer insights into the model's performance across subsets of the dataset. These scores reflect the model's accuracy when trained on different partitions of the data and evaluated on the remaining portions. The closer the individual scores to the mean cross-validation accuracy and the higher the mean cross-validation accuracy the better, as the estimates are more robust, and the model has more generalization ability.

Once this is done a much smaller amount of assets shall be left in the potential pool. It will be much easier to manually inspect this limited amount and if all are considered correct use them in the next steps to build efficient safe haven portfolios. This will be addressed by optimization of the sharpe ratio as presented by Elton et al. in their book “Modern Portfolio Theory and Investment Analysis” (2017) and using the CVXPY library (Python-embedded modelling language for convex optimization problems) that assess performance of potential portfolios. Within this study the portfolio with the highest sharpe ratio is chosen as the efficient portfolio and thus the objective is to maximize the Sharpe ratio S of the portfolio:

$$S = \frac{R_p - R_f}{\sigma_p}$$

where R_p is the portfolio return, R_f is the risk-free rate, and σ_p is the standard deviation (risk) of the portfolio returns.

The decision variables are the weights w_i of each asset in the portfolio. These represent the asset allocation within the portfolio and give us two constraints. The budget constraint:

$$\sum_{i=1}^N w_i = 1$$

that ensures that the sum of weights equals 1, indicating a fully invested portfolio, and the non-negativity constraint:

$$w_i \geq 0$$

that ensures that the weights of individual assets are non-negative, preventing short selling. Given this the sharpe ratio can be expressed in terms of the individual asset returns (R_i), standard deviations (σ_{ij}), and weights (w_i) of the individual assets in the portfolio:

$$S = \frac{\sum_{i=1}^N w_i (R_i - R_f)}{\sqrt{\sum_{i=1}^N (w_i^2 \sigma_i^2) \sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}}}$$

Now in order to maximize the sharpe ratio subject to the constraints above the sharpe ratio function must be differentiated with respect to each w_i , in general:

$$\frac{\partial S}{\partial w_i} = \frac{(R_i - R_f)(\sum_{i=1}^N (w_i^2 \sigma_i^2) \sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}) - (\sum_{i=1}^N w_i (R_i - R_f)) (w_i \sigma_i^2 + \sum_{j=1}^N w_j \sigma_{ij})}{\sqrt{\sum_{i=1}^N (w_i^2 \sigma_i^2) \sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}}^3}$$

Then setting the gradient to zero and simplifying yields:

$$0 = \frac{(R_i - R_f) \sigma_p}{\sigma_p^{\frac{3}{2}}} - \frac{(\sum_{i=1}^N w_i (R_i - R_f)) (w_i \sigma_i^2 + \sum_{j=1}^N w_j \sigma_{ij})}{\sigma_p^{\frac{3}{2}}}$$

$$\frac{(R_i - R_f)}{\sigma_p} = \frac{(R_p - R_f) (w_i \sigma_i^2)}{\sigma_p^{\frac{3}{2}}} \frac{(R_p - R_f) (\sum_{j=1}^N w_j \sigma_{ij})}{\sigma_p^{\frac{3}{2}}}$$

$$R_i - R_f = \frac{(R_p - R_f) (w_i \sigma_i^2)}{\sigma_p^2} \frac{(R_p - R_f) (\sum_{j=1}^N w_j \sigma_{ij})}{\sigma_p^2}$$

Now with the use of λ :

$$\lambda = \frac{\sum_{i=1}^N w_i (R_i - R_f)}{\sum_{i=1}^N (w_i^2 \sigma_i^2) \sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij}} \text{ which is } \lambda = \frac{R_p - R_f}{\sigma_p^2}$$

The equation can be adjusted to:

$$R_i - R_f = \lambda w_1 \sigma_{1i} + \lambda w_2 \sigma_{2i} + \dots + \lambda w_i \sigma_i^2 + \dots + \lambda w_{N-1} \sigma_{N-1i} + \lambda w_N \sigma_{Ni}$$

After defining a new variable $Z_k = \lambda w_k$ the formulation simplifies to a system of N equations:

$$R_1 - R_f = Z_2 \sigma_1^2 + Z_2 \sigma_{1N} + \dots + Z_N \sigma_{1N}$$

$$R_2 - R_f = Z_1 \sigma_{12} + Z_2 \sigma_2^2 + \dots + Z_N \sigma_{2N}$$

...

$$R_N - R_f = Z_1 \sigma_{1N} + Z_2 \sigma_{2N} + \dots + Z_N \sigma_N^2$$

Since the optimum investment amounts in each security are proportional to the Z_N it is possible to first solve the equation system from above and then calculate the optimum weight w_i^* for each asset by using:

$$w_i^* = \frac{Z_k}{\sum_{i=1}^N Z_i}$$

This optimization problem together with a set of starting weights is provided to the CVXPY solvers. These efficient solvers provided from the CVXPY library are designed to find the global optimal solutions of the specified convex optimization problems within the feasible region whilst satisfying the given constraints. Once the optimization problem is solved, we can use the optimal weights w_i^* to construct portfolios with the highest sharpe ratios.

These portfolios should be comprised out of all the assets, but also out of a restricted subgroup of the assets Wendlberger has used, to illustrate differences in return and risk between the enriched and the restricted asset pools. The same approach will be taken with the timeframes to make the reader aware of the impact of the different investment and divestment times.

And finally, thereafter based on the available data the times of crisis will be split into subsections with contrasting characteristics in an attempt to further dynamize the asset allocation within the investment strategies. Hence, these strategies should be based on the assumed type of the current crisis. The most looked at factor is probably going to be inflation as it could have a significantly large impact on the value of a large part of our portfolios, because of the susceptibility of assets, which are likely to appear within the safe haven portfolios mainly currencies and bonds.

Within the analysis adjusted closing prices will be used for all necessary price data points. If it is meaningful and beneficial acquired data will be tabulated and/or visualized. Towards the end the performance shall be compared with reference strategies to determine if the use of safe haven assets in the described manner is indeed advantageous for a rational investor. These strategies shall include a buy and hold of the DAX, and the investment strategy using the original Gebert indicator.

Within this study the perspective of a European investor is chosen, thus exchange rates, which are bilateral in their nature, will be gathered from this perspective. The same will be done with the gold rate. Also, as already evident from the text above VIX and MSCI World daily data will be gathered and converted to Euro values. Of course, the same will be done with all other assets when necessary.

4. Model Setup

4.1 Data

For better clarity the gathering process and the characteristics of the data will be described in subgroups, corresponding to the parts of the analysis which they were used for. Of course, some of the data has been used at multiple points, but the reader will be reminded if this is the case. These fragments of the analysis can be grouped into two parts first of which is the model setup which contains the descriptive analysis of the crises' timeframes, the Gebert indicator, training and testing of the Naïve Bayes classifier and then the outcomes and results of the used within the second part the prediction of safe haven stocks made with the Naïve Bayes classifier and building of portfolios.

Descriptive analysis of the crises' timeframes

For this part only data on the MSCI World index and the VIX index was needed. It has been acquired from www.finance.yahoo.com, the start of the data is limited to the availability of the data on VIX which only starts from 1993 (as will be seen later this is long prior to the start of data on other assets and thus was not a limitation within further analysis, just here). The end date has been set as the 31st of December 2022. And will be set so during all further analysis parts.

Gebert indicator

For the construction of the Gebert indicator data on interest rates, inflation, exchange rates between the US Dollar and Euro (and previously Deutsche Mark) was needed. The fourth sub indicator seasonality is based purely on dates and thus no specific data had to be gathered for this one. The data on both interest rates and exchange rates were available at www.bundesbank.de. For inflation the Harmonised index of consumer prices (HICP) had to be obtained from the Eurostat, which can be found on www.ec.europa.eu/eurostat. In this case the limitation date was the 1st of January of 1999, which is the start date of the Euro monetary union. Availability of interest rate data and inflation data is much lower before the establishment of the Euro monetary union and the costs of obtaining such data would probably not be meaningful in the context of its use within this research.

Training and testing of the Naïve Bayes classifier

Apart of the already acquired MSCI and VIX, which are also used within this part, the reference pool of assets has been filled with currencies (also cryptocurrencies), commodities and bonds. The currency pairs include the US Dollar, Japanese Yen, Swiss Franc, British Pound, Canadian Dollar, Australian Dollar, New Zealand Dollar and South African Rand and of course all are paired with the Euro. Furthermore, the two Cryptocurrencies that are used in the study Bitcoin and Ethereum are paired with the Euro as well. Commodities consist of Gold, Silver, Copper, Crude Oil, Brent Crude Oil, Natural Gas, Palladium, Platinum, Heating Oil, RBOB Gasoline, Corn, Oat, KCHRW Wheat, Rough Rice, Soybean, Lean Hogs, Live Cattle, Cocoa, Coffee, Cotton, and Sugar. Both currencies and commodities have again been downloaded from www.finance.yahoo.com, the available data does only cover the burst of the dotcom bubble in quarter of these cases and the majority of these assets only has data from 1st of December 2003. Some of course start later as for example the cryptocurrencies. The data on bonds was obtained in form of Bond Indices from www.capitaliq.com/ the start dates of these do vary, but in majority they were well before the 1st of December 2003. The only indices that start later are the ones of Italian Government bonds and the UK Gilts.

Predicting safe haven stocks with the Naïve Bayes classifier

As already mentioned, the stocks that should be included in the predictions were narrowed down using two heuristic criteria. First of them is the inclusion of only mega cap and large cap stocks and second the preselection of stocks from companies operating in healthcare, utilities, and consumer staples. The start date and end date were set at the same date as for the assets from the reference pool, 1st of December 2003 and 31st of December 2022. This has resulted in 3810 stocks which were downloaded from www.finance.yahoo.com. In a further step during the analysis, stocks of companies that have gone bankrupt during the observed period or have had their IPO after the end of 2017 have been excluded. Of course, to create the predictions on these stocks also the data of the assets from the reference pool had to be used.

Building portfolios

In this part essentially no new data is introduced only the already stored data on the assets that are considered to be safe haven or have been predicted to be such is used for the specific periods labelled as crisis to derive efficient portfolios under the given assumptions.

4.2 Results

The structure of the previous chapter will be used to present the results of the individual parts of the analysis to retain a clear overview and enable a better understanding for the reader. This time of course the results from previous parts are essential and thus integrated in the next part of the analysis.

4.2.1 Descriptive analysis of the crises' timeframes

Based on the previously explained method, the months that were in the first decile of the MSCI monthly returns, or in other words months with the lowest returns, were intersected with the months that exhibited the highest increase of the VIX price, these are the months with the increases in price of VIX in the last decile. From 1993 this has resulted in 24 months (if we were to consider only the later examined time frame from December 2003 it would only be 16 months). During this time the lowest MSCI return in first decile was -19.04% and the highest equaled -4.48% (within the shorter time frame the lowest return would remain the same and the highest would change just slightly to -4.32%). When it comes to the VIX the lowest monthly increase within the selected crises time frames would be equal to 5.38 and the highest in the last decile would be 21.27 (within the cropped period the lowest increase would be slightly higher at 5.59). If we were to look at the absolute values the lowest price within the last decile would be 16.95 (from 2003 onwards this would be 18.71) and the highest 59.89.

Of course, if we would want to compare these values with the thresholds set in the methodology used by Wendlberger we would see that he used a more relaxed one for the MSCI returns, where any negative return (a return below 0) would be sufficient, but that the VIX constraint of an absolute price of at least 25 was stricter. Another difference is that his methodology does not have to include whole months but is more granular. Together this naturally results in differences in the selected time frames. This can also be seen in the Figure 1.



Figure 1: Crises time frames according to Habib & Stracca (2015) - List 1 and Wendlberger (2019) – List 2 1993-2022.

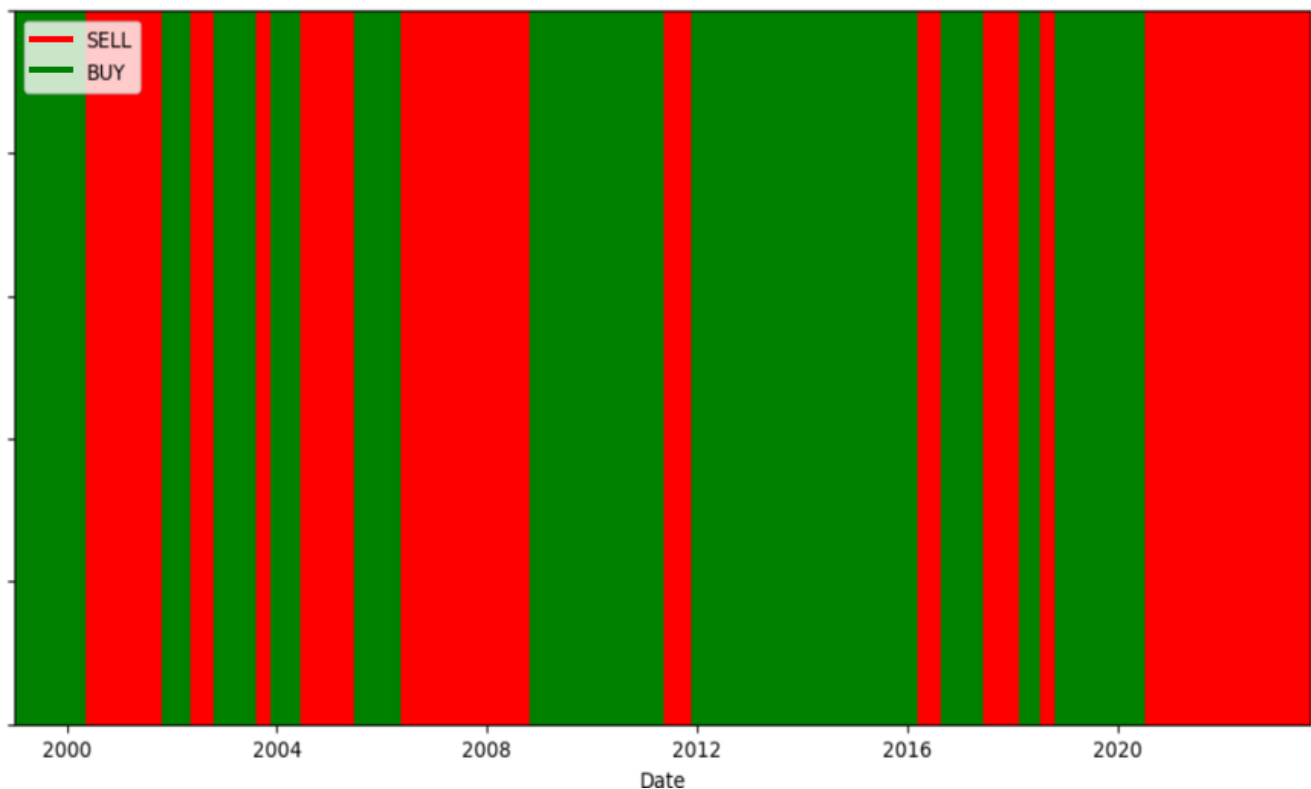
Obviously, we can observe that the second method could be indeed slightly more precise at dating crises periods when they really do appear. For instance, we can see this quite well in 2015, 2018, 2020 or 2022 where the red list starts a bit sooner, since it has to include the entire month and the blue list can pick out the days within the month when the slump in prices occurred. However, this method also seems to have a weakness in some detections that could be considered as false, for example the time during 1999 and 2000, when there was higher volatility (and thus also episodes of negative returns) but overall, the trend was positive. This is not to say that this positive trend was healthy or follows something that we would call fundamental values, it was an unhealthy boom known as the dotcom bubble, but we probably do not want to label it as a crisis. This of course results in a higher total amount of crisis days than in case of the first method, in fact there are almost two times as many with 1291. Of course, due to the different granularity it is hard to compare them directly.

For the purpose of identifying safe haven assets, which is the main objective here the first method originally developed by Habib & Stracca seems to be confirmed as superior since it manages to identify the times of the most severe market downturns (at least on monthly level). And exactly this should be of interest as the safe haven asset should perform the most, unlike the other market assets during these periods.

4.2.2 Gebert indicator

A further step was to construct a copy of the Gebert indicator. The method and the ways in which the results will be used have already been discussed above. But few additional remarks can be made. First is on the use of the 2-point signal. This signal results tells the investor to keep the previously set strategy, so if the last signal was to buy, he should keep buying and if it was sell, he should keep selling. This is of course different to what we have observed above not only because it is a forward-facing predictive indicator, but also because the Gebert indicator may also include times when the signals are mixed (and depend on the last previous buy or sell), which is not the case in the above methods. This is of course not a fault or something wrong, it should just be kept in mind when comparing these methods from above and the timing provided by the Gebert indicator. Second remark that should be made deals precisely with the fact that this is a forward-facing indicator. Originally this tool should help investors with timing in a pre-set investment strategy in order to achieve positive returns, or in other words buy low and sell high. This goal is a bit different as the one to determine the start and end of a crisis, but generally prices are high before a crisis and tend to fall during one. Therefore, these two goals tend to align and the Gebert indicator can thus mimic the behaviour of a (well informed, rational) investor.

As we already know the actual signals which result out of the indicator are given monthly. In the observed period between the start of 1999 and the end of 2022 there have been 131 months with the sell signal (out of this 77 have had the value of 0 or 1 and the rest were 2s but were converted to a sell since it was the last previous signal). The graphic representation of the results can be seen in Figure 2, where the sell signal is depicted in red and buy in green.



4.2.3 Training and testing of the Naïve Bayes classifier

After the crises timeframes have been determined the analysis could proceed with the selection of the reference pool. As previously mentioned, these 39 assets were chosen since they were the most demanded and used assets within commodities and currencies, for bond this approach was not entirely possible. Bonds have proved to be more complicated, because of data availability and also because if only the most demanded were chosen this would reduce the diversity within the category. Therefore, some of the selected bonds were included, not because they are necessarily highly demanded, but since they enrich the sample as they carry more risk than others and can certainly not be considered safe haven. Out of the whole reference pool, 9 assets were labelled as safe haven and the rest, 30, were not (of course based on the literature review). The whole list can be found in the in the Table 1 below.

Safe Haven or not?					
Commodities		Currencies		Bonds	
Gold	YES	USD	YES	UK	YES
Silver	NO	JPY	YES	Canada	NO
Copper	NO	CHF	YES	Germany	YES
Crude Oil	NO	GBP	NO	Spain	NO
Brent Crude Oil	NO	CAD	NO	Greece	NO
Natural Gas	NO	AUD	NO	Portugal	NO
Palladium	NO	NZD	NO	US	YES
Platinum	NO	ZAR	NO	Japan	NO
Heating Oil	NO				
RBOB Gasoline	NO	Bitcoin	YES		
Corn	NO	Ethereum	YES		
Oat	NO				
KCHRW Wheat	NO				
Rough Rice	NO				
Soybean	NO				
Lean Hogs	NO				
Live Cattle	NO				
Cocoa	NO				
Coffee	NO				
Cotton	NO				
Sugar	NO				

Table 1: Assets in the reference Pool and their classification.

After this price data on all of these assets has been downloaded, relative returns were calculated on daily basis and then separated for the individual crises' timeframes, which were chosen based on the method of Habib & Stracca. After this, indicators that were later used as features in the Naïve Bayes classifier were calculated for each crisis period. These finally included correlation with the MSCI World index returns, correlation with gold, correlation with US bonds and correlation with the US Dollar. Also, others such as the volatility (as standard deviation), beta value compared to the MSCI World, but also to the DAX, correlation with the DAX, with German bonds, Swiss Francs or Japanese Yen have been tried out. Ultimately these were not chosen as the model achieved worse results with combinations that included these features than without them, or in some cases they should not have been combined due to high correlation with other features and the others proved to be superior. These choices were made according to classification reports and cross-validation accuracy scores, actual examples of both can be seen in Figure 3 and Figure 4.

```

Accuracy on the Original Test Set: 0.8
Classification Report:

```

	precision	recall	f1-score	support
0	0.75	1.00	0.86	3
1	1.00	0.50	0.67	2
accuracy			0.80	5
macro avg	0.88	0.75	0.76	5
weighted avg	0.85	0.80	0.78	5

```

Confusion Matrix:
[[3 0]
 [1 1]]

```

Figure 3: Example of a classification report made during the analysis.

This classification report provides additional insights into the model's performance beyond accuracy, revealing precision, recall, and F1-score values for both classes. In this test set example of 5 assets 3 were non-safe haven (0) and 2 safe haven (1). The confusion matrix illustrates the distribution of correct and incorrect predictions, the model estimated 3 assets correctly as non-safe haven, 1 safe haven asset was correctly estimated, and 1 was falsely estimated as non-safe haven. Naturally as 4 out of 5 assets were estimated correctly the accuracy of 0,8 was achieved.

```

Cross-Validation Accuracy Scores:
[0.77777778 0.88888889 0.75      0.875      0.875      ]
Mean Cross-Validation Accuracy: 0.8333333333333333

```

Figure 4: Example of a Cross-Validation accuracy score made during the analysis.

In the presented cross-validation accuracy scores range from 0.75 to 0.89 and the mean accuracy is 0.83. Thus, the model seems to have fairly consistent performance, indicating its ability to generalize well.

In the end the best model had a test size of 0.1 (training size of 0.9) and achieved an accuracy of around 85% (an exact number can only be estimated for one run of the code, every time the code is re-run there is a slight difference in the results). Due to the partial imbalance of the dataset a fixed threshold of 0.25 is chosen (meaning that the classes are not divided half to half, but rather a quarter is assigned to safe havens and three quarters are given to non-safe haven assets – this also translates to normalized posterior probabilities, here 0.25 would be the threshold and not 0.5), in order to achieve the best predicting performance whilst still remaining on the safe side with just a slight tendency to get more false cyclical assets and less false safe

havens. Although this could be highly undesirable in some other contexts here it rather means a more cautious selection between the assets, which ensures that a cyclical asset could be selected with much lower probability.

5. Results

5.1 Predicting safe haven stocks with the Naïve Bayes classifier

Once the Naïve Bayes classifier is trained, tested, and deemed to have good (enough) results it can be used for predictions on assets out of the training sample. As explained in the methodology, mega cap and large cap stocks from firms operating in healthcare, utilities, and consumer staples. Together this dataset has thus included 3810 stocks. Once again, the price data has been downloaded, the desired crises timeframes were cut out, relative returns were calculated from the prices of the selected stocks, and the determined set of features (correlation with the MSCI World index returns, correlation with gold, correlation with US bonds and correlation with the US Dollar) was calculated. With these features predictions were made based on the best model from previous training of the Naïve Bayes classifier. Which has resulted in the following list of stocks:

Name	Exchange	Currency	Ticker
Medical System Network Co., Ltd.	Tokyo	JPY	4350.T
MTI Ltd	Tokyo	JPY	9438.T
Bikurey Hasade (Holdings) Ltd	Tel Aviv	ILA (0.01 ILS)	BKRY.TA
ELECTRA POWER (2019) LTD	Tel Aviv	ILA (0.01 ILS)	ELCP.TA
Arca Continental, S.A.B. de C.V.	Other OTC	USD	EMBVF
Intuitive Surgical, Inc.	XETRA	EUR	IUI1.DE
Japan Tobacco Inc.	Frankfurt	EUR	JAT.F
Kenon Holdings Ltd.	Tel Aviv	ILA (0.01 ILS)	KEN.TA
Neto M.E Holdings Ltd	Tel Aviv	ILA (0.01 ILS)	NTO.TA
Revolution Beauty Group plc	LSE	GBp (0.01 GBP)	REVB.L
SofWave Medical Ltd.	Tel Aviv	ILA (0.01 ILS)	SOFW.TA
Astellas Pharma Inc.	Frankfurt	EUR	YPH.F

Table 2: Predictions from the Naïve Bayes Classifier.

These predictions were then reviewed and filtered. Bankrupt companies, stocks with large numbers of missing data, or firms that were floated “too late”, after 31st of December 2017, and could therefore only display a small part of the data points were excluded.

Finally, one cannot forget that fluctuations in foreign exchange rates directly impact stock trading for foreign investors. When investing in foreign stocks, foreign exchange rate changes

affect the returns on investments due to currency conversion. Thus, it is possible that only the combination of a certain currency and a stock led to the desired safe haven effect. To remain on the safe side and to avoid considerations on heading strategies, which would be out of scope of this research, and which could or could not eliminate the safe haven properties, stocks that are not traded in US Dollars, Japanese Yen, Swiss Franc or Euro have also been excluded at this stage. The filtered results are listed here in Table 3.

Name	Exchange	Currency	Ticker
Medical System Network Co., Ltd.	Tokyo	JPY	4350.T
MTI Ltd	Tokyo	JPY	9438.T
Arca Continental, S.A.B. de C.V.	Other OTC	USD	EMBVF
Intuitive Surgical, Inc.	XETRA	EUR	IUI1.DE
Japan Tobacco Inc.	Frankfurt	EUR	JAT.F
Astellas Pharma Inc.	Frankfurt	EUR	YPH.F

Table 3: Filtered predictions from the Naïve Bayes Classifier.

5.2 Building portfolios

Comparisons with Wendlberger 2005-2019

Now when all relevant timeframes have been determined and all (potential) safe haven assets that shall be used within the portfolios are picked the process of building efficient portfolios can be initiated.

First the more realistic portfolio of Wendlberger has been replicated to create a reference point, here the method of Wendlberger has been followed to determine the crises periods (between 2005-2019). Unfortunately, whilst Wendlberger's portfolio that consisted out of 73% gold, 15% Japanese Yen and 12% US Bonds has been said to achieve a cumulative return⁸ of 0.28% the replica in this analysis achieved only 0.04% (and a standard deviation of 0.0002). One of the possible causes behind this could be a difference in the returns of US Bonds, since data on these has been obtained from another source, but without having access to the data Wendlberger has used in his analysis it is impossible to know exactly where the difference between the two lies.

⁸ All further portfolio returns within this subchapter 4.2.5 are cumulative returns the portfolios achieved during the periods of crises, p.a. returns are included in the appendices.

Next step was to analyse if a more efficient portfolio, i.e. portfolio with a higher sharpe ratio can be found under the same timing. This has indeed been possible, and lead to a portfolio with attributes that can be seen on the Figure 5.

An (new more) efficient portfolio

- Return: 0,0517% // Risk(Standard Deviation): 0,012959
 - Gold: 67,54%
 - US Bonds: 13,72%
 - German Bonds: 9,72%
 - CHF: 3,95%
 - USD: 2,83%
 - JPY: 2,24%

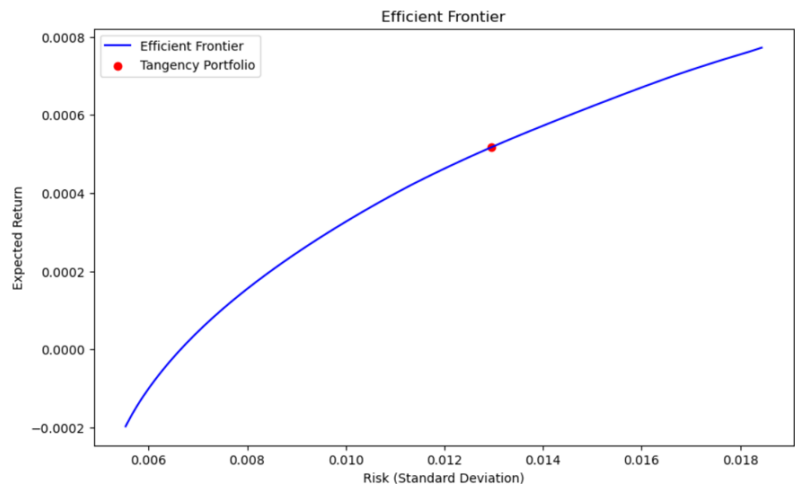


Figure 5: An efficient portfolio under Wendelberger's crises determination method and restricted assets (2003-2019).

At this point the same exercise can be done with the same restricted asset pool, but now with the methodology that has been and will be used throughout this study so that the differences between these two timings can be observed when everything else remains the same.

- Return: 0,0979% // Risk(Standard Deviation): 0,012601
 - US Bonds: 87,07%
 - Gold: 7,24%
 - German Bonds: 2,55%
 - CHF: 1,44%
 - JPY: 0,90%
 - USD: 0,80%

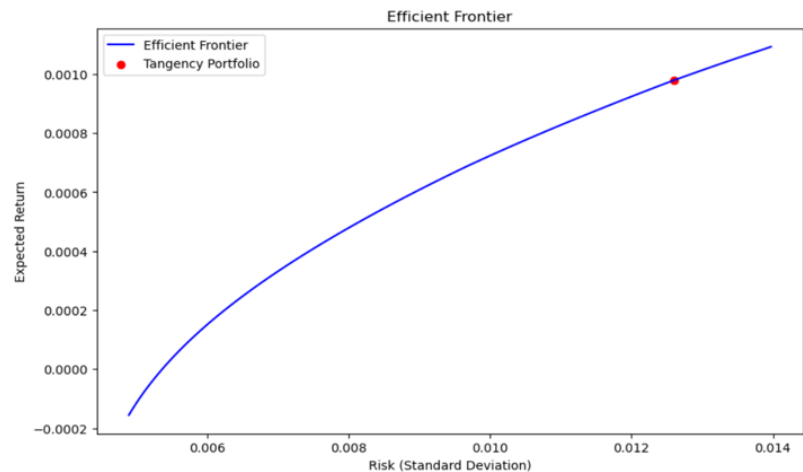


Figure 6: An efficient portfolio using only restricted assets (2003-2019).

Two interesting changes can be seen between these two portfolios. First, the second portfolio achieves a bigger return and second, the composition of the two portfolios is dramatically different. The first phenomenon is clearly linked with the inherent nature of safe haven assets and that is their negative correlation with the market (during the crises periods). Since the second portfolio was built using the method that captures only the biggest downturns, times when the returns of the market are highly negative, conversely this should be the moments

when an asset that is negatively correlated (at this time) has to achieve the largest (positive) returns. Again, the composition. The change in composition could have more explanations, but the “amount” of negative correlation is also a factor here. This time however, other factors could be at play, mainly the liquidity shock effect where the currencies and gold could prove to be more liquid and sold first at in times of need, which could arguably come up during the biggest downturns.

Restricted assets 2003-2022

A further step was to analyse the complete timeframe from 2003 to 2022. First with the descriptive ex-post method and then with the Gebert timing, the Figures below are also in this order. The difference between the restricted timeframe from above and the full one is evidently that the only remaining asset which seems to have maintained its attractiveness is the one of the US Bonds. Behind this is of course the negative development of the other assets during the crises the world faced in this three-year period. The exact reasoning as is hard to pinpoint, but some possible explanations have already been named in the chapter on recent developments in safe haven assets, for example the bigger correlation of gold (but also other safe haven assets) with the whole financial market in the recent years due to the changes in monetary and fiscal policy (Akhtaruzzaman et al., 2021).

- Return: 0,0939% // Risk(Standard Deviation): 0,012459
 - US Bonds: 100,00%

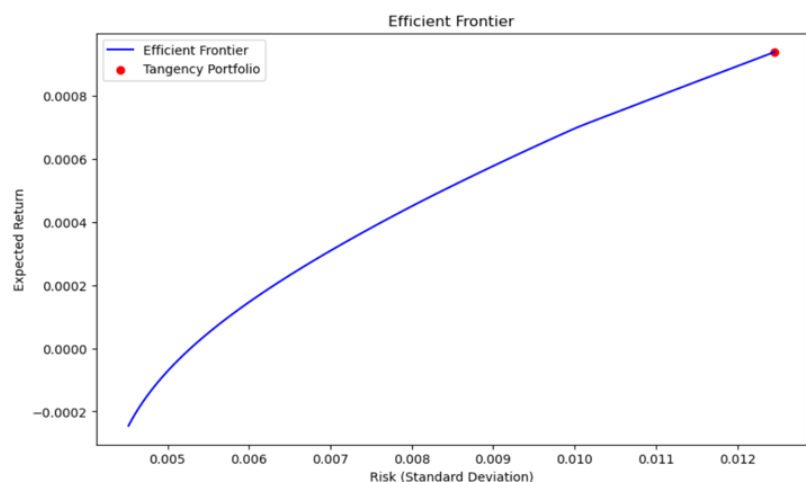


Figure 7: An efficient portfolio using only restricted assets (2003-2022).

Now we can shift the focus to the contrasts between the above portfolio and the one below, displayed on Figure 8, which is the result of the Gebert timing.

- Return: 0,0016% // Risk(Standard Deviation): 0,009570
- Gold: 81,96%
- US Bonds: 11,68%
- German Bonds: 2,43%
- USD: 1,38%
- CHF: 1,31%
- JPY: 1,24%

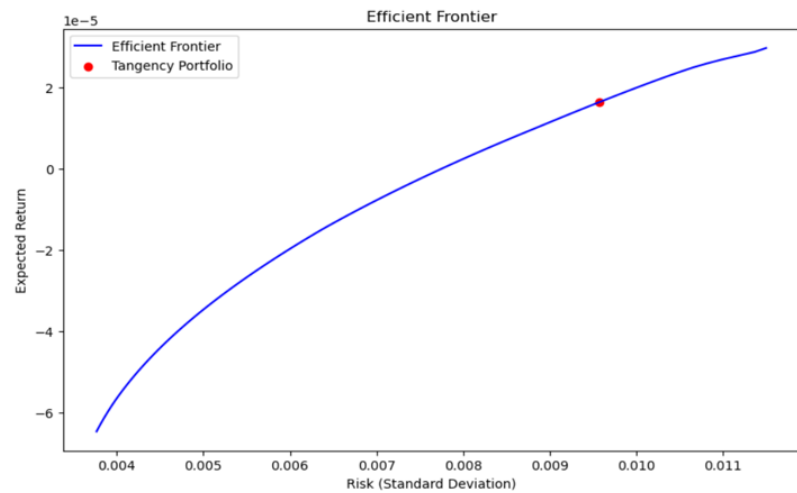


Figure 8: An efficient portfolio based on the Gebert timing with restricted assets only (2003-2022).

First of all, as expected the Gebert timing has resulted in noticeably lower returns accompanied with just slightly less risk (and thus a decrease in the sharpe ratio). This is of course the outcome of the change in timing, as the time of investment and divestment cannot and is not determined ideally with this method the resulting risk and return relationship is worse. Another easily observable change is the shift in composition of the portfolios. The main reason of course is that the Gebert timing does include large periods that are certainly not the ones with the biggest drops in asset prices, meaning that the chosen assets also need to behave well at certain times around or maybe even outside of the periods of crises. Another explanation could again be attributed to the changes hinted above resulting from the fiscal and monetary policies, which have even more influence in this larger and less precise timeframe.

All assets 2003-2022

The analysis above with restricted assets did not only enable us to compare more easily with Wendlberger, but also made it possible to see hints of the effects and phenomena mentioned in the literature review. In the following parts of this study these are arguably harder to see but are most certainly still highly relevant. Again, also in this part the portfolio made with the ex-post method is shown first and the one built using the Gebert timing follows.

Here the most interesting highlight visible in both portfolios manifests itself. In the presented portfolios the desired outcome has been a portfolio with the highest possible sharp ratio. And with the inclusion of more assets a higher diversification effect can be achieved. Thus,

the portfolios below achieve higher sharpe ratios. In other words, a portfolio with the same return is accompanied by lower risk and a portfolio with the same risk level can attain higher returns.

The diversification effect is of course also visible on the asset weights, which have become smaller. With lower weights one asset naturally has a lower effect on the whole portfolio, which can be desirable under certain circumstances.

Return: 0,40% // Risk(Standard Deviation): 0,0267

- US Bonds: 68,45%
- VIX: 19,13%
- Astellas Pharma: 8,43%
- Japan Tobacco: 3,99%

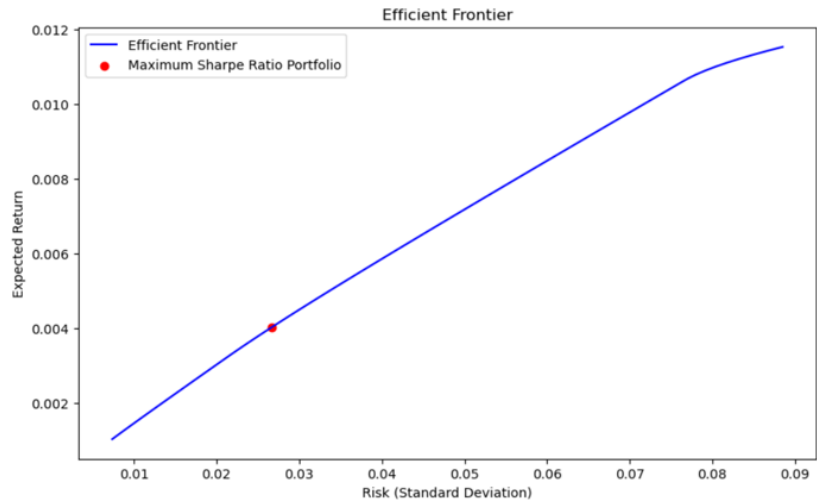


Figure 9: An efficient portfolio with all assets (2003-2022).

When comparing the two portfolios the same expectable/anticipated phenomena are present. The first portfolio has a larger return and similar changes to the composition occur. It is once more visible that US bonds were more appealing in the first one, but in the second one they had a lower weight. Similarly, the opposite shift occurred with Gold, Currencies and the German bonds. Apart from VIX, where it is clear that its price and thus returns are higher with bigger uncertainty in the market (and this is of course bigger in the first one as in the second it averages out with the less adverse times included in the Gebert timing), reasons behind the movement of weights of other assets are hard to pinpoint.

Return: 0,0943% // Risk(Standard Deviation): 0,083972

- Japan Tobacco: 33,11%
- BTC: 4,92%
- Arca Continental: 4,89%
- ETH: 4,89%
- Medical Systems Network: 4,89%
- US Bonds: 4,88%
- Gold: 4,88%
- CHF: 4,87%
- German Bonds: 4,87%
- UK Bonds: 4,87%
- USD: 4,87%
- JPY: 4,87%
- MTI: 4,81%
- VIX: 4,74%
- Astellas Pharma: 3,63%
- Intuitive Surgical: 0,00%

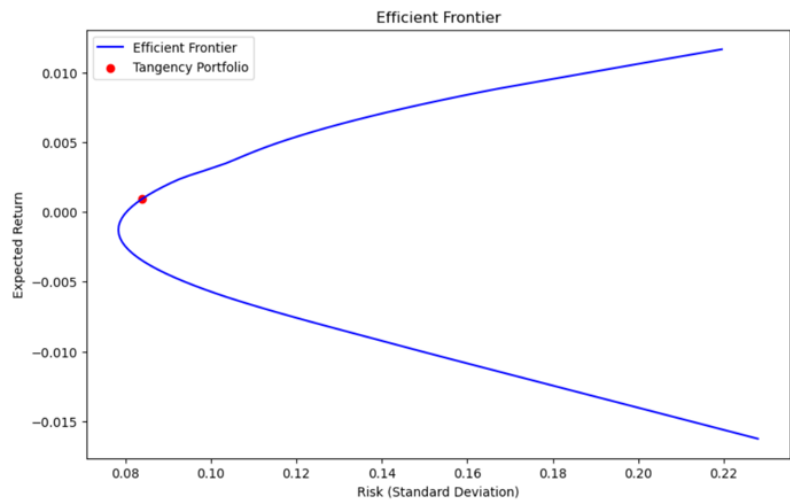


Figure 10: An efficient portfolio based on the Gebert timing with all assets (2003-2022).

Dynamized portfolios 2003-2022

Knowing that the differences caused by changes in investment timing to the more realistic approach of an investor, who tries to remain informed and invests following the timing based on the Gebert indicator, lead to worse results (decrease in sharpe ratios, decrease in returns and/or increase in risk). It might be tempting to try and improve upon these by trying to utilize further information, which could be known by an investor who would try to follow the news around the Gebert indicator. If we suppose he is able to observe the sub-indicators he could try and distinguish between crises periods based on if they have been assigned points in the sub-indicators.

Looking at the sub-indicators it can be concluded that perhaps the most information can be pulled out of the duo of interest rates and inflation. There are essentially three possible relative outcomes of these two sub-indicators.

The first is Interest point > Inflation point, which is a past reduction in interest rates and an increase in inflation. Together it is plausible that this could lead to an increase in inflationary pressure.

The second is the opposite situation, when Interest point < Inflation point. This represents a past increase in interest rates and a reduction in inflation. Here it could be reasonable to assume that this could result in a decrease in inflationary pressure.

Third would be the state when Interest point = Inflation point, this could have been both a simultaneous decrease in inflation and interest rates, but also a concurrent increase. Either way it is impossible to know what this could result to, because we do not know the magnitudes of the changes and other details. However, it can be argued that the (monetary) policy is aligned with the economic trends at these points in time. Which could have led or will lead to a more stable economic environment than the previous two situations.

With the restricted set of assets this last constellation has led to a portfolio consisting solely out of US Bonds. This could again be due to the changes in policy and the quickness of its execution that has led to higher correlations of Gold with the market (Akhtaruzzaman et al., 2021).

Return: 0,0088% // Risk(Standard Deviation): 0,009083
 • US Bonds: 100%

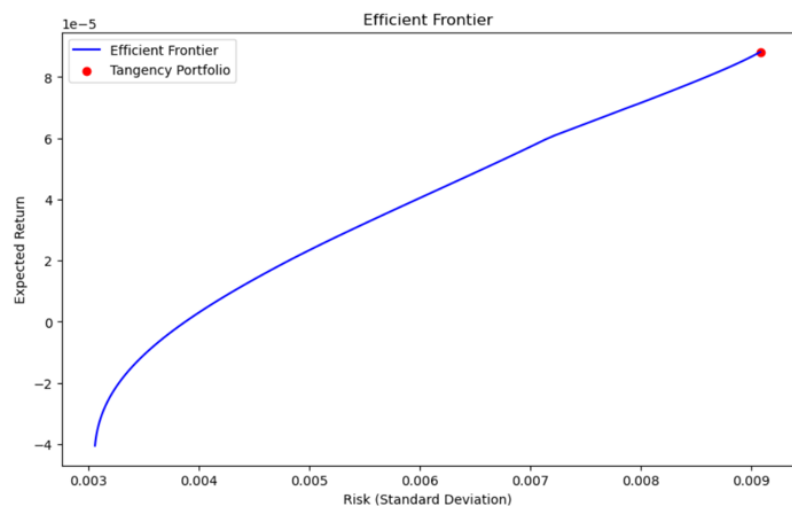


Figure 11: A dynamized portfolio with restricted assets when Interest point = Inflation point (2003-2022).

An exact opposite can be observed in the other two portfolios, where the policies are not aligned with the inflationary trend. It is more prevalent in the portfolio chosen for periods of high inflationary pressure. Bonds and currencies naturally lose attractivity at these times and gold rises to the forefront, leading to a portfolio consisting only of Gold.

Return: 0,0219% // Risk(Standard Deviation): 0,010541

- Gold: 100%

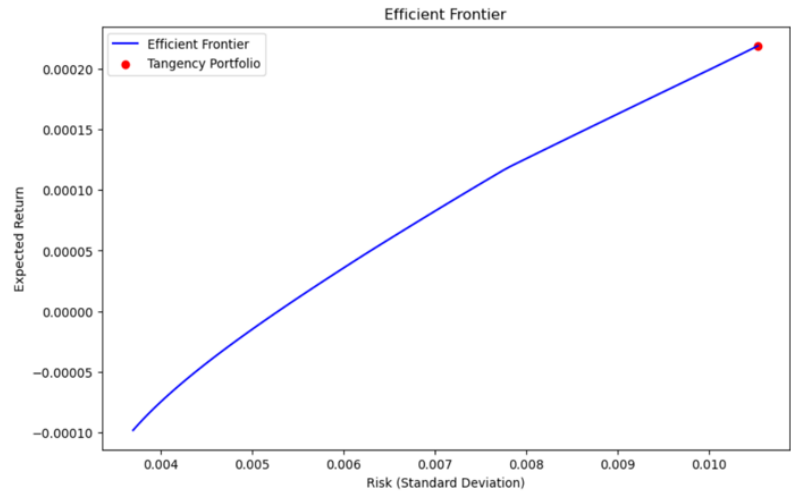


Figure 12: A dynamized portfolio with restricted assets when Interest point > Inflation point (2003-2022).

In the third portfolio, which shall be the best at times of decrease in inflationary pressure, also gold is not as dominant and investments into currencies and bonds are also interesting.

Return: 0,0042% // Risk(Standard Deviation): 0,004177

- Gold: 45,92%
- US Bonds: 24,78%
- German Bonds: 15,04%
- USD: 7,82%
- CHF: 3,83%
- JPY: 2,61%

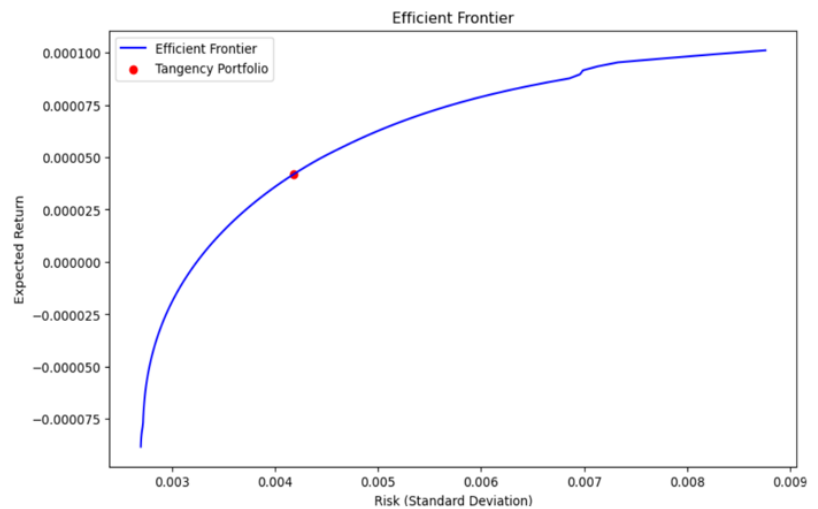


Figure 13: A dynamized portfolio with restricted assets when Interest point < Inflation point (2003-2022).

Looking at the portfolios with all assets these effects are not observable since the dominant stocks of Japan Tobacco and Astellas Pharma have overshadowed everything else. If they would be excluded their parts would not just be split between the rest of the portfolio equally but would tend to be allocated towards the other assets with similar effects as above, so for example in the periods with increasing inflationary pressure gold would be preferred again (thus this would be the same as above) and in the first portfolio Bitcoin would replace US Bonds as the only asset (and achieve a return of 0.0219% and have a standard deviation of 0.010541). The third portfolio would again be more complex in composition (it can be found in the appendix and has a return of 0.0560% and standard deviation of 0.009612).

Return: 1,1403% // Risk(Standard Deviation): 0,209782

- Japan Tobacco: 96,77%
- Astellas Pharma: 0,79%
- BTC: 0,20%
- Arca Continental: 0,19%
- ETH: 0,19%
- Gold: 0,19%
- US Bonds: 0,19%
- German Bonds: 0,19%
- UK Bonds: 0,19%
- USD: 0,19%
- CHF: 0,19%
- Medical Systems Network: 0,19%
- JPY: 0,19%
- MTI: 0,17%
- VIX: 0,17%
- Intuitive Surgical: 0.00%

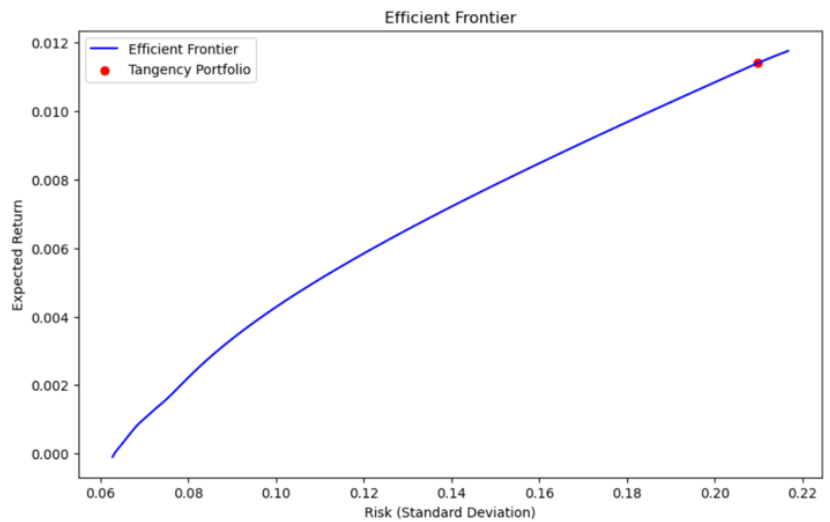


Figure 14: A dynamized portfolio with all assets when Interest point = Inflation point (2003-2022).

Return: 1,5188% // Risk(Standard Deviation): 0,265978

- Japan Tobacco: 100,00%

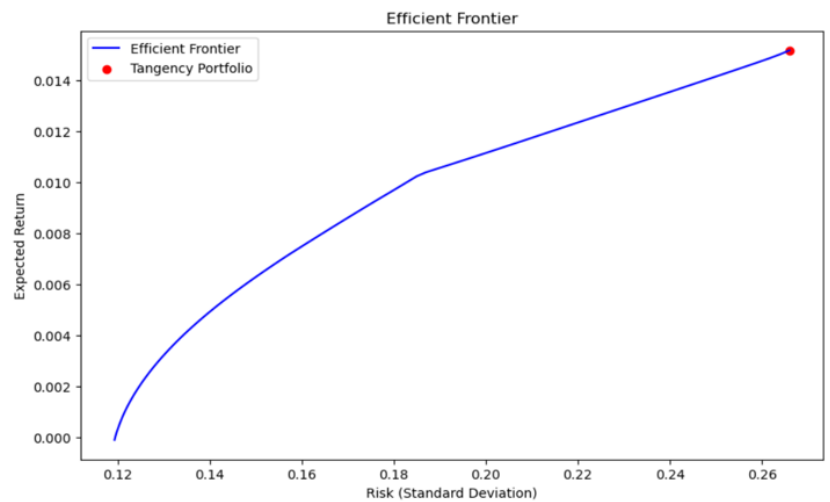


Figure 15: A dynamized portfolio with all assets when Interest point > Inflation point (2003-2022).

Return: 0,3489% // Risk(Standard Deviation): 0,055781

- Astellas Pharma: 49,08%
- Japan Tobacco: 9,17%
- Arca Continental: 4,91%
- MTI: 4,54%
- ETH: 3,84%
- BTC: 3,54%
- Gold: 3,15%
- US Bonds: 3,15%
- German Bonds: 3,12%
- UK Bonds: 3,06%
- USD: 3,04%
- CHF: 2,92%
- Medical Systems Network: 2,85%
- JPY: 2,84%
- VIX: 2,48%
- Intuitive Surgical: 0.00%

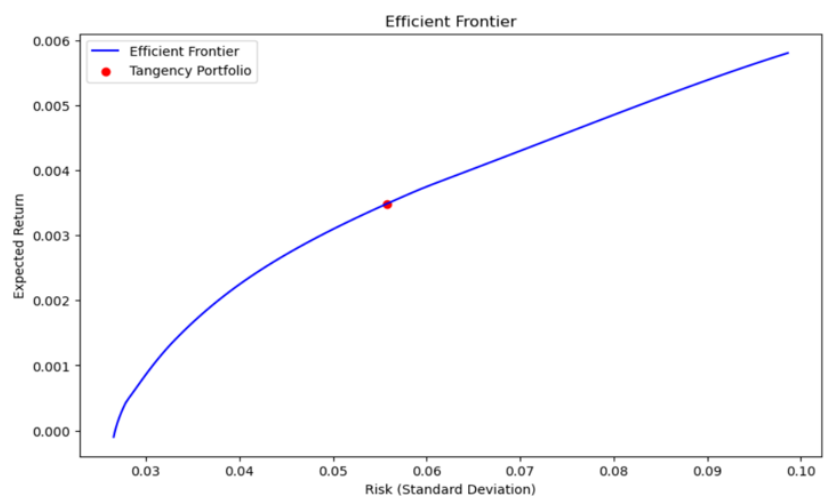


Figure 16: A dynamized portfolio with all assets when Interest point < Inflation point (2003-2022).

Other than that, we again see that inclusion of more assets leads to higher sharp ratios.

The main goal of improving against the case where there has been no differentiation based on the sub-indicators will be best seen in the next part, performance comparison.

5.3 Performance comparison

The performance comparison has to start with the reference strategy of buy and hold of the DAX index, this fully passive strategy delivers a cumulative return of 264.38% (7.45% p.a.). A second and in our case more important reference value is formed by the investment strategy of buying and selling of the DAX based on the timing provided by the Gebert indicator and is equal to 310.80% (8.17% p.a.). From the selected portfolios only the one with restricted assets did not manage to outperform the Gebert reference cumulative return and that only by around 2.52 percentage points as the strategy using this portfolio managed to get a cumulative return of 308.28% (8.13% p.a.). All others outperformed the reference values and also the expectations of higher returns for the strategies with dynamic asset allocation than their static counterparts have been fulfilled. The dynamic asset allocation with restricted assets only achieved a cumulative return of 339.55% (8.57% p.a.), which is approximately 21.27 percentage points more than the static variant. The one utilizing the whole asset pool achieved the highest cumulative return 359.90% (8.85% p.a.), this is about 23.82 percentage points more than the cumulative return of 326.08% (8.39% p.a.) of the static variant with all assets.

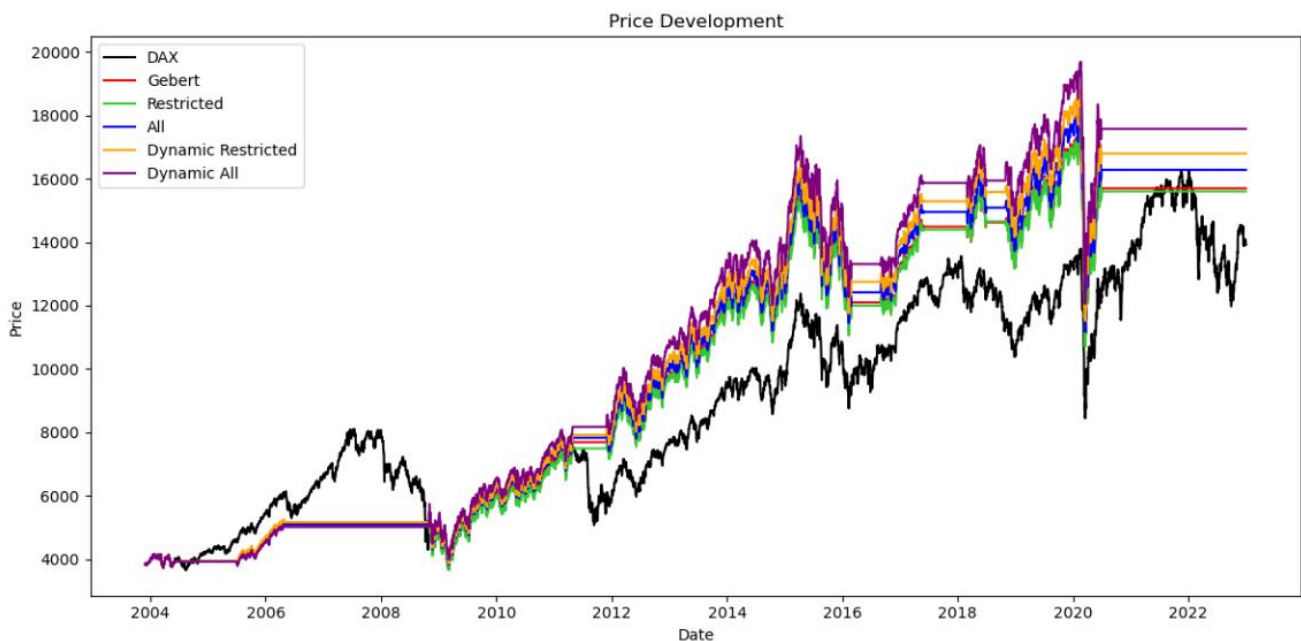


Figure 17: Performance comparison (2003-2022).

At this point it is possible to make and illustrate the comparison between the previously presented (more) realistic timing expectations and a scenario when an investor could forecast the exact start and end dates of crisis based on the descriptive ex-post method (which is of course

completely unrealistic) to visualize and underline the answer to the last but perhaps central research question. Even if such an investor only had the restricted asset pool, he would achieve a cumulative return of 1445.83% (16.43% p.a.). This is of course the result of being able to avoid (at least a large part of) the impact of the major slumps whilst taking advantage of the increasing market prices from the first day of recovery until the last day before a crisis. These results are far from reach of even the most successful scenario using the Gebert timing.

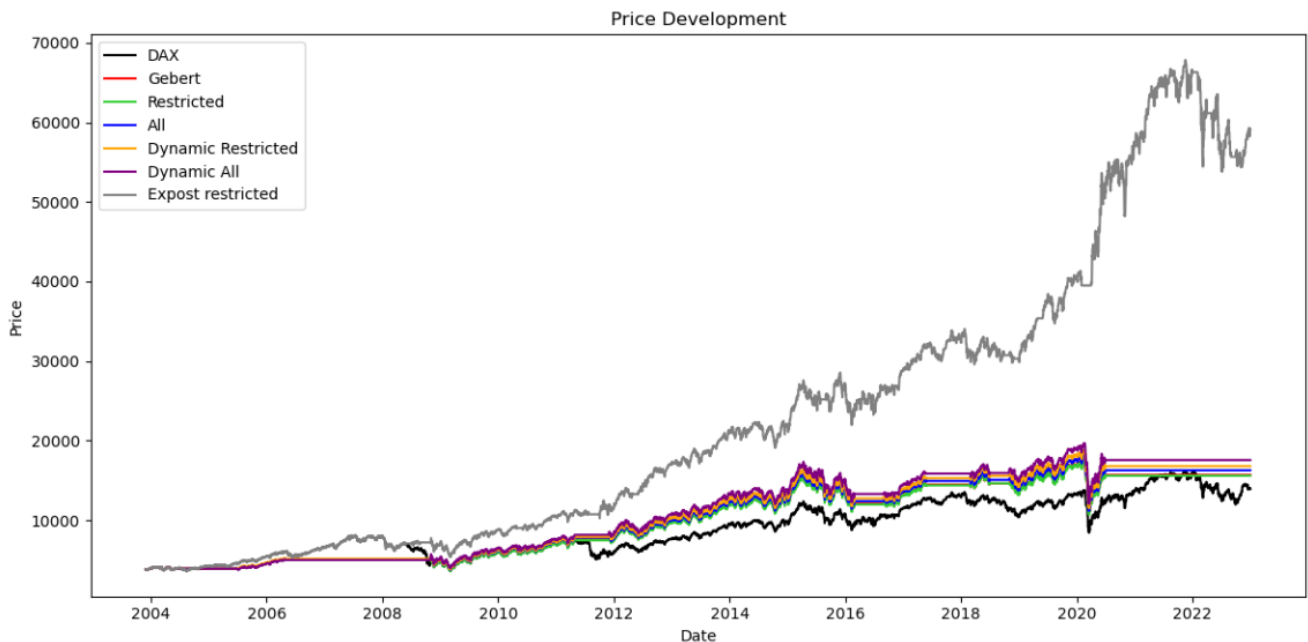


Figure 18: Performance comparison including unrealistic ex-post timing (2003-2022).

Further visualizations with less strategies in one graph (for better legibility) can be found in the appendices.

6. Critical Reflection and Conclusion

6.1 Limitations

The analysis presented above is based and thus reliant on price data on the individual assets. The methods of obtaining data and the chosen structure have already been described above, however at this point it is necessary to state that the analysis can only be as good as the data inputs. The limitations of data availability have already been partially addressed, but the largest are worth mentioning again. Firstly, the examined timeframe from 2003 until 2022 had to be chosen due to unavailability of data on many crucial assets before the start of this period. Similarly, some equities had to be excluded because of the small amount of data available.

Furthermore, it is assumed that the obtained price data is right and does not include any hidden mistakes or misinformation, should this not be the case within the price data on the numerous stocks it would probably be overlooked due to the fact that such a large dataset is impossible to inspect manually as a whole.

The selection of the inspected equities has also relied on rather heuristic assumptions as the availability of data on liquidity is rather limited. This is of course not only a problem in the selection of the pool of equities, but also at other points in the analysis such as determining of the crisis's timeframes, or the inability to use a such features in the Naïve Bayes classifier.

Moreover, the selection of assets that are considered to be safe haven and are used within the training and testing data for the Naïve Bayes classifier was based on academic literature. However, a scientific consensus is not always found and sometimes assumptions are made on what seems to be a majority opinion. A further level of complexity is added by the fact that each considered study was done at different times or under different economic circumstances and with another methodological approach. And although a rather conservative approach is taken to avoid the inclusion of assets that might not be safe haven this could also lead to omission of assets that should have been considered as safe haven, which could have had an impact on the results of the analysis as a whole.

Lastly this analysis is only theoretical and omits transaction costs, spreads and fees that could and would apply in the real world, also no tax considerations are made. As the achieved returns are rather small during the individual crisis even in this theoretical setting it could happen that in the real world they would be overshadowed by the transaction costs and thus making so many trades might not be the most profitable solution in the end.

6.2 Conclusion

The purpose of this thesis was to review and extend the findings on safe haven portfolios made by Sandro Wendlberger. The thesis had three objectives, the first was to incorporate current trends in safe haven assets and include the impact of the crises following the outbreak of COVID 19. The second dealt with the dating of crises and the abilities of an investor to predict

and time the buying and selling of safe haven assets. The third objective was to dynamize the allocation of assets within the safe haven portfolio based on the characteristics of a given crisis.

The thesis includes a literature review that does not only provide a categorization and an overview of the most common safe haven assets and their attributes, but also includes an excursus into crises and a subchapter dealing with the recent developments in safe haven assets. Especially these two parts contributed towards the completion of the first objective and together with the results of the empirical analysis it is possible to see that the demand for individual safe haven assets does not only vary throughout time but also reflects economic realities. Thus, it can be pointed out that out of the usual suspects gold and the select currencies (US Dollar, Japanese Yen, or Swiss Franc) have relatively lost attractiveness compared to US Bonds, but also that new assets, cryptocurrencies, especially Bitcoin and Ethereum have managed to gain (at least some) safe haven properties and establish themselves as demanded assets in times of crises.

Together with the cryptocurrencies the addition of equities based on a machine learning selection using the Naïve Bayes classifier has proved to be beneficial as it increased the sharpe ratios (in our case, but it could have made the portfolio returns higher or decreased risk) and thus achieved the desired outcome.

Next the timing methods were compared, and here the results did not surprise, as even the most restricted and thus worst performing portfolio that used the ex-post timing outclassed the ones using the Gebert timing. Leading to the conclusion that the use of such descriptive methods makes sense only under very strong assumption, which usually cannot be fulfilled in reality. This of course limits the practical implications of results achieved by such descriptive methods. Another noticeable difference was that the portfolios with comparably worse timing generally made use of more assets (with more balanced weights) which leads to more diversification effects. This is logical as in a longer timeframe (that also includes times other than the peak crises periods) diversification of unsystematic risk makes much more sense than in cases where the crises periods are relatively sharply determined and when the market risk should dominate.

Lastly a dynamized asset allocation based on the indicators showing a relatively higher or lower possibility of inflationary pressure has led to higher sharpe ratios (but this could again be higher returns or decreased risk, based on what is the desired outcome). This again highlights that even safe haven assets perform differently based on the current economic situation and mainly the policies and steps taken by regulators, central banks, or governments.

Together the results of the conducted analysis presented in this thesis hint that although a moderate amount of protection against market downfall can be achieved by following generalized solutions an investor could largely benefit from obtaining more information on the current economic realities, government policies and trends in various (safe haven or other investment) assets.

Of course, there are numerous ways how this analysis could be extended. One of these would be to introduce liquidity measures both to determine the times of crises as periods of illiquidity and as an inclusion or exclusion criterium for the assets themselves. This could also provide more opportunities for grouping of crises under different types and thus another type of dynamic asset allocation.

Another interesting extension would be the use of large language models to derive the investment timing based on prevailing investor sentiment in news, articles, or relevant posts on social media. This could once more be a step closer to the perception of the economic realities by an actual investor and could thus result in even more realistic timing.

Lastly as already evident from this study, there are always surprising events, changes in the economy, novel ways of regulation, or new assets on the rise. Thus, after another or few another crises new data emerges under a different set of circumstances which could make another analysis of these new trends and changes interesting.

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8. Appendices

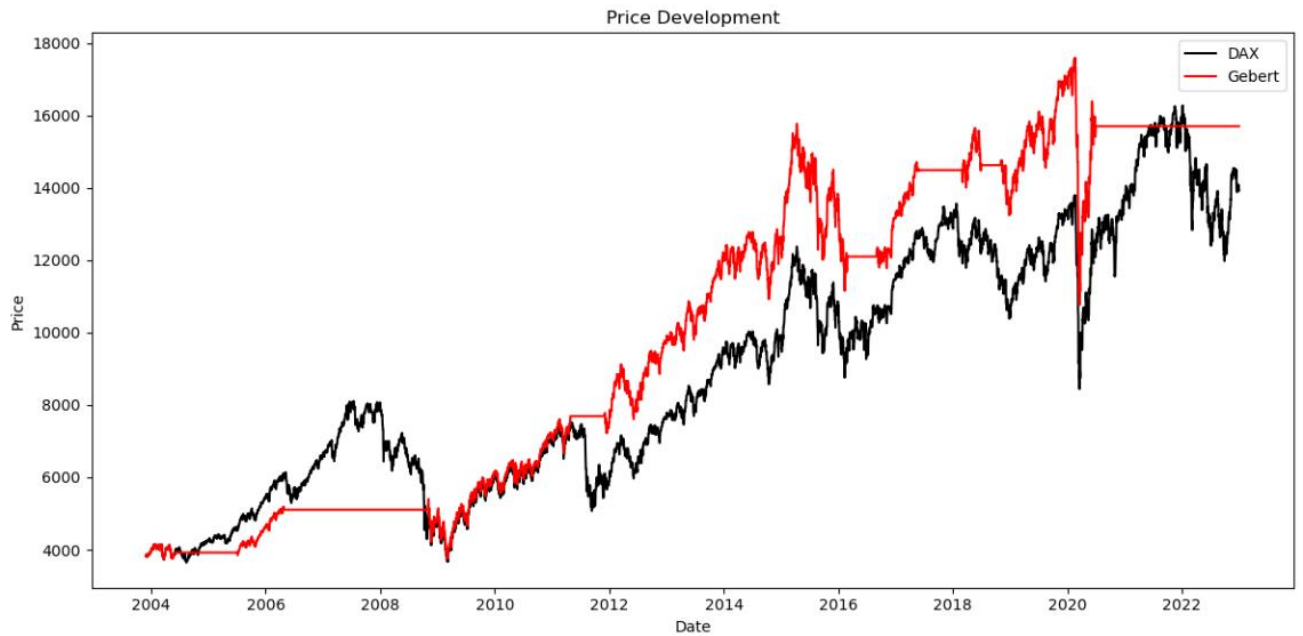
1. Per annum returns of the portfolios from subchapter 4.2.5:

		Cumulative return	Return p.a.
Static	Wendlberger original (2005-2019)	0.28%	0.0027375%
	Wendlberger reconstructed (2005-2019)	0.04%	0.0003911%
	Restricted (Wendlberger timing, 2005-2019)	0.0517%	0.0003931%
	Restricted (ex-post timing, 2005-2019)	0.0979%	0.0007444%
	Restricted (ex-post timing, 2003-2022)	0.0939%	0.0007140%
	Restricted (Gebert timing, 2003-2022)	0.0016%	0.0000122%
	Unrestricted (ex-post timing, 2003-2022)	0.40%	0.0030417%
	Unrestricted (Gebert timing, 2003-2022)	0.0943%	0.0007171%
Dynamic	Restricted, Interest point = Inflation point (Gebert timing, 2003-2022)	0.0088%	0.0000669%
	Restricted, Interest point > Inflation point (Gebert timing, 2003-2022)	0.0219%	0.0001665%
	Restricted, Interest point < Inflation point (Gebert timing, 2003-2022)	0.0042%	0.0000319%
	Unrestricted, Interest point = Inflation point (Gebert timing, 2003-2022)	1.1403%	0.0086709%
	Unrestricted, Interest point > Inflation point (Gebert timing, 2003-2022)	1.5188%	0.0115490%
	Unrestricted, Interest point < Inflation point (Gebert timing, 2003-2022)	0.3489%	0.0026531%

2. A dynamized portfolio with all assets when Interest point < Inflation point (2003-2022):

Tangency Portfolio:
 Return: 0.000560
 Risk: 0.009612
 Weights:
 IUI1.DE: 0.000000
 9438.T: 0.301574
 4350.T: 0.052259
 EMBVF: 0.061198
 VIX: 0.042668
 USD: 0.056988
 JPY: 0.051926
 CHF: 0.053952
 Gold: 0.059611
 BTC: 0.068637
 ETH: 0.075344
 UKGiltIndex: 0.057366
 Germany: 0.058989
 US: 0.059488

3. Comparison of DAX buy and hold, and investment strategy based on the Gebert indicator (2003-2022):



4. Comparison of DAX buy and hold, and investment strategy based on the Gebert indicator and the two strategies additionally buying safe haven assets in the time when Gebert sells DAX, one with restricted safe haven assets only and one with all(2003-2022):

