Optimized Portfolios, Hedge, and Inflation: The Case of Turkey

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Banking and Finance

Eastern Mediterranean University
September 2023
Gazimağusa, North Cyprus

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ABSTRACT

This thesis unfolds in three successive phases, considering the pivotal role of inflation in investors' decisions, particularly in the Turkish economic landscape. The first phase examines the hedging potential of several asset classes, namely gold, foreign currencies, real estate, and the stock market, in light of escalating inflation rates in Turkey. Following the identification of viable hedging instruments, optimized portfolios are formed in the second phase using Sharpe ratio and CVaR optimization techniques. In the final phase, the interaction between the realized returns of these optimized portfolios and the Economic Confidence Index (ECI) is examined. Different quantiles of conditional distributions, as well as time domain and frequency domain are considered. Methods such as quantile correlation, dynamic conditional correlation and wavelet coherence are applied. This comprehensive study not only contributes to the existing body of knowledge through its unique methodology, structure, and variable selection, but also offers practical insights for investors at times when large shocks to the economy are expected.

Keywords: ECI, Inflation Hedging, Optimized Portfolios, CVaR

ÖZ

Bu tez, özellikle Türkiye'nin ekonomik ortamında enflasyonun yatırımcıların kararlarındaki önemli rolünü göz önünde bulundurarak birbirini takip eden üç aşamada ortaya çıkmaktadır. İlk aşamada, Türkiye'de artan enflasyon oranları ışığında altın, yabancı para birimleri, gayrimenkul ve borsa gibi çeşitli varlık sınıflarının riskten korunma potansiyeli incelenmektedir. Uygun riskten korunma araçlarının belirlenmesinin ardından, ikinci aşamada Sharpe oranı ve CVaR optimizasyon teknikleri kullanılarak optimize edilmiş portföyler oluşturulmaktadır. Son aşamada ise bu optimize portföylerin gerçekleşen getirileri ile Ekonomik Güven Endeksi (ECI) arasındaki etkileşim incelenmiştir. Koşullu dağılımların farklı kantillerinin yanı sıra zaman alanı ve frekans alanı da dikkate alınmıştır. Kantil korelasyonu, dinamik koşullu korelasyon ve dalgacık tutarlılığı gibi yöntemler uygulanmıştır. Bu kapsamlı çalışma, özgün metodolojisi, yapısı ve değişken seçimi ile mevcut bilgi birikimine katkıda bulunmanın yanı sıra, ekonomide büyük şokların beklendiği zamanlarda yatırımcılar için pratik bilgiler de sunmaktadır.

Anahtar Kelimeler: ECI, Enflasyondan Korunma, Optimize Edilmiş Portföyler, CVaR

ACKNOWLEDGMENT

I express my deepest gratitude to my dear supervisor Assist. Prof. Dr. Nigar Taşpınar for her invaluable guidance and support throughout this journey.

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Chapter 1

INTRODUCTION

Consumption-based asset pricing models take into account another aspect of investor behavior. Such models rely heavily on the consumption-based definition of an investment process, where investment is simply defined as the procrastination of current consumption and the allocation of resources resulting from this consumption postponement with an expectation of higher future consumption. According to this perspective, not only is the expected risk-premium a function of the asset's risk, also a function of the volatility in the future consumption. Therefore, the perceived value of the assets by investors also depends on the risk in the investors' future consumption. Consequently, the inflation is one of the factors that an economic agent must contend with in the struggle to achieve higher returns while lowering risk. Inflation refers to the phenomenon of consistent rise in general price levels of goods and services in the scope of the respective economy. It can thus be measured by the change in the Consumer Price Index (CPI) or other available price indices. Recently, we have witnessed the inflation rate to soar in Turkey. Even though this surge is attributed to several factors, the gradual cut in the central bank's policy rate stands out as an underlying reason for this rise.

This study, based on the nontrivial role of inflation in investors' decisions, consists of three stages. In the first stage, we verify the hedging possibilities of different asset classes, namely gold, foreign currencies, real estate and stock market against inflation in Turkey. The selection of the asset classes under investigation is based on the literature on inflation hedgers. We use the price of gold in the open market in Turkey (Gold), the historical value of the USD/TRY currency pair (USD_TRY), the Real Estate Investment Trust (REIT) index and the BIST 100 index to represent the mentioned asset classes in Turkey. We follow the approaches outlined in Salisu et al. (2020) and Hoang et al. (2016) to investigate the potential hedging power of these variables, which allow us to account for the presence of heteroscedasticity, structural breaks and asymmetry in series. We, therefore, estimate two strands of models: in the first model, we use the definition of Shin et al. (2014) to define asymmetry in return series and employ Feasible Generalized Least Squares (FGLS) approach of Westerlund and Narayan (2012) after taking care of structural breaks. The second model, however, operates on level series, where we make use of the Auto Regressive Distributed Lag (ARDL) model (Pesaran & Shin, 1999; Pesaran et al., 2001), and Non-linear ARDL of Shin et al. (2014).

Based on different perspectives, three definitions of an inflation hedge could be made (Bodie, 1976). In the first definition, the asset is considered as a hedge if the probability of its real return to be less than a cut-off point (generally zero) is statistically trivial. The second definition, however, focuses on the second moment of distribution. An asset is called an inflation hedge based on its effectiveness in the proportional reduction of the variability of a default-free bond's real returns when a portfolio of the asset and the default-free bond are considered. Ultimately, the last perspective defines the hedger as an asset with real returns independent of inflation. Consequently, a positive correlation between nominal returns of the asset and inflation. The correlation of one between returns and inflation implies that the increase in the price levels are completely compensated with an increase in the asset return. Such assets are called a perfect hedge. It is worth considering that a positive return-inflation relationship still could introduce the asset as an effective hedge against inflation. Following the extensive literature founded on the third definition, we adopt this definition to investigate the hedging ability of the selected variables.

In the second stage, portfolios are formed from the assets that proved to be hedges in the first stage. We focus on the retail investors' point of view and try to model how retail investors should have invested in hedgers to optimize their portfolios. The importance of such portfolios becomes even more highlighted when we consider the current sentiment and uncertainty existing in the Turkish economy due to galloping inflation. Such portfolios offer retail investors with lower risk appetite the opportunity to preserve or even increase their purchasing power. We consider two approaches of thinking about investors' loss perception and risk aversion to find the optimized portfolio proportions using Sharpe Ratio (SR) and Conditional Value at Risk (CVaR). SR builds on the standard deviation of the risk premium. It thus captures both positive and negative volatilities around the expected return. On the other hand, CVAR focuses heavily on negative deviations from the mean and thus specializes in including potential loss in the definition of risk. Since both perspectives on risk, either positive and negative volatilities or only negative deviations, are common among investors, we use both measures in this study.

Consequently, we optimize the portfolios twice with two different objectives: Maximizing the SR (Markowitz, 1952; Sharpe, 1966) and minimizing the CVaR (Krokhmal et al., 2001). For this purpose, we employ rolling window portfolio optimization technique with a window length of four years. This technique helps us avoid the look-ahead bias in its full capacity. The choice of four years as the length of the time window is not limited to avoiding biased estimates of standard errors. It also aims to capture short-term and longer-term patterns in the time series to provide a more comprehensive picture of the series.

Portfolio optimization techniques yield the best portfolio among a finite possible set of portfolios given an objective. The objective is generally determined based on the investors'risk profile, their requirements and preferences. In this study, the objectives are the maximization of SR and the minimization of CVaR. SR or reward to variability (volatility) was first introduced in Sharpe (1966) as a measure of investment performance. SR indicates the excess return per each unit of realized risk. Alternatively, SR is defined as the expected risk premium per each unit of risk in a probabilistic space. Given the rationality of investors, higher SRs are preferred since it implies higher return per one unit of risk or, equivalently, lower risk per each unit of return. On the other hand, contrary to VaR that fails to meet some of the requirements of a coherent measure of risk in the sense of Artzner et al. (1999), CVaR extends VaR as a coherent measure of risk (Rockafellar & Uryasev, 2002). Simply put, CVaR characterizes the expectation of returns that fall below VaR. In contrast with standard deviation, that captures both upside and downside risk, CVaR is particularly focused on downside risk. This pronounces the CVaR's importance as it aligns with the loss-aversion nature of humans.

In the third stage, the realized portfolio returns are extracted to form the inflation premium (GAP) time-series. In this study, the inflation premium serves as an indicator of how well the optimized portfolios perform in an inflationary environment. Furthermore, given that high level of inflation, sentiment, and uncertainty are closely associated we also examine the dependence of GAP and the Economic Confidence Index (ECI) in Turkey to assess the joint movement of confidence in the economy (as a function of sentiment and uncertainty) and the GAP series. This also helps us to develop an investment strategy that protects investors in times of strong economic shocks.

Sentiment refers to beliefs about future cash flows (and consequently risk) that fundamental factors fail to justify. Such beliefs could be formed by investors' emotions due to various potential environmental factors. Birru and Young (2022) documented more powerful role of sentiment in financial markets when economic agents experience a high level of uncertainty about future. Hence the association of uncertainty and sentiment. Furthermore, in an inflationary environment or in times of crisis the uncertainty and sentiments reach their peak. In this study, we employ ECI to capture the effect of both sentiment and uncertainty in Turkey. Basically, we pose the question that how would an optimized portfolio of hedgers react to relatively low level of confidence in economy.

As a first step, this study aims to examine the hedging ability of a selected set of proxies that serve as representatives of different asset classes in Turkey. Although the literature is enriched with such studies, the mixed results on the hedgeability for a given asset class and the lack of a comprehensive study for different asset classes justify our first step. To determine whether an asset is an inflation hedge in Turkey, we follow the approaches described in Salisu et al. (2020) and Hoang et al. (2016). Moreover, to the best of our knowledge, this step extends the current literature in terms of methodology and variable selection for the case of Turkey. In the second step, we form optimized portfolios from the asset classes that have been shown to be hedgers in the first step. We follow the empirical Critical Line Algorithm (CLA) of Markowitz (1952) and the CVaR optimization proposed by Krokhmal et al. (2001). In the third step, we employ the realized return derived from the optimized portfolio and study its interaction with the ECI, taking into account different locations in the conditional distributions as well as the time and frequency domains. For this purpose, we use various methods such as quantile correlation (Choi & Shin, 2021), dynamic conditional correlation (Engle, 2002), and wavelet coherence (Torrence & Webster, 1998; Grinsted et al., 2004). In summary, to the best of our knowledge, the methodology, variable selection, and structure of this study contribute to its uniqueness compared to the literature. Figure 1.1 shows a brief overview of each step.

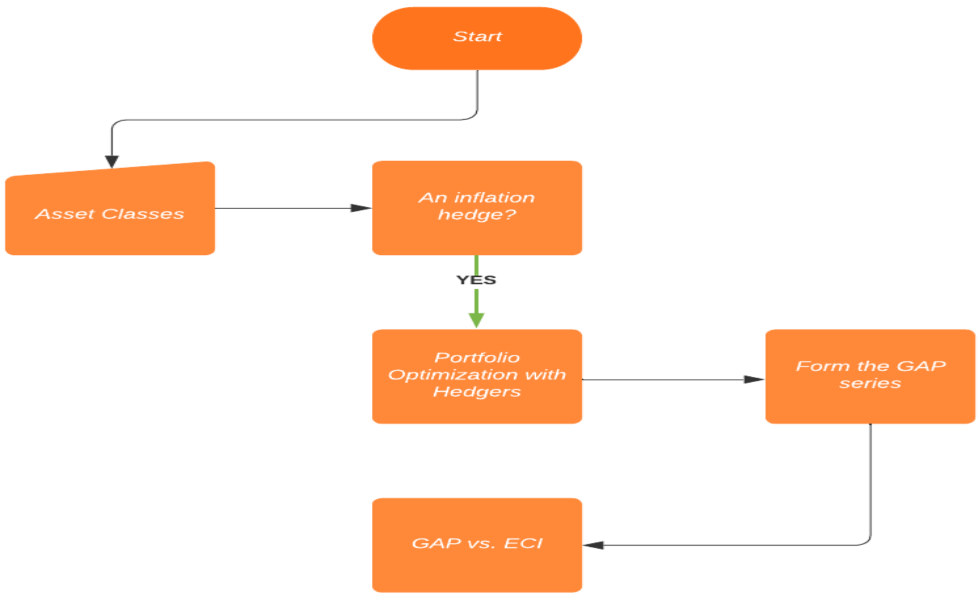

Figure 1.1: The overview

Note: This figure represents a brief overview of the three stages applied in this study.

We have organized the remainder of this thesis to provide a brief literature review of hedge and portfolio optimization in the second chapter, and a description of the data and methodology in the third chapter. The fourth and the last chapters contain the empirical results and the concluding remarks, respectively.

Chapter 2

LITERATURE REVIEW

Hedging against inflation is a way for investors to reduce their risk in the risky world of investing. In the broadest sense, it involves taking a position in one or more financial instruments to offset potential losses in another. While hedging against inflation primarily aims to protect the purchasing power of one's investments, there are many other types of hedging strategies that investors employ to address various forms of risk such as hedges against currency fluctuations, interest rate changes, and commodity price swings, just to name a few. It is one of the oldest strategies that investors used to cope with the inherent risk that comes with investing, and historically, hedging against inflation has been a topic of great debate and the literature presents mixed results on which asset classes provide the best hedges against inflation. As our study is focused on the four asset classes - gold, real estate, foreign currency, and the equity market - that is precisely where our attention will be concentrated in this literature review.

Gold, the illustrious "safe haven" asset, has held a special place in the annals of financial history. Renowned for shielding wealth from the gnawing teeth of inflation, gold’s price movements reveal a layered tale of short-term volatility juxtaposed with long-term stability. Although, studies studying it is hedging abilities have shown mixed results in the literature.

Beginning with the insights from Ghosh et al. (2004), gold's value is influenced by myriad forces. While its long-term trajectory may mirror general inflation rates, affirming its role as a hedge, short-term disturbances often punctuate this stable ascent. Variables such as gold lease rates, real interest rates, and even global exchange dynamics could cause these fleeting disruptions, as evidenced from data spanning 1976 to 1999. Dempster and Artigas (2010) weave a historical tapestry of gold's sterling performance during heightened inflationary climates, notably between 1974 and 2008. Whenever the U.S. inflation exceeded the 5% threshold, gold not only held its ground but also surged by an average of 14.9% in real terms, often overshadowing other asset classes. They astutely remind investors that gold's merit in a portfolio is not set in stone and can oscillate based on prevailing macroeconomic winds.

But, can gold's anti-inflationary prowess be universally declared? Beckmann and Czudaj (2013) prompt us to consider gold's role with a broader lens, examining its performance across financial behemoths like the USA, UK, Euro Area, and Japan. Through innovative modeling, they unearth that gold's shield against inflation, while potent, varies temporally. In a juxtaposition, Chua and Woodward (1982) unearthed that from 1975 to 1980, among six industrial powerhouses, gold's hedging capabilities shone brightest in the US and only during specific investment periods. Bampinas and Panagiotidis (2015) stretch this timeline further, analyzing data from as early as 1791. Their findings resonated with the notion of gold as a formidable hedge, especially in the US when contrasted with the UK.

Yet, every narrative encounters its counter. Hoang et al. (2016) brought a fresh perspective, challenging traditional paradigms with a touch of nonlinearity. Their models suggest that gold's long-term hedging prowess may be more folklore than fact in several countries. In the short-term spectrum, countries like the UK, USA, and India stand as notable outliers. Further complementing this nonlinear narrative, Aye et al. (2016) delved deeper into the bond between gold prices and inflation, simultaneously accounting for other assets. Their research showcased the long-term fidelity of gold as an inflation hedge, albeit with periodic hiccups along the journey.

In the case of Gold, its credentials as an inflation hedge remain predominantly uncontested, but there is still room for understanding the nuances of temporal and regional variations is pivotal for investors to harness its true potential.

Drawing parallels from the world of precious metals, real estate too has often been viewed through the prism of its potential as an inflation hedge. Throughout history, the intrinsic value of real estate, rooted in its tangibility, has frequently been heralded as a shield against the gnawing effects of inflation. Numerous studies spanning different geographies and timeframes lend weight to this claim, albeit with nuanced insights.

For instance, Rubens et al. (1989)'s exploration into the periods between 1960-86 pointed to the remarkable prowess of residential real estate and farmland in hedging against inflation, highlighting a gap in contemporary research on these sectors. However, when the canvas is broadened to international landscapes, the narrative becomes intricate. Liu et al. (1997) found that real estate securities' effectiveness as inflation hedges varied from country to country, with certain regions demonstrating subpar hedging capabilities compared to even common stocks. Switzerland, for example, witnessed its real estate assets overshadowing stocks as inflation buffers, especially during unpredicted inflation surges, as illustrated by Hoesli (1994) spanning from 1943 to 1991. A deep dive by Hartzell et al. (1987) foregrounded the merits of a diversified real estate portfolio, emphasizing its power to protect investors from both foreseen and unforeseen inflationary pressures. Yet, when contrasting tangible assets with their securitized equivalents, Larsen and Mcqueen (1995) warned of the disparities. Their findings suggested that equity REITs might not be the perfect proxies for real estate's inflation-proofing attributes.

A curious study by Lee and Lee (2014) on European real estate stocks from 1990 to 2011 drew a dividing line. While developed European real estate stocks stood out as a durable defense against expected inflation, emerging markets did not quite tell the same story. In a more encompassing scope, Salisu et al. (2020) weighed the inflation hedging merits of stocks, gold, and real estate in the US. The results painted a picture of diversity, with real estate emerging as a strong hedge in specific timelines. Bond & Seiler (1998) further reinforced real estate's reputation, unveiling how residential properties from 1969-94 effectively fended off both expected and unexpected inflation. Korea's direct commercial real estate, as researched by Park and Bang (2012), was found to be a formidable hedge in both the short and long run. In addition, in the bustling city-state of Singapore, a comparative assessment by National and Low (2000) drew clear lines. Real estate outperformed stocks and even its securitized counterpart, with industrial properties taking the crown as the most formidable barriers against both anticipated and unanticipated inflationary waves.

Moving on to foreign exchange, despite Erdogan’s call to Turks to keep their savings in the local currency (Reuters, 2021), amongst whom there is an increasing trend of people trying to hedge against inflation by mainly keeping their savings in a more stable foreign currency (Egilmez, 2023), and given the context of this study, we are primarily going to be looking at the case for Turkey, and studies that look at how well foreign currencies can hedge against inflation, Parlak and İlhan (2016)'s exploration provides an essential starting point. The duo pinpointed the vulnerabilities faced by companies, especially those holding short foreign exchange positions, during periods when the local currency devalues. This underscores the inherent risks of not employing foreign exchange as a buffer against inflating local currencies. Such a narrative aligns with Kiymaz (2003)'s findings that many Turkish firms, especially in industries like textile and machinery, grapple with high foreign exchange exposure risks amidst inflating environments. The implications are clear: failure to hedge against these exposures, especially in contexts like Turkey, can pose significant threats to firms.

Shifting the spotlight to SMEs (Small & Medium-sized Enterprises), Kula (2012)'s research underlines a different challenge. Even though the majority of SMEs in Turkey seem to understand the risks of foreign exchange exposure conceptually, they disproportionately emphasize transaction exposure over economic exposure. This insight suggests a potential gap in their comprehensive hedging strategies against rising inflationary pressures. From a policy angle, Erol and Van Wijnbergen (1997)'s study provides an intriguing dimension. Their empirical lens reveals the nuances of using nominal exchange rates as a policy tool for sustaining external competitiveness. While such an approach might cushion the blow from external shocks, its utility as an inflation hedge hinges significantly on the policy's trustworthiness. In Tsang (2023)'s case study offers a contemporary reflection of Turkey's economic climate in 2021. The significant depreciation of the Turkish lira, leading to amplified inflation, directed many towards equities and cryptocurrencies as hedging avenues. Beyond emphasizing the intrinsic link between local currency devaluation and inflation, Tsang's observations underscores the intricate dynamics of hedging strategies, especially when examining them through foreign exchange.

Turkey, positioned uniquely between Europe and Asia, provides a compelling backdrop to analyze the dynamics of the equity market as a hedge against inflation. In synthesizing findings from various studies, we see a diverse set of conclusions on the matter.

One of the central insights comes from Bekaert and Wang (2010), who found that standard securities, even those as diverse as well-diversified equity indices, are poor inflation hedges across a broad swath of 45 countries. This broad-reaching insight might serve as a warning for those looking to use equities solely as an inflation hedge. Supporting this, (Erb et al., 1995) identified a negative relationship between inflation and stock returns across 41 markets, underscoring the complexity of this relationship. Intriguingly, their study suggests that while stock returns might decrease with inflation, the inflation premium itself might be a useful risk indicator. While these findings might lean towards caution in the equity market's role as a hedge, Cooper & Kaplanis (1994) proposed that the home bias in equity portfolios could be attributed to investors' attempts at hedging against inflation risk. They, however, caveat that this only holds true if equity returns are negatively correlated with domestic inflation. This potential negative correlation is echoed by Hoesli et al. (2008), who found that stocks sometimes provide a perverse hedge against inflation, which might be a result of real and monetary shocks affecting the economy.

The landscape is not entirely gloomy. Ang et al. (2012) provided an avenue of optimism by suggesting that portfolios of individual stocks might offer a more nuanced approach to hedging against inflation. While the aggregate stock market might not be the best inflation hedge, specific sectors, like oil/gas and technology, exhibited positive inflation betas, thereby providing some hope.

The Emerging Stock Market (ESM) analysis by Spyrou (2004) brings a refreshing perspective, indicating that the relationship between equities and inflation is not universally negative. While industrialized economies often show a negative trend, the ESMs exhibit more variance. Some show positive relationships, revealing a more complex interplay perhaps due to factors like the relationship between consumer prices and output. Nevertheless, what about equity markets beyond traditional stocks? Murphy and Kleiman, (1989) explored the realm of equity REITs, revealing that they may not be effective hedges against inflation, especially over short holding periods. This is consistent with other findings such as those by Stevenson (1999) and Matysiak et al. (1996) on property returns. It is also worth noting the global perspectives. Brière and Signori (2013) study on Brazil emphasized the effectiveness of foreign currencies, especially the US dollar and euro, in hedging inflation risks. This global lens is broadened by the findings from Umar et al. (2020) which investigated both Islamic and conventional equities, revealing that differentiation in their inflation-hedging capabilities is not as pronounced as one might expect. While Arnold and Auer (2015) overview aptly summarizes the complexity of the relationship between asset returns and inflation. With varying methodologies, data sets, and samples, the conclusions on inflation hedging remain nuanced and multifaceted.

As the Turkish energy and financial markets undergo significant transformations, understanding the intricacies of portfolio optimization within these contexts becomes indispensable for investors and policymakers. Delving into a series of research works, we unravel the multifaceted nature of the challenges and solutions related to portfolio optimization, shedding light on both the electricity and financial sectors of Turkey. (Gökgöz & Atmaca, 2017) highlighted the distinctive challenge faced by electricity markets, which is the simultaneous generation and consumption of electricity. Using real data from the Turkish day-ahead market spanning 2009-2012, they compared three optimization techniques - mean-variance, downside, and semi-variance. Their findings elucidated the effectiveness of these methods, especially the financial optimization using Lower Partial Moments constraints, in delineating efficient frontiers for Turkey's electricity markets.

Building upon these findings, Gökgöz and Atmaca's earlier work in 2011 brought forward the Markowitz mean-variance optimization. By viewing hourly spot market prices as unique risky assets, they shed light on risk management complexities faced by generation companies in a market characterized by instantaneous electricity production and consumption.

The importance of sustainable development in portfolio planning was accentuated by (Selçuklu et al., 2023). Their research underscored Turkey's growth as a significant energy consumer, presenting an optimization algorithm with a lens on uncertainties. The study presented enlightening insights such as the environmental and economic implications of different energy sources like nuclear, natural gas, and renewables in Turkish energy portfolio planning. Taking a pivot towards financial markets, İskenderoglu and Akdag investigated the role of market regimes in portfolio optimization outcomes. Their work, spanning the period from 2000-2016 on the BIST 100 index, drew attention to the nuanced differences in optimization results between bear and bull market conditions. Another dimension was added by (Azimova, 2022) who evaluated domestic diversification opportunities at an industry level in Turkey from 2007-2020. The study found retail trade, transportation, and wholesale as priority sectors, emphasizing the nuanced ways different industries play a role in portfolio optimization.

Yilmaz (2010) ventured into the realm of the Istanbul Stock Exchange, emphasizing the influence of fluctuating variance and evolving correlations on portfolio optimization. The research highlighted the DCC-GARCH method as a superior choice in constructing portfolios for reduced volatility. In a more recent exploration, (Atmaca, 2022) approached portfolio optimization in the electricity markets by integrating well-established financial metrics – the Sharpe and Treynor ratios. Validating the approach with Turkish Day-ahead Market data, the study revealed the ratios' ability to refine the performance of conventional optimization tools, hinting at a blended approach's potential.

Portfolio optimization is not just about methods. (Dengiz et al., 2022) displayed an actionable tool: a Decision Support System (DSS) tailored for the daily management of natural gas-fired power plants in Turkey. By marrying mixed integer programming and fuzzy programming, the DSS facilitates holistic operational management, from electricity trading to natural gas procurement. Kayakutlu and Ercan, (2015), explored the regional dimension of energy management. Their study carved out a path for hybrid energy portfolio models, considering renewable. The growing emphasis on financial and energy portfolio optimization in Turkey, as reflected in the various studies above, mirrors the nation's aspirations in economic and energy sectors. Turkey's status as a rapidly growing energy consumer, combined with its unique challenges in electricity markets, has prompted in-depth research into how portfolio planning and optimization can help to navigate these complexities. However, while electricity market studies primarily deal with the tangible product – electricity – and its instantaneous production-consumption dichotomy, there is a parallel challenge of assessing the intangible yet critical economic pulse of the nation.

The Economic Confidence Index (ECI) serves as an important barometer to gauge the overall economic health of a country. Genç (2019) dives deep into the intricacies of ECI, examining its underlying components. Recognizing the importance of careful selection and analysis of the sub-indices that make up the ECI, Genç investigates the predictive power of various sectoral indices using the recently developed MIDAS regression model. This study underscores the pivotal role of sectoral confidence indices such as Consumer, seasonally adjusted Real Sector, Service, Retail Trade, and Construction Confidence Index sampled at a monthly frequency. Interestingly, Genç's evaluation through the Autoregressive Distributed Lag (ADL) MIDAS method, by parameterizing one of the MIDAS polynomial weights, reveals superior forecasting performance.

Chapter 3

METHODOLOGY

This chapter briefly outlines the methodologies used in this thesis. We employed several statistical software such as EViews, R, and GAUSS to implement the methodologies.

3.1 The First Stage

According to the lifetime utility maximization problem, the following equation satisfies the first order condition of lifetime utility of an investor between time T and $T + 1$ (single investment horizon):

$$p_T = E_T\ (m_{T+1}\ X_{T+1}) \qquad (1)$$

Where, p_T is the price of the asset at time t. E_T is the conditional expectation given the information set at T. Also, m_{T+1} and X_{T+1} denote the Stochastic Discount Factor (SDF) and payoff from assets at $T + 1$. One can easily derive from (1) that:

$$E_T\ (r_{T+1}) - r_f = -r_f\ \rho_{m,X}\ \sigma_m\ \sigma_r \qquad (2)$$

With r representing the rate of return from an investment. Based on the aforementioned equation, the volatility of consumption (σ_m) is one of the key components that determines the level of the required expected risk premium by a rational investor. Consequently, apart from the volatility around the expected payoffs, consumption risk is a striking factor for investors' decision-making process. Therefore, a rational investor would try to fight the deterioration in her purchasing power. One strategy to achieve this goal is to hedge against the inflation.

The Fisher's hypothesis (Fisher, 1930), as the cornerstone of the theory of return-inflation nexus, suggests the following equation:

$$1 + r_R = \frac{1+r_N}{1+r_{CPI}} \quad (3)$$

With r_R, r_N, and r_{CPI} as the real rate of return, nominal rate of return, and the inflation rate, respectively. If we consider the logarithmic form of growth changes, the following is observable:

$$R_N = R_R + R_{CPI} \quad (4)$$

Where R denotes the continuous rate of change. Considering the Fisher's effect and that the expected nominal rates of return for all asset classes signal about the market assessment of the expected inflation, Fama & Schwert (1977) generalises the Fisher's hypothesis as follows:

$$E(r_t^N \,|I_{t-1}) = E(r_t^R \,|I_{t-1}) + E(r_t^{CPI} \,|I_{t-1}) \quad (5)$$

I_{t-1} represents the available information set up to time t-1. According to this equation, the conditional expectation of the nominal rate of return for any asset class at time t could be formulized as the sum of the conditional expectations of percentage changes in the asset's real rate of return and CPI at time t. The realized nominal rate of return at time t can be decomposed into the conditional nominal expected return given information at time t-1 and an unexpected shock component at time t. On the other hand, several empirical studies suggest that the conditional expectations of real rate of returns are constant (Aktürk, 2016). Thus, we can write accordingly:

$$r_t^N = E(r_t^N \,|I_{t-1}) + \varepsilon_t \quad (6)$$

$$E(r_t^R \,|I_{t-1}) = r_R \quad (7)$$

With ε_t being a standardized Gaussian white noise process under rational expectations. If we substitute equations (5) and (7) into equation (6), we will have equation (8):

$$r_t^N = r_R + E(r_t^{CPI} \,|I_{t-1}) + \varepsilon_t \quad (8)$$

Ultimately, considering the equation 8 the following linear regression is derived:

$$r_t^N = r_R + \theta E(r_t^{CPI} | I_{t-1}) + \varepsilon_t \quad (9)$$

The importance of this equation is in its power to verify hedging ability of an asset against inflation under the Fisher's hypothesis framework. To confirm the potential hedging performance of an asset against inflation, θ should be greater than zero. Particularly, for a given asset $0 < \theta < 1$ characterizes the partial hedge, and θ = 1 describes the full hedge (Arnold & Auer, 2015). Furthermore, θ > 1 indicates the extraordinary hedge.

Since $E(r_t^{CPI} | I_{t-1})$ in equation (9) is not directly observable, to make a transition from theoretical grounds to empirical framework, one should deal with this component in the regression equation. Following one of the strands in the literature including the work of Salisu et al. (2020), we use r_t^{CPI} as a proxy of $E(r_t^{CPI} | I_{t-1})$. Therefore, we can re-write equation (9) as:

$$r_t^N = r_R + \theta r_t^{CPI} + \varepsilon_t \quad (10)$$

Equation 10 is the baseline equation to determine the feasibility of hedging versus inflation for the asset under question. The baseline equation assumes a so-called linear inflation-beta model i.e. a symmetric relationship between nominal rate of return and the inflation rate. However, as suggested by several articles namely Ahmed and Cardinale (2005), Knif et al. (2008), Wang et al. (2011), Hoang et al. (2016), and Yeap and Lean (2017) asymmetric models potentially provide a more advantageous function in unveiling the return-inflation dynamic. Consequently, we make use of the idea of asymmetry as described in Shin et al. (2014) to capture the variables' dynamic in both higher and lower inflation states. Therefore, the regression equation would follow the following functional form:

$$r_t^N = r_R + \theta^+ r_t^{CPI^+} + + \theta^- r_t^{CPI^-} + \varepsilon_t \tag{11}$$

Where $r_t^{CPI^+}$ and $r_t^{CPI^-}$ are defined as the following partial sums:

$$r_t^{CPI^+} = \sum_{m=1}^{t} \Delta r_t^{CPI^+} = \sum_{m=1}^{t} Max(\Delta r_m^{CPI}, 0) \tag{12}$$

$$r_t^{CPI^-} = \sum_{m=1}^{t} \Delta r_t^{CPI^-} = \sum_{m=1}^{t} Min\,(\Delta r_m^{CPI}, 0) \tag{13}$$

To put differently, we calculate the partial sum when we have an increase (decrease) in inflation series, and separate them as positive and negative changes. Furthermore, due to potential presence of heteroscedasticity, we model $AR\ (P|P \leq 13)$ for each series to find the best model, and then we run ARCH LM-test to verify the potential autocorrelation among the squared errors with a null hypothesis of $H_0 =$ no ARCH effect. To consider the potential heteroscedasticity in our regression model, we follow Feasible Generalized Least Squares (FGLS) approach of Westerlund and Narayan (2012). FGLS offers a robust estimation of the parameters when there is a potential change in conditional variance of error terms. Hence, precluding inconsistent estimations.

Additionally, we examine series for the presence of structural break(s) using sequential ($L + 1$ vs. L breaks) structural break test of Bai and Perron (1998). We further investigate the presence of structural breaks using the framework developed in the GARCH (1, 1) unit root test of Narayan and Liu (2015). The advantage of Narayan and Liu (2015)'s framework lies in its incorporation of heteroscedasticity and potential trends when estimating structural break date(s). Narayan and Liu (2015)'s test builds on the structural break test of Bai and Perron (2003) and selects the break date(s) using the approach proposed in Narayan and Popp (2010). Equation (14) represents the final regression after the incorporation of dummy variables to explain the breaks.

$$r_t^N = r_R + \theta^+ r_t^{CPI^+} + + \theta^- r_t^{CPI^-} + \sum_{z=1}^{B} \beta_t D_z + \varepsilon_t \tag{14}$$

Where, B indicates the total number of breaks, and D represent the dummy variable defined to explain the break at time z. Therefore, our model accounts for asymmetry, heteroscedasticity, and structural break(s).

We extend our analysis by considering both ARDL and NARDL models (Pesaran & Shin, 1999; Pesaran et al., 2001; Shin et al., 2014) to investigate the potential equilibrium relationship between the level variables and CPI. Positive and significant relationship between a level variable and CPI implies the hedging ability of the variable (Hoang et al., 2016).

Before proceeding with models estimation, we should make sure that the return series are not $I\ (1)$. Otherwise, in equation (14) we will have the so-called spurious regression problem (Granger & Newbold, 1974). On the other hand, as the requirement of ARDL's world, the series must not be $I\ (d)$ with d≥ 2. Therefore, we run several unit root test to ensure that return and inflation series (the first differences) are not unit root processes.

3.2 Unit Root Tests

We examine the presence of unit root in series firstly by using the conventional tests of Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979), Phillips and Perron (PP) (Phillips & Perron, 1988), and Zivot-Andrews (ZA) (Zivot and Andrews, 1992). ADF test is an extension to solve the potential serial correlation problem which DF test is not able to address because of the limited included lags in the model. Thus, ADF by operating on Auto Regressive (AR) models with an order of $P = q + 1$, confronts the autocorrelation issue. Equation (15) demonstrates the general representation of ADF with a deterministic drift term:

$$\Delta y_t = \beta_0 + \beta_1 t + \alpha_1 y_{t-1} + \sum_{j=1}^{q} \alpha_{j+1} \Delta y_{t-j} + u_t \tag{15}$$

Dickey & Fuller (1979) proposed τ as the test statistics where:

$$\tau = \frac{\widehat{\alpha_1}}{SE(\widehat{\alpha_1})} \tag{16}$$

ADF tests the null hypothesis of $\widehat{\alpha_1} = 0$ against $\widehat{\alpha_1} < 0$ asymptotically. The rejection of null hypothesis provides evidence against the persistence of shocks to the series under investigation. Hence, concluding the existence of mean-reverting patterns in the series. Opposed to ADF test that adopts a parametric approach, PP test implements a non-parametric methodology to approximate the residuals. Thanks to the modifications made on its tests statistic, the PP unit root test shows robustness when the residuals are prone to unspecified heteroscedasticity and/or serial correlation. The PP test has the following regression representation, where u_t represents the error term with an integration order of zero.

$$\Delta Y_t = M' D_t + \rho Y_{t-1} + u_t \tag{17}$$

The last but not the least in our list of the conventional unit root tests is the ZA test. Unlike Perron (1989) that exogenously incorporated structural break in the ADF test, the ZA test draws on endogenous determination of the break. The problem with the former test was the over rejection of the null of unit root which could lead a unit root process to be mistakenly treated as a unit root stationary process. The ZA test in its most generalized form, assumes one potential endogenous structural break in each of constant and trend. Equation (18) formulizes the regression equation of the test.

$$\Delta Y_t = (c + \acute{c} D_1) + (\beta_t + \varphi D_2 T_t) + \vartheta Y_{t-1} + \sum_{j=1}^{M} \theta_j \Delta Y_{t-1} + \epsilon_t \tag{18}$$

Where dummy variables D_1 and D_2 are zero-valued variables that take the value of 1 after the corresponding break date.

Moreover, we put the potential unit root behavior of series to test using the GARCH (1,1)-based unit root test of Narayan and Liu (2015) which allows for multiple endogenous structural breaks in addition to the presence of deterministic trend in the series. The representation of the test is as follows:

$$\Delta Y_t = c + \beta_t + \vartheta \, Y_{t-1} + \sum_{j=1}^{k} \delta_j \, D_j + \varepsilon_t \tag{19}$$

$$\varepsilon_t = \alpha_t \sqrt{\omega_t} \, ; \, \omega_t = \mu + \rho \, (\omega_{t-1}) + \tau \, (\varepsilon_{t-1})^2 \tag{20}$$

Equation (19) indicates the regression model and equation (20) presents the GARCH (1,1) process.

3.3 The Second Stage

This stage entails the optimization of portfolios with hedger constituents. Our optimization objectives are to maximize SR and to minimize CVaR, respectively. In both optimization models, we exclude the possibility of short sale. Consequently, the weights are not negative by design. The following describes the first optimization problem:

$$w^* = argmax_w \left\{ \frac{[\acute{w}\, r - r_f]}{(\acute{w}\Sigma w)^{\frac{1}{2}}} \right\}; \quad \text{s.t.} \ \sum w_i = 1 \ and \ w_i > 0 \tag{21}$$

Where, Σ is the covariance matrix, and r denotes the return matrix. The output is a vector of weights for assets. In both optimization problems, we adopt rolling window optimization approach. As we repeat this process for each time window with a length of M, we will have $N - M + 1$ subsamples of weights for each asset ultimately, if the returns are sampled at N time points. Furthermore, we choose a length of 48 months for the rolling window. Considering the monthly frequency of our data, we optimize the portfolios each month, using the update version of our vector of information set ($I_t \in \mathcal{R}^{48}$).

On the other hand, we can formulate the second optimization problem as follows.

$$w^* = argmin_w \{\frac{1}{1-\gamma} \int_\gamma^1 q_k \, F_L \, dk\}, ; \quad \text{s.t. } \sum w_i = 1 \; and \; w_i > 0 \tag{22}$$

With F_L as the c.d.f of L. L is a random variable that represents the portfolio loss ($L = -\acute{w}\, r$). Assuming the continuity of the c.d.f and that L is integrable, CVAR can be re-written as the following:

$$\text{CVaR} = \frac{1}{1-\gamma} \int_\gamma^1 q_k \, F_L \, dk = E(\, L | L \geq VaR \,(\gamma; w)) \tag{23}$$

With a series of linearization and re-parameterization of equation (23), (22) could be modelled, using sample data. We collect the realized portfolio returns after optimization to gain more insight into the return of investors if they had invested in the optimized portfolios. Then, we form the GAP series ($GAP_t = r_t^* - Inf_t$). GAP will measure the performance of portfolios at gaining higher return than inflation.

3.4 The Third Stage

In the last part, we use ECI as an aggregate indicator of both sentiment and uncertainty to investigate the dynamic interaction between portfolios and the index. We use Pearson's pairwise correlation and quantile correlation (Pearson, 1948; Choi & Shin, 2021) in the first step. Unlike, Pearson's coefficient of correlation that focusses on conditional means, the quantile correlation measures the association of series in different part of their conditional distributions. The quantile correlation of X and Y at quantile $\tau \in [0,1]$ is the geometric mean of the slope of two quantile regressions:

$$L_{YX}^{\tau}\,(\alpha, \beta) = E[s_\tau\,(Y - \alpha - \beta X)] \tag{24}$$

$$L_{XY}^{\tau}\,(a, b) = E[s_\tau(X - a - bY)] \tag{25}$$

With, $s_\tau(m) = m(\tau - I\ (m < 0))$ and I (*), representing an indicator function on event *. The objective is to find a set of vectors of coefficients $(\alpha, \beta, a, b)'$ over different values of τ with a target of minimizing (24) and (25).

The second class of methods that we used to investigate the dependency was Dynamic Conditional Correlation (DCC) of Engle (2002). Dynamic estimators generally call for set of constraints on parameters. In Engle (2002)'s DCC, a by-product of estimation and modelling performs as an auxiliary variable. The generalized form of the relationship between dynamic variances, covariance, and correlation between X and Y conditional on the information set generated up to t is given below.

$$\sigma_{XY,t+1\,|t} = \rho_{XY,t+1\,|t}\, \sigma_{X,t+1\,|t}\, \sigma_{Y,t+1\,|t} \qquad (26)$$

One can easily re-write the above as (27):

$$\Sigma_{t+1\,|t} = \Pi_{t+1}\, \mathrm{H}_{t+1\,|t}\, \Pi_{t+1} \qquad (27)$$

Where, Π_{t+1} is a diagonal matrix (N.N) with estimated $\sigma_{i,t+1}$ on the diagonal ($i = 1,2, \dots, N$). Furthermore $\mathrm{H}_{t+1\,|t}$ characterizes a N.N matrix with ones on its main diagonal and $\rho_{ij,t+1\,|t}$ otherwise ($i, j = 1,2, \dots, N$). The methodology involves the estimation of variances through a GARCH (1,1) model, and then the modelling of the dynamic conditional covariance/correlation indirectly via auxiliary variables.

After examining the correlation using different locations of the conditional distribution and adding the time domain using the DCC model, we also add the frequency domain to observe how the variables interact in both the time and frequency domains. For this purpose, we use the wavelet transform to decompose the series into different domains. The power of wavelet modelling is not limited to adding the time dimension; it is also interpretable when series exhibit non-stationary behaviour (unlike the Fourier transform, whose interpretability degrades when the signal is non-stationary). Torrence and Webster (1998) defined wavelet coherence between X and Y as follows.

$$R_m^2 = \frac{|\, S(s^{-1}\, W_m^{XY}(s))|^2}{S\left(s^{-1}|W_m^X(s)|^2\right) S\left(s^{-1}|W_m^Y(s)|^2\right)} \tag{28}$$

With S (.) defined as a smoothing operator. Also, s is the circular standard deviation defined as: $s = \sqrt{-2\ln(\frac{R}{m})}$; $R = (X^2 + Y^2)^{1/2}$. The smoothing operator has the following general fom.

$$S(W)|s = S_{scale}\,(S_{time}\left(W_m\,(s)\right)) \tag{29}$$

S_* shows the smoothing in * space. One of the most commonly used wavelets is the Morlet wavelet. This class of wavelets is generated simply by manipulating sinusoidal signals using Gaussian functions. In a Morlet wavelet, the smoothing operator is described as follows.

$$S(W)_{time}|s = \left(W_m(s) * c_1^{\frac{-t^2}{2s^2}}\right) \tag{30}$$

$$S(W)_{time}|s = \left(W_m(s) * c_2\, \Pi(0.6s)\right)|m \tag{31}$$

With c as normalization factors, and Π as a rectangular function.

Chapter 4

DATA AND EMPIRICAL FINDINGS

This chapter begins with the introduction of data used in this study and continues with the presentation and discussion of empirical findings.

4.1 Data And Preliminary Analysis

This study employed several variables for the case of Turkey. In the first stage, we used Gold price (GOLD), the historical value of the USD/TRY currency pair (USD_TRY), the Real Estate Investment Trust (REIT) index and the BIST 100 index (BIST 100). The series were constructed monthly, with a starting point in January 2003 and an end-point in July 2023. We also used the general consumer price index (CPI) as a proxy to measure inflation. In the final stage, we used the Economic Confidence Index (ECI), whose data were collected monthly. The time series of the ECI started in 2007 and ended at the end of July 2023. The reason for the different time span for the ECI is the choice of the lookback period for the rolling window in the second stage. We collected the data using several online resources, namely Investing website (www.investing.com), TCMB website (www.tcmb.gov.tr), and Turkiye Statistic Kurumu website (www.data.tuick.gov.tr). We also used logarithmic transformation of each series to scale the data and mitigate the problem of outliers and heteroscedasticity.

To begin the preliminary analysis, we plotted the data. Figure 4.1 exhibits the time series plot of the return series of the variables used in stage 1 and 3. Return series were defined as the first difference of the natural logarithm of the level data. Henceforth, DX denotes the first log-difference of X. According to Figure 4.1, series potentially appear to have structural break(s). However, in some series such as DREIT and DBIST100, and DPI, potential breaks are more evident. This observation calls for a thorough analysis of the structural breaks in the series. In addition, the series exhibit volatility clustering properties that should be statistically investigated.

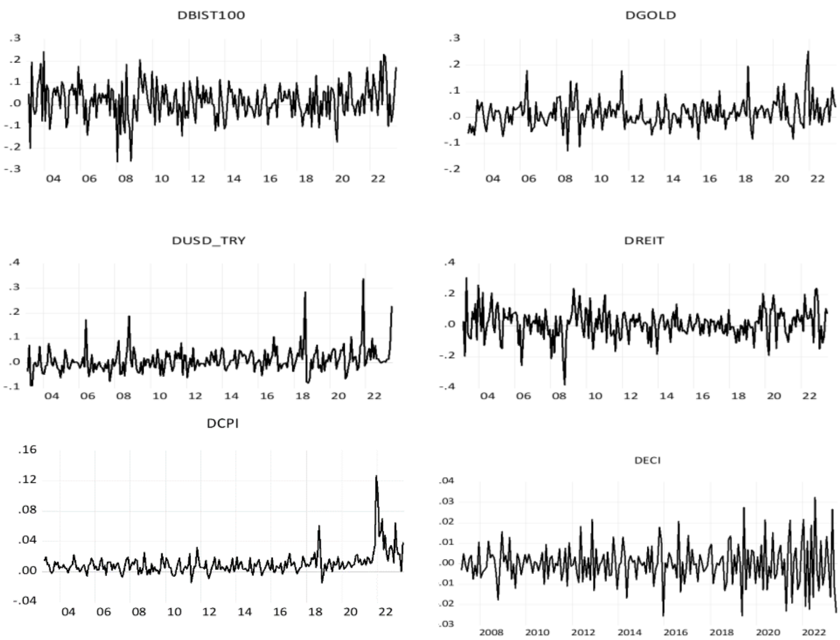

Figure 4.1: Plot of return series

Table 4.1 demonstrates the descriptive statistics for the variables used in the first stage. The ARCH-LM test statistic is also embedded in the table. The Jarque-Bera (JB) test tests the series under the null hypothesis for excess kurtosis of zero and skewness of zero jointly (Jarque & Bera, 1987). According to the test result, we reject the normality hypothesis for all series except DBIST100. Given the sensitivity of the Jarque-Bera test to structural breaks, this unexpected result could be due to the possible sharp structural break of DBIST100 around 2008.

In addition, since SC information criterion (SIC) suggests parsimonious models on average, we used the SIC to determine the optimal lags. ARCH-LM Test examines the autocorrelation of squared residuals. Under the null hypothesis, the test assumes that there is no ARCH effect for the specified lags. The test reported the presence of the ARCH effect for DGOLD, DREIT, and DCPI at a 1% significance level. Furthermore, the null hypothesis was not rejected for DECI in the 5% significance level.

Table 4.1: Descriptive statistics

	DBIST100	DGOLD	DUSD_TRY	DREIT	DCPI	DECI
Mean	0.0161	0.0176	0.0112	0.0118	0.010847	-0.00009
STD	0.0822	0.0507	0.0505	0.0950	0.015040	0.0090
Maximum	0.2422	0.2540	0.3384	0.3079	0.127300	0.0324
Minimum	-0.2629	-0.1270	-0.0913	-0.3815	-0.014500	-0.0255
Median	0.0241	0.0150	0.0040	0.0135	0.008100	-0.00002
Skewness	-0.1107	0.9244	2.3175	-0.2156	3.691531	0.2128
Kurtosis	3.5433	5.9128	14.093	4.2975	24.29709	3.6913
JB P-value	0.1725	0.0000	0.0000	0.0000	0.0000	0.0000
Optimal lag	1	1	1	1	3	5
ARCH-LM	2.1833	11.2380^{***}	0.3932	7.9811^{***}	80.7^{***}	3.7031^{**}

Note: X^{***}, X^{**} and X^{*} denote the rejection of null hypothesis at the 1%, 5% and 10% significance level, respectively, given the test statistic X.

4.2 Empirical Findings

This section begins with the report of structural break tests result for return series of stage-one variables. We first utilized the structural break test of Bai and Perron (1998). According to table 4.2, the test reports maximum significant break of 1 for the series. Due to the presence of ARCH effect in the series, we extended our analysis to the robust test of Narayan and Liu (2015), which is based on Narayan and Popp (2010), to estimate the number and location of break dates. As seen in table 4.2, the test results align more coordinately with our expectations of break dates. These expectations are formed based on various economic events such as the global financial crisis (GFC), the Covid-19 pandemic and the recent currency depreciation in Turkey. Accordingly, we relied on Narayan and Liu (2015) to incorporate the structural breaks in our model.

Table 4.2: Structural break tests

	DBIST100	DGOLD	DUSD_TRY	DREIT	DCPI
BP:					
Number of breaks	1	1	1	0	1
Breaks dates	2020M07	2018M04	2018M03	-	2018M04
NL:					
Number of breaks	2	1	2	2	2
Breaks dates	2006M02	2011M08	2006M09	2011M01	2008M10
	2021M10	-	2023M02	2019M05	2016M07

Note: This table reports the results of BP (Bai & Perron, 1998) and NL (Narayan & Liu, 2015) structural break tests.

We examined the persistence of shocks from different perspectives by using different unit root tests. We used the most generalized form of each test and chose the optimal lag length based on SIC. As shown in table 4.3, both parametric and non-parametric tests of ADF and PP rejected the unit root hypothesis for all series at the 1% significance level. Considering endogenous structural break, ZA test also reject the persistence of shocks for all series. Ultimately, the GARCH unit root test of Narayan and Liu (2015), which accounts for endogenous structural breaks, rejected the presence of unit root for all variables at the 5% level.

Table 4.3: Unit root tests result

	DBIST100	DGOLD	DUSD_TRY	DREIT	DCPI
ADF	-15.3739^{***}	-12.0310^{***}	-12.8732^{***}	-13.9912^{***}	-4.7219^{***}
PP	-15.3748^{***}	-11.9781^{***}	-13.4279^{***}	-13.9695^{***}	-8.6397^{***}
ZA	-15.9129^{***}	-11.8001^{***}	-9.9641^{***}	-14.6107^{***}	-6.0529^{***}
NL	-15.41^{**}	-4.81^{**}	-11.37^{**}	-14.21^{***}	-10.72^{**}

Note: X^{***}, X^{**} and X^{*} denote the rejection of null hypothesis at the 1%, 5% and 10% significance level, respectively, given the test statistic X.

Considering the structural breaks, we ran an asymmetric FGLS regression to verify the hedging ability of asset classes. Table 4.4 reports the estimated $\theta^{+}$and θ^{-} of equation (14). We require positive and statistically significant coefficients to call the asset an inflation hedge. Furthermore, the magnitude of the coefficient determines the degree of hedging ability. We found that gold exhibited a positive association with inflation. According to results, when inflation in Turkey increases by 1%, the gold return, on average, increases by 2.83%. On the other hand, when the inflation rate decreases by 1%, the gold return decreases by 0.008% on average. Consequently, we conclude the hedging possibility of gold against inflation. To put differently, gold acts as an extraordinary hedge against inflation at higher levels of inflation, and it acts as a partial hedge, considering the lower levels of inflation. Furthermore, we observed that USD/TRY currency pair showed hedging ability at the 10% significance level.

Table 4.4: Asymmetric FGLS regression

	BIST100	**GOLD**	**USD_TRY**	**REIT**
$\boldsymbol{\theta^{+}}$	-1.037	2.83^{**}	1.901^{*}	-0.173
$\boldsymbol{\theta^{-}}$	-1.046	0.008^{**}	1.790^{*}	0.157

Note: X^{**} and X^{*} denote the rejection of null hypothesis at the 5% and 10% significance level, respectively.

Furthermore, we studied the hedgeability of series (at level) with the NARDL model. We are particularly interested in the long-run behaviour of asset classes. The NARDL model assumes that the series are integrated of order 1 at most. Since, according to Table 4.3, all series are stationary at the first difference, we can conclude that the requirement of the NARDL model is satisfied. NARDL only confirmed USD/TRY as a hedge in the long run. Accordingly, to save space, we report only the results of the F-bounds test for the significant case of USD_TRY. Table 4.5 shows that we rejected the null hypothesis that there is no cointegration relationship between USD_TRY and

CPI at the 1% level for both the ARDL and NARDL models. Moreover, the significance of the cointegration equation is confirmed in both the ARDL and NARDL models. Our results indicate that 7.86% of departures from equilibrium are corrected within one month under the ARDL model and 81.26% under the NARDL model. Additionally, according to the F-bounds test of NARDL, the USD/TRY pair will only hedge against positive changes in inflation. This finding corroborates that USD/TRY is an extraordinary hedge in an inflationary environment due to the significant coefficient of 1.6678. On the contrary, in a deflationary environment, USD/TRY does not seem to be a hedge in the long run. Our findings also supports the existence of an asymmetry in the relationship between asset returns and inflation (Hoang et al., 2016; Yeap & Lean, 2017).

Table 4.5: F-bounds test results

	F-bounds test statistic	**Speed of adjustment**	**Equilibrium equation: coefficient (CPI)**	**Equilibrium equation: coefficient (CPI^{+})**	**Equilibrium equation: coefficient (CPI^{-})**
ARDL	8.3454^{***}	-0.0786^{***}	1.6115^{***}	-	-
NARDL	5.6076^{**}	-0.8126^{***}	-	1.6678^{***}	2.7099

Note: X^{***} and X^{**} denote the rejection of null hypothesis at the 1% and 5% significance level.

Our findings presented evidence in the favor of gold and USD/TRY being hedgers versus inflation. Based on this conclusion, we formed optimized portfolios of hedgers. We are interested in the value of returns that would have been realized, if one had invested in optimal portfolio of hedgers. Figure 4.2 depicts the returns of portfolios optimized with the two series of objectives. MAX_SR denotes the return of portfolios with the objective of SR maximization. Likewise, MIN_CVAR denotes return of portfolios optimized to minimize CVaR. According to Figure 4.2, the optimization methods indicate similar performance. However, we plotted their differences over time to gain numerical insight into their differences. Consequently, DIFF denotes MIN_CVAR subtracted from MAX_SR at each time point. Interestingly, the difference between MAX_SR and MIN_CVAR began to decrease after 2012. This observation could be attributed to GFC and the extensive attention it brought to heavy tailed distributions. We also tested the men difference of MAX_SR and MIN_CVAR. The test statistic was 1.9898 and we rejected the null of the no difference between MAX_SR and MIN_CVAR on average at the 5% significance level. Furthermore, we could not reject the null of MAX_SR to be greater than MIN_CVAR on average. Furthermore, Figure 4.3 demonstrates GAP_SR and GAP_CVAR that, respectively, denote GAP series for MAX_SR and MIN_CVAR.

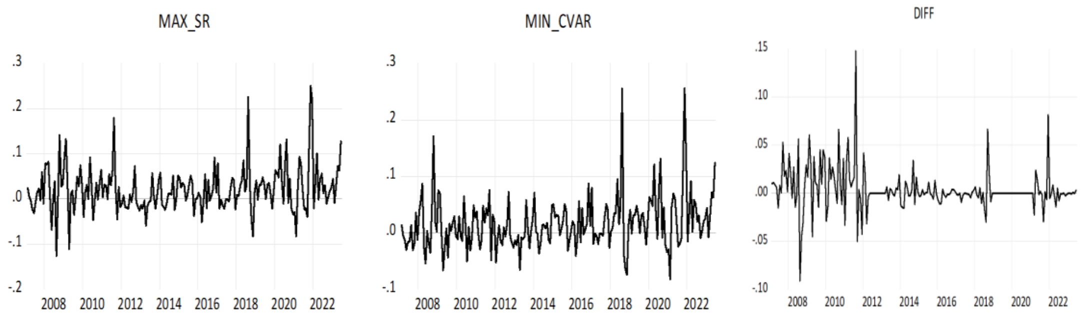

Figure 4.2: Optimized portfolio realized returns

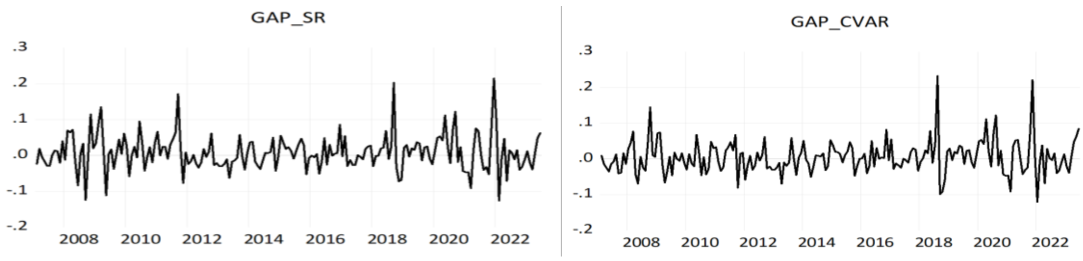

Figure 4.3: The GAP series

Table 4.6 contains the Pearson product moment, Kendall's tau, and Spearman correlation coefficients for each GAP series and ECI. We created pseudo-observations of series to examine their dependence using Kendall's tau and Spearman methods. This step was performed using the help of probability integral transformation of the data. The goal was to reveal the correlation with and without considering the marginal distributions. This is the first step towards modeling the dependence. The goal is to find out how portfolio returns would respond to a low level of ECI as an aggregate measure of uncertainty and sentiment in the economy. From one perspective, this dependence modeling could be viewed as a generalized portfolio stress test. The table shows a negative relationship between each series and the ECI. This shows that when confidence in the economy is low, portfolio returns exhibit a higher level of performance. Due to the limitations of such correlation coefficients, we extend our analysis by the investigation of correlation in different quantiles of conditional distributions.

Table 4.5: Pairwise correlations

	Pearson	**Kendall**	**Spearman**
GAP_SR vs. ECI	-0.1404**	-0.1055**	-476.4162**
GAP_CVAR vs. ECI	-0.0724	-0.0525	-252.9137

Note: X** denotes the rejection of null hypothesis at the 5% significance level.

Figure 4.4 exhibits the results of quantile correlation (Choi & Shin, 2021). The strength of this method is in explaining the change in scale, shape, and location of the conditional distributions. We examined different quantiles (τ) with $\tau = (0.01,0.02,\ldots,0.98,0.99)'$. The results indicate negative co-movement between variables in the lower quantiles. This demonstrates the high performance of the portfolios in fighting inflation during periods of low confidence. However, when we consider the extreme low quantiles $\tau = (0.01,0.02)'$ for the case of GAP _CVAR, the correlations are slightly larger than zero. Such extreme cases are usually associated with market collapses caused by Black Swans. Moreover, the correlations become less negative as we move from the lower quantiles to the median. For the case of GAP_CVAR, we observe a periodic pattern compared with the case of GAP_SR.

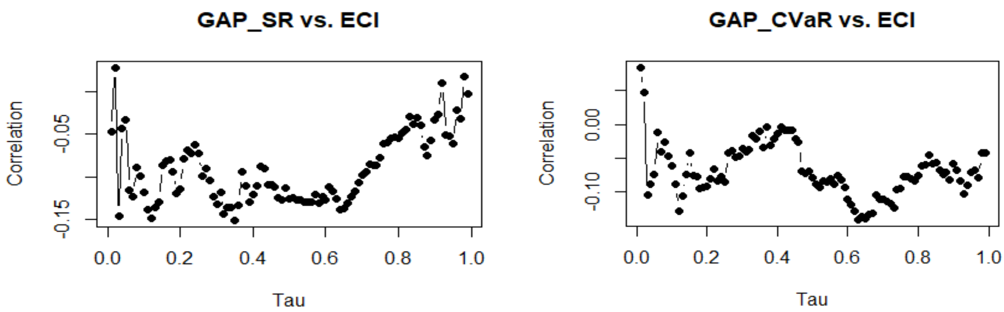

Figure 4.4: Quantile correlations

To learn more about the dynamics of the conditional correlations, we used a DCC model (Engle, 2002) based on GARCH (1,1). Table 4.6 presents F-statistics for the white test. From the table, we can see that the null of homoscedasticity of the data is rejected at the 1% significance level in both cases. We continued our model by considering a VAR (1) model to estimate the DCC data generation process. Consequently, we considered a GARCH (1,1) model and used the log-likelihood method to estimate the parameters (BFGS). According to Table 4.6, the estimated parameters of DCC (α_{DCC} and β_{DCC}) satisfy the stability condition.

Table 4.6: White test and DCC parameters

	F-statistic	$\boldsymbol{\alpha_{DCC}}$	$\boldsymbol{\beta_{DCC}}$
GAP_SR vs. ECI	13.4831^{***}	0.4322	0.8790^{***}
GAP_CVAR vs. ECI	7.1515^{***}	-0.0335^{***}	0.8098^{***}

Note: X^{***} denotes the rejection of null hypothesis at the 1% significance level. F-statistic signifies the White test statistic. Furthermore, α_{DCC} and β_{DCC} represent DCC's parameters.

Figure 4.5 shows the estimated DCCs that are of particular interest to us. Even though the magnitude varies over time, both series mostly show a negative correlation with the ECI. This shows the ability of portfolios to perform well during episodes of time when economic agents anticipate large shocks to the economy. GAP_SR vs. ECI shows an increasing trend since 2018. On the other hand, GAP_CVAR vs. ECI indicates less variability around its mean.

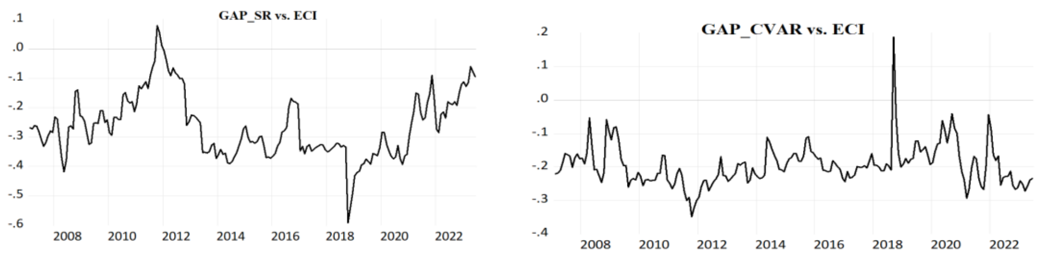

Figure 4.5: DCCs

We further extended the dependence model by including the frequency domain. Figure 4.6 shows the wavelet coherence scalograms. The gray line and gray area indicate the cone of influence where we may have an edge effect caused by stretched wavelets crossing the edges of the time interval of the sample data. Areas with warmer colors show high coherence. On the contrary, when the hue becomes colder, the coherence decreases. Also, the significant areas (at 5%) are outlined in black. The directions of the arrows reveal the sign of the joint movements. If the arrow points to the left, it means that the series are in anti- phase. In other words, they move together in a negative direction. On the other hand, if the arrows are pointing to the right, it means positive co-movement. Furthermore, if the arrows point upward, this means that the first variable is running ahead of the second. If, on the other hand, the arrows point downwards, this means that the second variable is leading. Based on the scalograms, considering short-term and mid-term horizons (up to 8 months), both GAP_SR and

GAP_CVAR show significant correlations with ECI. GAP_CVAR, nonetheless, around 2013 to 2016 shows significant relationship in longer terms. In terms of the sign of correlation, both GSP_SR and GAP_CVAR, on average, move in an opposite direction with ECI. However, GAP_SR shows a more negative correlation with ECI.

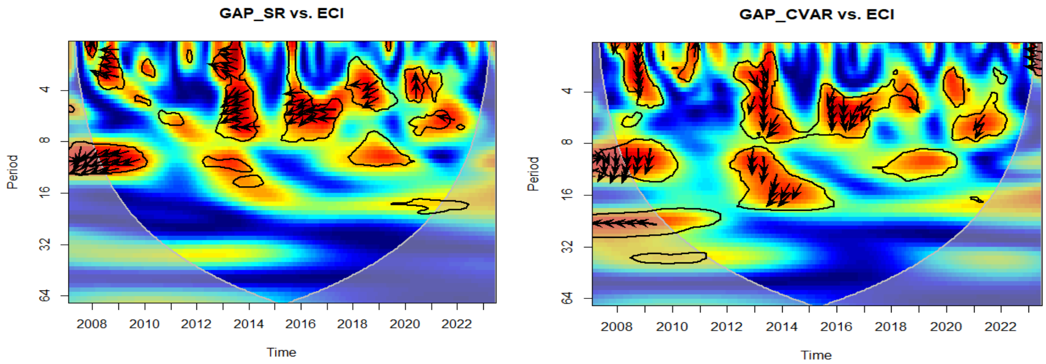

Figure 4.6: The wavelet coherence

Chapter 5

CONCLUSION

This study was structured to include three layers of empirical practices. First, we examined the hedgeability of four asset classes for the case of Turkey: gold, equity market, foreign exchange, and real estate. We used GOLD, BIST100, USD_TRY and REIT as the variables representing the log-price of the asset classes. The existing literature on asset hedgability depends on the methodology used and the data sample. In this study, we followed the inflation- beta methods of Salisu et al. (2020) and Hoang et al. (2016) to find out which asset class hold the potential for inflation hedging in the case of Turkey. In our study, we considered structural breaks, asymmetry, and heteroscedasticity. Our results suggested gold and USD/TRY as two hedges against inflation. Moreover, the results were consistent with the literature that had confirmed an asymmetric relationship between return/price and inflation (Ahmed & Cardinale, 2005; Knif et al., 2008; Wang et al., 2011; Hoang et al., 2016; Yeap & Lean, 2017).

The second layer involved the creation of optimized portfolios with gold and USD/TRY. We created the portfolios using rolling-window optimization techniques with two distinct objectives: Maximizing the Sharpe Ratio (SR) and minimizing the Conditional Value at Risk (CVaR). This allowed us to determine how much return a retail investor would have earned if they had invested in optimized portfolios. In the final stage, we used the GAP series as an indicator of the inflation premium for the optimized portfolios and the Economic Confidence Index (ECI) as an indicator of general uncertainty and sentiment in the Turkish economy. We used different methods to model the dependence of the GAP series and the ECI. The main objective was to perform a kind of stress test on the portfolios to understand how they would react if the confidence in the economy reached a low level. We started with conditional mean and rank-based correlation models and then proceeded with quantile correlation to capture the different conditional location of the distributions. We then added the time domain to capture the dynamics of the dependence. We also further modeled the correlation by adding the frequency domain. We found that the GAP series shows robust performance on average when the confidence is low. It is worth noting that ECI captures the overall picture of the economy and is not limited to inflation. In addition, we found that the magnitude of negative correlations was higher for the GAP series of portfolios optimized with the goal of SR maximization.

The empirical results of this study have several implications. First, if we take into account structural breaks, asymmetry, and heteroscedasticity of the data generating process of BIST100 and REIT, they cannot claim a place on the list of inflation hedges. Second, the hedging properties of gold and USD/TRY deteriorate in a deflationary environment: in other words, when inflation rises, gold and USD/TRY offer a higher return than when inflation falls. This is especially important for the economic agent using a momentum investment strategy (managed futures strategy). Third, portfolio optimization using SR maximization has historically produced higher average returns than CVaR-minimizing portfolios. Although, for some investments, this result is to be expected in a probabilistic risk-return space, it provides portfolio managers with insightful information when considering realized returns. Fourth, a portfolio with hedges not only protects investors from inflation fluctuations, but also shows robust performance when economic confidence is low. This could be used as a strategy for financial crisis management. Moreover, this result shows that such portfolios are useful players as a component of portfolio diversification for investors. Fifth, the finding that portfolios optimized with the SR maximization objective were more robust during periods of high sentiment and low certainty could be taken into account by portfolio optimizers to adjust their portfolios accordingly. Finally, hedge portfolios' performance in fighting inflation is particularly high when the economy is anticipating imminent shocks (low confidence). This should be taken into account by traders and portfolio managers in their trading systems.

This study placed an emphasis on portfolio return modeling, although conditional risks were also considered directly and indirectly. However, one can extend this study by emphasizing the risk side and revealing more information about the dynamics of ECI and portfolios.

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