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Link between inflation and stock prices in selected countries

Master's thesis

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Abstract

In macroeconomics, inflation is a significant factor that refers to the overall increase in the prices of goods and services in an economy. The relationship between inflation and stock prices has been the subject of several studies, but there is still no clear consensus on whether the link is positive or negative. This thesis aims to conduct a comprehensive analysis of the relationship between inflation and stock returns in three specific countries - Japan, Turkey, and Argentina. These countries have experienced abnormal inflationary situations throughout history, making them interesting case studies for understanding the underlying relationship between stock prices and inflation.

JEL Classification	E31, E37, G12, G17
Keywords	inflation, returns, linear regression, link between inflation and stock prices
Title	Link between inflation and stock prices in selected countries

Abstrakt

V makroekonomii je inflace významným faktorem, který se vztahuje k celkovému nárůstu cen zboží a služeb v ekonomice. Vztah mezi inflací a cenami akcií byl předmětem několika studií, ale stále neexistuje jasný konsensus ohledně toho, zda je tento vztah pozitivní nebo negativní. Tato práce si klade za cíl provést komplexní analýzu vztahu mezi inflací a výnosem akcií v třech konkrétních zemích - Japonsku, Turecku a Argentině. Tyto země zažily v minulosti neobvyklé inflační situace, což z nich dělá zajímavé případové studie pro pochopení podstaty vztahu mezi cenami akcií a inflací.

Klasifikace JEL	E31, E37, G12, G17
Klíčová slova	inflace, výnosy, lineární regrese, spojitost mezi inflací a cenami akcií
Název práce	Spojitost mezi inflací a cenami akcií ve vybraných zemích

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Chapter 1

Introduction

Inflation is among the most significant macroeconomics factors, which describes an increase in the general price level of goods and services in an economy. The question whether the link between stock returns and inflation exists is quite clear and most of the literature agrees that the link exists. But on the other hand much more challenging question is whether the link is positive or negative as there is not a clear consensus. This question was studied for decades, but the answer is still unclear. It was believed that hypothesis stated in Fischer (1930) may also be true for the relation between inflation and stock returns. This hypothesis states that all the information available concerning the future rate of inflation values is fully reflected in a nominal interest rate. Fama (1981), in contrast with this, asserts that it is surprising that common stocks, which are considered to be an excellent inflation hedge, have a negative correlation with inflation since 1953. The same outcomes are obtained by Bodie (1976), who comes to the conclusion that shorting common stocks is necessary for using them as an inflation hedge. As a reaction to this unexpected observation multiple hypotheses were stated in order to explain why the link can be negative. To list some of them, Fama (1981, 1983) proposes the proxy hypothesis, Brandt and Wang (2003) developed a theory called the time-varying risk aversion hypothesis or changing equity risk premium hypothesis. On the other hand, the more recent paper Ang, Brière and Signori (2012) concludes that certain individual stocks have the ability to be good inflation hedges and it is demonstrated in Wei (2010) that there exists a connection between the yield of dividends and inflation that is favorable. Furthermore, Afees, Umar and Lateef (2020) claim that using the information based on the returns of individual stocks, rather than the information based on the returns of an in-

dex, could potentially lead to different findings. As we can see the link between inflation and stock prices is far from clear and we discuss this issue further in the literature review.

Main goal of this thesis is to carry out a comprehensive analysis into the relationship between inflation and stock returns in three particular countries: Japan, Turkey, and Argentina. The reason for picking these countries is that doing so provides a new viewpoint on the issue because the majority of the writing on the topic to far concentrates on the US stock market. Additionally, these countries have unique inflationary patterns, offering a rare chance to examine the connection between inflation and stock returns under various conditions. With some years recording rates as high as 3000 percent, Argentina in particular has a history of having high inflation rates. The situation in this country offers an extreme illustration of inflationary behavior that can clarify the relationship between inflation and stock returns under such conditions. However, despite Turkey's inflation rate not being as high as Argentina's, there have been times when it has been consistently high. As a result, investigating the relationship between inflation and stock returns in Turkey will shed light on how inflation affects stock returns in situations that are different from those in Argentina. Japan, on the other hand, stands out as a special case because of its chronically low inflation rates and difficult deflationary circumstances. Since Japan has experienced the reverse of inflation, analyzing the relationship between inflation and stock gains in that country offers a unique viewpoint on the issue.

To study relation between inflation and stock prices is important even these days as inflation is high not only in the Czech Republic, but in most of the countries. The results of this paper could help to answer the 70 old year question whether hedging against the inflation can be done through acquiring stocks and whether these stocks can be undervalued because of the inadequate reaction of investors to the inflation.

Chapter 2

Literature review

The two sections of this chapter are titled "Theoretical Framework" and "Empirical Framework." The first provides an overview of concepts that set our analysis of the link between inflation and stock prices into the context. The second is centered around empirical research done on this topic.

2.1 Theoretical Framework

A prolonged and widespread increase in the average price of goods and services over time within an economy is referred to as inflation. It denotes a decline in a currency unit's purchasing power. Consumers must spend more money to get the same amount of products and services they could previously get for less as the price of goods and services rises. An important gauge of inflation is the consumer price index. It is a metric that keeps track of price changes for a sample selection of goods and services that are often bought by households. The CPI offers useful information about the trends in the cost of necessities including food, housing, healthcare, transportation, education, and other things needed for everyday life. Although methods used to estimate biases, when calculating CPI, suffer from a lack of reproducibility, it is the one of the most frequently used methods Diewert (1998). In this paper when we say that an instrument is a hedge against inflation, then we mean that the higher is the inflation the higher is also the return of the instrument, so the real return remains the same.

There are several papers that are trying to find a connection between inflation and behavior of stocks. Eldomiaty, Saeed, Hammam and AboulSoud (2020) claims that literature includes an agreement that the influence that interest rates and inflation rate have on stock markets exists. They suggest that

while the relationship between inflation rates and interest rates exhibits a certain amount of intersection, a clear agreement does not exist on the significance and magnitude of the effect of these rates on stock prices.

For decades, researchers have been examining the relationship between inflation and stock prices. Due to the fact that stocks represent allegation of control over tangible assets stocks have historically been seen as a solid inflation hedge, because returns of tangible assets should be resistant to inflation. There was a belief that the Fisher (1930) hypothesis, which suggests that a nominal interest rate incorporates all relevant information about future inflation rates, could also be applicable to the connection between stock returns and inflation. Fischer claims that there is a relationship between inflation and stock prices. He believed that increase in inflation tends to increase in stock prices as well, because when the cost of services and goods increases, companies tend to increase their pricing model to keep their profit margins, which results in higher stock prices. On the other hand, in case inflation decreases, stock prices may also tend to decline as companies may not be able to keep their profit margins at the same level. Fischer also points out that this relationship does not always have to be linear.

Numerous empirical researches have found a negative association between inflation and actual stock returns in post-war data from both the United States and other countries, despite the Fisher hypothesis claiming otherwise. In Fama (1981), the author argues that it is surprising that common stocks, which demonstrates ownership of the income produced by real assets, should be an effective inflation hedge despite compelling evidence showing a negative correlation between common stock returns and inflation since 1953. Bodie (1976) discovered a negative relationship between stock prices and inflation. He suggests that this could be the case because rising inflation can induce uncertainty, which can reduce confidence in the economy and have an adverse impact on stock values. In his paper he discovers that the ability of stocks as a inflationary hedge is dependant on ratio of two variances - variance of unexpected inflation which divides the variance of the non-inflation stochastic component of the stocks real return. As this variance ratio increases the ability of equity to serve as inflationary hedge decreases. He unexpectedly concludes that the only way to utilize stocks as an inflationary hedge is necessary to open a short position, because of the negative link between them.

Gultekin (1983) notes that, because of the fast price increase since 1973, it has revived interest in the hedging properties of financial assets such as

stocks against inflation. Because of the many papers written focusing on the US stock market, this paper finds it appropriate to also study different countries than the US. He follows up on the papers Branch (1974) and Cagan (1974). Cagan concluded from the data presented in his paper that a comprehensive group of stocks protects against inflation, but not against extreme inflationary conditions such as hyperinflation, but their inflationary hedging behavior holds only in long time periods, 15 years as a median time for stocks to catch up with the inflation. Branch claims that based on his data that in the long run stocks tend to increase for 4.5 percent a year plus about one-half of the inflation rate, but he acknowledges that actual returns are higher because of the dividend payments. Thus the stocks are according to his paper partial but not complete long run inflation hedge. Gultekin studies 26 countries and concludes that he does not find any reliable relation between nominal stock returns and inflation rates between 1947-1979.

The study conducted by Jaffe and Mandelker (1976) revealed a negative association between returns and concurrent inflation rates during a 20-year timeframe. However, they discovered a favorable link between these two factors over a noticeably longer time frame. We can find other papers focusing on the hedging possibilities of stock under the different periods of time. Schotman and Schweitzer (2000) focuses on hedging properties of stocks against the inflation in the different time horizons. They note that Fischer hypothesis predicts a direct relationship between anticipated nominal stock return and anticipated inflation, however the data from several research suggests that inflation and stock returns are inversely related. They claim that more recent papers concluded that when using a 5 year long horizon there is a positive relationship between stock returns and inflation, for example in Siegel (1998) and Boudoukh and Richardson (1993). The result of the paper is that if the investment horizon is long enough then stocks' ability to hedge against inflation can change from negative to positive. The crucial parameter when considering stocks as an inflation hedge is inflation persistence, as lower levels of inflation persistence can negatively affect their performance. When the Fisher coefficient is only slightly positive, stocks can provide a positive inflation hedge over longer timeframes due to inflation persistence.

Several papers have been written to give an explanation of the observed negative relationship between inflation and stock returns. Modigliani and Cohn (1979) brings forward the inflation illusion hypothesis. The inflation illusion hypothesis proposes that people tend to overemphasize the rate of inflation

and thus this overestimation influences their behavior in the economy. From this follows that people demand higher wages or prices for goods and services, leading to an actual increase in inflation, because inflation expectation has a real effect on the inflation. This hypothesis claims that this overestimation is due to a psychological bias in people's perceptions, rather than a factical increase in the cost of living. The hypothesis suggests that this illusion can have a negative impact on the economy as it can lead to distorted pricing and decision-making, which overall lead to a negative relation between stocks returns and inflation. Ritter and Warr (2002) tests the hypothesis whether investors in the times of high inflation give in to the inflation illusion which leads to the undervaluation of equities and the most undervalued firms being the leveraged one. The paper presents evidence that supports the hypothesis that the level of debt and inflation influence the undervaluation of assets. The magnitude of the results is also notable because it suggests a meaningful relationship. In a low inflation environment, the missvaluation of assets may decrease, but this could be due to the decrease in inflation rather than an improved ability of the market to value assets in the presence of inflation. French, Ruback, and Schwert (1983) studied the effect of nominal contracts on a company's value when facing the unexpected inflation. Theoretically upon the pronouncement of unexpected inflation firms that are net debtors should experience positive stock returns. They concluded that this statement does not hold, because the nominal contracts has close to nothing influence on the sensitivity of the stock returns to unexpected inflation. This evidence supports the hypothesis with the investors making mistakes in valuation as suggested by Modigliani and Cohn by failing to comprehend the dependencies for valuation of nominal liabilities in a firm's structure of capital.

Some researchers, including Feldstein (1980), have proposed that the inclusion of taxes and traditional depreciation expenses in accounting may lead to lower real cash flow for a company. This is because commonly used depreciation does not adequately cover the cost of replacing assets when prices are rising quickly. As a result, the accounting earnings of firms with significant depreciation charges may overestimate the company's ability to pay dividends during high inflation times. This lower "quality" of earnings could result in lower price-to-earnings ratios for companies with low leverage following periods of high inflation, holding other factors constant. When inflation is stable, there is a possibility of overestimation of earnings due to the fact that historical cost depreciation does not equal replacement costs. This can offset the undervaluation

created by the usage of nominal discount rate that doesn't particularly take growth into account. The overestimation of historical cost accounting earnings in comparison to replacement cost accounting earnings is larger the longer the asset takes to devaluate, so this is specifically important for companies which assets are devaluated over a long period of time. For firms that are using leverage is less probable to cancel out these opposing distortions, because higher nominal interest costs reduce earnings per share without offsetting debt capital gain being included. In extreme cases of sharp fall of inflation after a high inflationary phase, the quick drop in discount rate is imminent, but historical cost depreciation will stay below replacement cost, overestimating earnings, until the replacement of existing capital stock. The proxy hypothesis is put out by Fama (1981, 1983) to explain, in his words, the surprising relationship between the price of stocks and the rate of inflation. The findings presented in this study do not disprove the theory that the inverse relationship between inflation and stock returns is a stand-in for the positive correlation between stock real variables and returns, which are more fundamental factors in determining equity values. The negative links between stock returns and inflation have their roots in actual activity and inflation. They are described by combining elements of the money quantity theory and the money demand theory. According to the proxy effect hypothesis, if real variables and measurements of expected and unexpected inflation are used to study stock returns, anomalous relationships between stock returns and inflation will vanish. Brandt and Wang (2003) developed a theory called the time-varying risk aversion hypothesis, which suggests that individuals may have irrational fears of unexpected inflation. Alternatively, this model can also be interpreted as a simplified representation of an economy where inflation reflects the impact of an omitted real variable or friction, or an economy with diverse preferences in which individuals with a higher tolerance for risk hold a larger share of their wealth in nominal assets. According to Kaul (1987), the equilibrium process in the monetary sector is thought to be the root source of the relationship of stock returns and inflation. Furthermore this link varies over time in a systematic way, partly depending on the influence of money demand and supply factors. The study's data analysis from four developed countries - the U.S., Canada, United Kingdom, and Germany - leads to the conclusion that the adverse link between stock returns and inflation in the post-war era can be attributed to the adverse relationship between inflation and actual economic activity, along with counter-cyclical monetary responses.However, data from the 1930's shows that due to pro-cyclical changes

in capital, costs, and the performance of stocks, stock returns could have no link with inflation or have a positive link with it. Kaul and Seyhun's (1990) study explores the relationship between supply shocks and relative price fluctuation, as well as how it affects output and the stock market. They also evaluate the effectiveness of inflation as a stand-in for relative pricing ability in stock-return regression. They discovered that the adverse relationship between stock returns and both anticipated and unexpected inflation can be attributable to the stock market's harmful effect on relative price volatility. The authors contend that the negative effects of relative price fluctuation on output and the stock market were mostly caused by supply shocks in the 1970s. Hess and Lee (1999) investigates the relationship between stock returns and inflation by taking into account supply and demand shocks. The relationship between stock returns and inflation is negatively impacted by supply shocks, which are connected to changes in real production. The link between stock returns and inflation, on the other hand, is positively impacted by demand shocks, which are generally brought on by monetary variables. The link between stock returns and inflation varies over time and among countries, depending on the relative importance of these two types of shocks, as shown by this paper's theoretical analysis and empirical examinations of the United States, United Kingdom, Japan, and Germany. The changing equity risk premium hypothesis is another explanation for the inverse connection among inflation and the price of stocks. The anticipated return on stocks over the risk-free rate is known as the equity risk premium. It is a measure of the additional compensation investors require for the risk of investing in the risky asset. As investors want a larger return on equities to make up for the anticipated loss in buying power, rising inflation expectations might result in a raise of the equity risk premium. Therefore higher inflation expectations may result in lower stock prices, which can have a negative impact on the link of inflation and the price of stocks. Ritter and Warr (2002) denotes that According to Blanchard (1993), Sharpe (2002), and Fama and French (2002), the increase in prices of stocks during the late 1970s was partly because of a decline in the equity risk premium. Furthermore they believe that the start of bull market in 1982 can be attributed, at least in part, to a decrease in the equity risk premium expected by investors. However, it is important to consider whether shareholders would change their stock investments if they were aware of the implicit equity risk premium or if they truly anticipate this implicit risk premium.

If the first one is the case, then it could be argued that stocks are mispriced. They conclude that their data reject the changing equity risk premium hypothesis.

In Santoni and Brian (1994) arrived at the conclusion that the negative connection between common stock returns and inflation can be due to the assumption that underlying the construction of published price indices like the CPI is that people's choice sets are restricted to present consumption. This is even more important where there is a relevant reason that the rate of gross investment or ex ante real interest rate has changed significantly during the period that we are analyzing. Because of that, these indices may lead to inappropriate estimates of the rate of inflation which then concludes in biased results.

According to Salisu, Ndako and Akanni (2020), previous empirical studies in the literature do not provide support for the effectiveness of US stocks as a reliable inflation hedge. However, the authors suggest that this conclusion may be reversed by analyzing price level data for individual components of US stock returns, rather than relying on index level data. According to their findings, using price level data makes it possible for US stock returns to act as a hedge against inflation. In a separate study by Salisu, Raheem and Ndako (2020), the findings indicate that both stocks and real estate are effective options for hedging against inflation.

We can see that the link between inflation and stock prices is far from clear, because it depends on a lot of factors such as which market we are focusing on, how developed the market is, whether we use single stocks or a whole index, how long period we take into consideration and other factors. Most of the literature concludes that the relation between inflation and stock returns is negative as we can see in the meta regression analysis Doucouliagos, Hann and Sturm (2021). They claim that inflation has an adverse effect on financial development, and the relationship is stronger for larger market capitalization. In their analysis, they found evidence of publication bias in the reporting of correlations between stock market development and various factors. Specifically, they observed a preference for reporting larger positive correlations in the case of institutions, and a preference for reporting larger positive correlations between financial openness and private credit, as well as larger negative correlations between private credit and inflation.

2.2 Empirical Framework

In this section we will focus on specific models that are used in the literature. As this problem is studied for more than 90 years a lot of models were developed, from simple regression analysis to very specific and neat models.

The success of stock hedging, according to Bodie (1976), relies on the extent to which it may be used to reduce the risk to an investor's real return. Risk is a measure of uncertainty regarding the future cost of consumer goods. The study uses the variance of the real return on single-period riskless bonds to calculate the inflation risk the proportional reduction in variance caused by the nominal bond and stocks combined in their variance-reducing ratios. The Markowitz-Tobin-mean-variance model of portfolio choice is used in the study to obtain that portfolio.

According to Gultekin (1983), Irvin Fisher is credited as the creator of the concept linking the nominal interest rate to anticipated inflation. According to Fisher (1930), the nominal interest rate is the product of the projected inflation rate and the actual interest rate. In efficient markets, according to Fischer, the predicted real rate is decided by actual factors like the savers' preferred saving schedule and the capital's productivity. Furthermore, he claimed that the actual interest rate is not linked to the expected inflation rate. The author tests the generalized Fisher hypothesis, which assumes that the market is efficient and that anticipated real returns on stocks and projected inflation rates vary independently, so that investors are, on average, compensated for changes in buying power. The author proposes using the following regression model's estimates to evaluate this combined hypothesis.

$$\tilde{R}_t = \alpha + \beta \mathbb{E}[\tilde{\pi}_t | \phi_{t-1}] + \tilde{\epsilon}_t \tag{2.1}$$

where $\tilde{R}_t$ stands for the nominal return on stocks, t is time subscript representing the time between end of period $t-1$ and the end of time period t. Investors based their expectations of period t based on the set of information ϕ_{t-1}. The regression model in (1.1) computes the conditional expected value of the stock market return based on the expected inflation rate. Given this information, the hypothesis stating that the expected nominal return on common stocks varies in direct proportion with the expected inflation rate is valid if the estimated value of β is statistically indistinguishable to 1. This result would imply that stocks provide a fully hedged investment against anticipated inflation. The expected real return of the asset is defined as its expected nominal

return less the expected inflation rate, so in the case that $\beta = 1$ the expected real return on stocks is independent with expected inflation rate.

Gultekin (1983) uses three different approaches to estimate the expected inflation rate, which is then used in the regression model (1.1). Firstly, he utilizes current inflation rates as a stand-in for predicted inflation. Secondly he divides inflation into anticipated and unanticipated factors, ARIMA models are employed to do this. Thirdly he employs short-term rates of interest as indicators of inflation.

As we have already noted, Schotman and Schweitzer (2000) is focusing on the link between inflation and stock prices during the longer time periods, such as 5 years and more. To understand how the hedge ratio evolves in relation to various time periods, they estimate stock returns using a stylized model in the study. They assume following equation generates the stock returns for one-period:

$$R_{t+1} = c + \beta \mathbb{E}_t[\pi_{t+1}] + \phi \eta_{t+1} + \epsilon_{t+1} \tag{2.2}$$

The expected value of inflation $\mathbb{E}_t[\pi_{t+1}]$, unexpected inflation η_{t+1}, and a special risk error term ϵ_{t+1} are all components of the stock return R_{t+1}. Model assumes that ϵ_{t+1} has expected value 0 and variance σ_ϵ^2. The correlation between stock returns and anticipated inflation, as stated by the Fischer hypothesis, is measured by the coefficient β. Coefficient β shouldn't deviate statistically substantially from unity if the Fischer hypothesis is true. This would immediately indicate a constant return on real stocks. The coefficient η, which is referred to as "inflation beta" of stocks in the study, illustrates how stock prices immediately respond to unexpected inflation.

It is assumed that what causes inflation is modeled by AR(1) process:

$$\pi_{t+1} = \mu + \alpha(\pi_t - \mu) + \eta_{t+1} \tag{2.3}$$

Inflation in time $t + 1$ is reliant on independent shocks η_{t+1} with variance σ_η^2, long-term inflation μ, and inflation's departure from the long-term mean in previous time period t .Although the model might be strengthened by including additional transitory noise elements, the paper claims that AR(1) model was chosen for its transparency with inflation persistence alpha as the primary parameter.

In Fama and French (2002) they calculate the expected stock return based on dividends and earnings, which is then used for analysis of the link. The expected return estimates from fundamentals, aid in assessing if the observed

mean return is higher or lower in relation to the anticipated value, combined with additional information. The mean stock return, which can then be contrasted with the realized return, is made up of the mean yield on dividends together with the mean rate of capital gain.

$$A(R_t) = A(D_t/P_{t-1}) + A(GP_t) \tag{2.4}$$

where R_t is average stock return, D_t stands for dividend in year t, the price at the end of year $t-1$ is P_{t-1}, rate of capital gain is denoted by $GP_t = (P_t - P_{t-1})/P_{t-1}$, and A( ) stands for a mean value.

Assume D_t/P_t, the dividend-price ratio, is stationary. According to stationarity, the compound rate of dividend growth will approach the compound rate of capital gain if the sample period is lengthy enough. Thus, different estimate of the anticipated returns of stock is as follows:

$$A(RD_t) = A(D_t/P_{t-1}) + A(GD_t) \tag{2.5}$$

where $GD_t = (D_t - D_{t-1})/D_{t-1}$ represents the rate of dividends growth. This model is known as the dividend growth model. Any variable that is linked with the stock price is subject to the same reasoning that leads to (2.5). For instance, the dividend-price ratio may not be stationary if companies switch from paying dividends to repurchasing shares to distribute profits to stockholders. Nevertheless, if the earnings-price ratio, Y_t/P_t, is stationary, an alternate estimate of the expected rate of capital gain is the average growth rate of earnings, $A(GY_t) = A((Y_t - Y_{t-1})/Y_{t-1})$. Moreover, $A(GY_t)$ and the typical dividend yield can be used together to obtain another estimate of the anticipated stock return. It can be summarized in earnings growth model:

$$A(RY_t) = A(D_t/P_{t-1}) + A(GY_t) \tag{2.6}$$

There are 2 different models used in Afees, Umar and Lateef (2020). In the first methodological approach there is an assumption of homogenous slope coefficient, and both the index level (time series data) and price level (panel data) are included in this assumption. With respect to the index level and price level data, they use the following regressions:

$$r_{it} = \alpha + \beta\pi_t + \mu_i + \epsilon_{it}; i = 1, 2, ..., N; t = 1, 2, ..., T \tag{2.7}$$

$$r_t = \alpha + \beta\pi_t + \epsilon_t \tag{2.8}$$

Equation (2.7) is used for price level data and (2.8) for index level data. Where for every firm i is stock returns r_t in time t computed as $log(p_t/p_{t-1})$ where p_t denotes a stock price at time t. The composite stock price index is used to calculate stock returns for the index level data used in the analysis of time series. The rate of inflation of consumer price π_t is calculated by differenciation of logarythm of aggregation of consumer prices. π_t is consistent across firms since it is company invariant. The method the stock data is used in the estimating process is a clear difference between equations (2.7) and (2.8). The price level data is organized in panel form since the separate stock prices that make up the index are utilized in the process of estimation, but the index level information is organized as a time series because it comprises the whole index including every one of the SP 500 companies.

The second approach assumes some degree of slope coefficient heterogeneity, as a result, a threshold regression model written in both time series and panel form is used. They use threshold-based regression models for up to three thresholds:

Single threshold:

$$r_{it} = \alpha + \pi_{it}(q_{it} < \gamma)\beta_1 + \pi_{it}(q_{it} \geq \gamma)\beta_2 + \mu_i + \epsilon_{it} \tag{2.9}$$

with threshold variable q_{it} and threshold parameter γ that splits the model into two regimes with either coefficient β_1 or β_2. μ_i represents the firm effect.
Double threshold:

$$r_{it} = \alpha + \pi_{it}(q_{it} < \gamma_1)\beta_1 + \pi_{it}(\gamma_1 \leq q_{it} < \gamma_2)\beta_2 + \pi_{it}(q_{it} \geq \gamma_2)\beta_3 + \mu_i + \epsilon_{it} \tag{2.10}$$

where the thresholds γ_1 and γ_2 separate the equation into three regimes, each with coefficients β_1, β_2 and β_3.
Triple threshold:

$$r_{it} = \alpha + \pi_{it}(q_{it} < \gamma_1)\beta_1 + \pi_{it}(\gamma_1 \leq q_{it} < \gamma_2)\beta_2 + \pi_{it}(\gamma_2 \leq q_{it} < \gamma_3)\beta_3 + \pi_{it}(q_{it} \geq \gamma_3)\beta_4 + \mu_i + \epsilon_{it} \tag{2.11}$$

where the thresholds γ_1, γ_2 and γ_3 separate the equation into four regimes, each with coefficients β_1, β_2, β_3 and β_4.

To determine whether it is needed to use the the threshold model , the sequential approach of Bai (1997) and Bai and Perron (1998) is utilized.

The following F statistic can be constructed to test if a threshold effect exists in the threshold-based regression model:

$$F_1 = \frac{(S_0 - S_1)}{\hat{\sigma}^2}; H_0 : \beta_1 = \beta_2; H_1 : \beta_1 \neq \beta_2 \tag{2.12}$$

S_0 is the restricted model's residual sum of squares (RSS) under H_0, while S_1 is the RSS under unrestricted model H_1. The estimated variance for the unrestricted model is the $\hat{\sigma}^2$. The absence of a threshold effect is implied by H_0's non-rejection, whereas the opposite is true if H_0 is rejected. Four possible results might occur when examining the potential for an asset class to hedge against inflation: a poorer or perverse hedge, a partial hedge, a full hedge, and superior hedge. The slope coefficient that paper uses is β for simplicity's sake. The partial hedge is produced when $0 < \beta < 1$; the complete hedge signifies $\beta = 1$; and the superior hedge denotes a circumstance where $\beta > 1$. The worse hedge denotes a condition where $\beta \leq 0$ and in this case assets are negatively linked.

Chapter 3

Data

Our thesis utilizes a specific methodology to study the relationship between inflation and stock prices. We obtain the relevant stock market returns from each country's index data and perform a regression analysis on the inflation rates, calculated from the consumer price index. To ensure the validity of our findings, we verify that the assumptions of our approach are met, which entails conducting several tests and discussing our country selection process. This chapter encompasses all of these aspects.

3.1 Selection of countries

3.1.1 Argentina

First country that we selected is Argentina. This South American country is interesting for us because of the extreme but not that persistent hyperinflation period. In this chapter we will briefly set into the context the situation that we want to focus on.

Inflationary behavior of Argentina is volatile, as it varies from -1.2 percent to extremely high 3079.8 percent. We will focus on the period 1988-1993 as this is the time period, when inflation has hit record highs. We illustrate the inflation of Argentina in the figure (3.1).

Figure 3.1: Inflation of Argentina

In Manzetti and Dell'Aquila (1988) the authors say that in spite of the fact that Argentina had rich natural resources and skilled manpower, the potential of Argentina has never been realized. In Backerman (1995) the author states that the main cause of hyperinflation in Argentina were stabilization programs that were right before hyperinflation, because they brought central banks into the 'debt distress'. During 1989-1990 Argentina had a series of hyperinflation seasons. First hyperinflation period was from February 1989 to July 1989. This hyperinflation period came after the failure of the 'Primavera plan' also called the Spring plan. This program was designed during the presidency of Raúl Alfonsín and it followed the Austral plan designed by Juan Vital Sourrouille. Both plans had similar goals to fight the high inflation by freezing the wages and limiting money printing. Unfortunately both plans failed, because export prices rose and international debt increased which escalated into extreme hyperinflation. We will use the Merval index which is a stock market index for the Bolsa de Comercio de Buenos Aires, which is the main stock exchange in Argentina. It consists of the top 50 publicly traded companies listed on the exchange and it is used as a benchmark for the overall performance of the Argentine stock market. The Merval index is calculated using market capitalization, which is the total value of all outstanding shares of a company's stock. It is updated regularly and is published by the Bolsa de Comercio de Buenos Aires. The weights are updated every 3 months. The base of MERVAL was on 30th June 1986 at the value 0.01 Argentine pesos. We illustrate the price of this index in the figure (3.2).

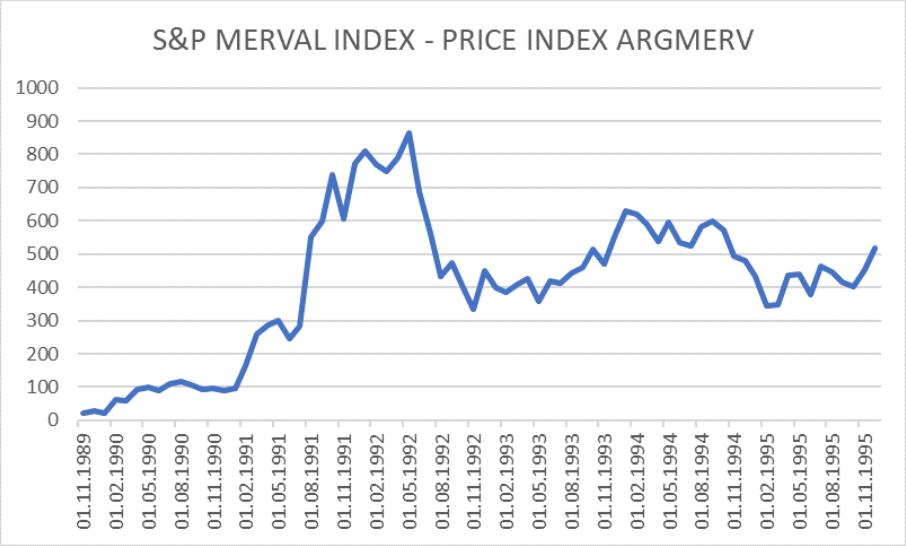

Figure 3.2: Merval index

3.1.2 Turkey

Another country that we want to focus on is Turkey. We selected Turkey because of its persistent high inflation. This is different than in Argentina case, where we were more focused on extreme hyperinflation in quite short period of time. Historic inflation in Turkey has been a significant issue for the country in recent decades. In the 1970s and 1980s, Turkey experienced high levels of inflation, with annual rates reaching as high as 200 percent. This was largely due to the government's reliance on printing more money to finance its deficits, which led to a decrease in the value of the currency. Furthermore From 1980 Turkey relied heavily on foreign investments but the government and financial system of Turkey did not support economic growth which led to a significant budget deficits. These deficits were financed through selling huge amount of high-interest bonds to Turkish banks. Alper (2001) states that in 2000 begins three year disinflation program supported by the International Monetary Fund which aim was to decrease the inflation. It is an exchange-rate based stabilization program. Shortly after a liquidity crisis strikes Turkey in 2001.

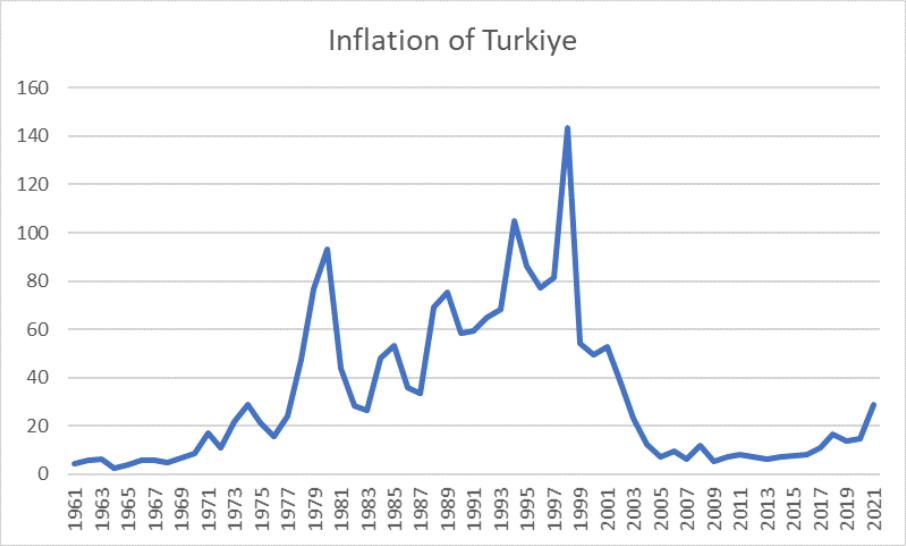

Figure 3.3: Inflation in Turkiye

The BIST100 index which states for the Borsa Instanbul 100 Index is the capitalization-weighted index. Base date is January 1986. The 100 firms with the greatest market capitalization and volume that are listed on the Istanbul Stock Exchange make up the index. It does not include investment trusts. The selection of the companies in to the BIST100 is based on the predefined criteria.

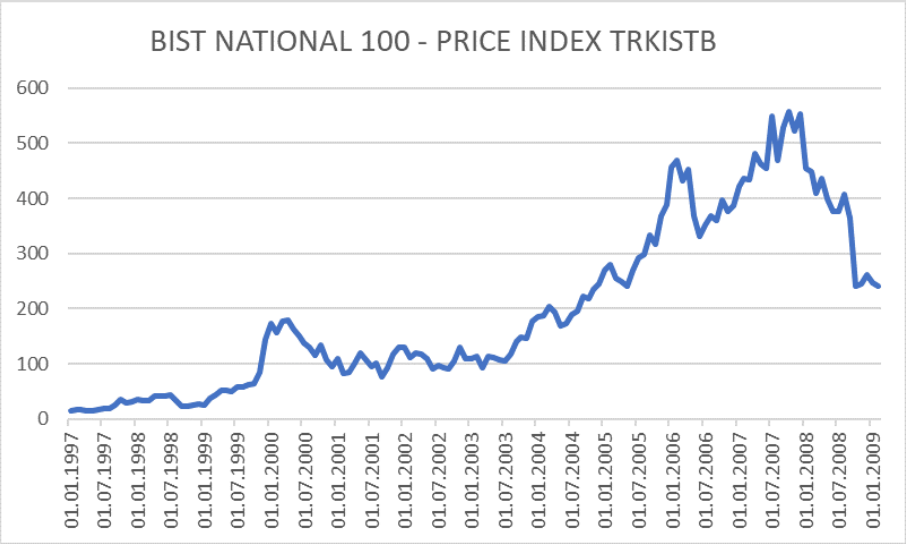

Figure 3.4: BIST national 100

3.1.3 Japan

Third country that we will be looking into is Japan. We selected this country because of its deflation period. Like in previous parts, we will now set Japan

deflation into the context. In early 1992 the Japanese asset price bubble burst. This bubble was forming from 1986 to 1991 in the real estate and stock sector. In Hossain and Rafiq (2011) authors claim that partial or undirected financial deregulation and monetary policy measured during the bubble period had contributed to a speculative behavior of banks during the asset price bubble in order of increasing their short term profit. Which then led into the banking crises. After the banking crisis followed overproduction and deflation which led to widespread cynicism as claimed by Clairmon (2001).

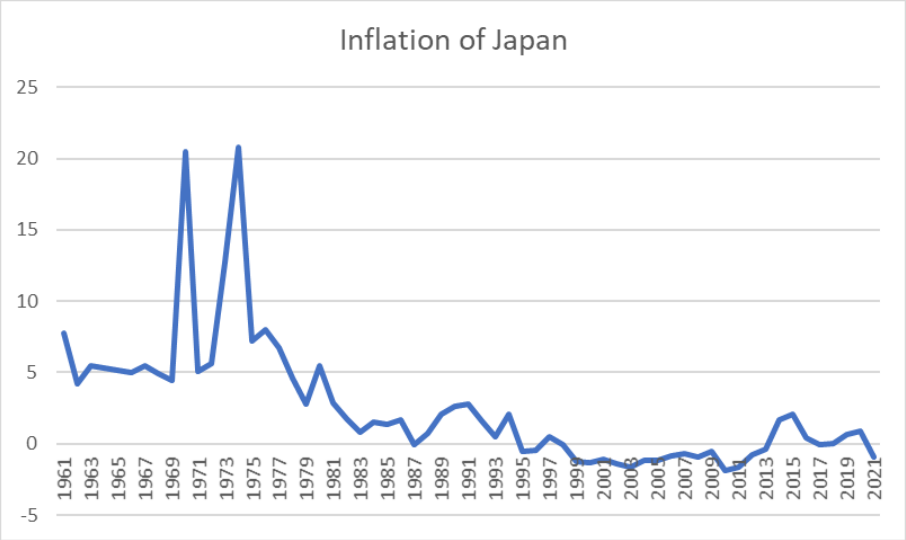

Figure 3.5: Inflation of Japan

The financial development of the top 225 Japanese firms listed on the Tokyo Stock Exchange (TSE) is reflected in the Nikkei 225 stock index. The index is calculated based on the market capitalization of each of the 225 companies included in the index, with a higher weight given to companies with a higher market capitalization. The Nikkei 225 has been calculated since 7th September 1950. Unlike the typical behavior of stock indices, Nikkei 225 reached its highest value on 29th December 1989, during the peak of the Japanese asset price bubble. It is a price weighted index, similarly to Merval.

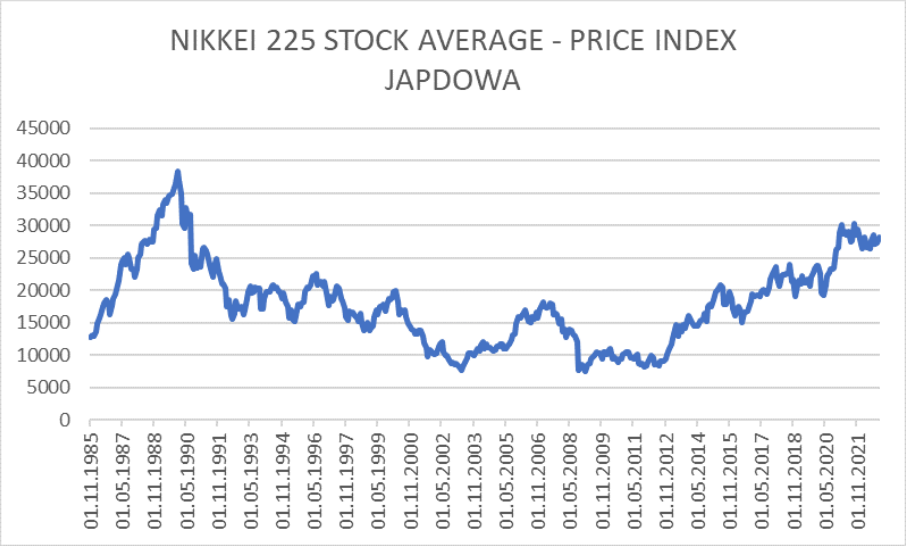

Figure 3.6: Nikkei 225

3.2 Data properties

In this section, we perform four tests to assess the characteristics of our data. Firstly, we employ the Ljung-Box test to examine the existence of autocorrelation in our inflation data, and to determine if it is possible to model it using an AR(1) model. We also display the ACF and PACF plots. Next, we utilize the Breusch-Pagan test to detect heteroskedasticity, which can result in biased linear regression outcomes. In such a case, generalized regression can be employed to verify the results. Another assumption of linear and generalized regression is stationarity. Therefore, we conduct the Dickey-Fuller Test, and if the result indicates that our time series are non-stationary, we conclude the Johansen cointegration test to determine whether the time series are cointegrated. Otherwise, our regression model could be spurious.

Our analysis is based on quarterly data spanning from 1990 to 2022 for all three countries. To obtain results for time periods longer than one quarter, we utilize 3, 5, and 10-year intervals, and compute the corresponding inflation and returns based on the quarterly data. This approach results in 9 time series, with 3 for each country.

3.2.1 Ljung-Box test

We use Ljung-Box test to uncover autocorrelation in the time series. As we want to model the inflation by AR(1) process we need to test that this approach is

relevant in our case. The null hypothesis is that time series are white noise, while the alternative hypothesis being that time series are not white noise, according to Hassani and Yeganegi (2020). The Ljung–Box test statistic can be defined followingly:

$$Q_H = (T+2)\sum_{h=1}^{H}(T-h)^{-1}\hat{\rho}_{T,h}^2 \tag{3.1}$$

with sample ACF $\hat{\rho}_{T,h}^2$ which have χ^2 distribution with H degrees of freedom, where H being arbitrary given representing the number of lags included into the test. For $H = 20$ we obtain $p - value < 2.2e^{-16}$ for Japan and Turkey and $p - value = 0.005737$ for Argentina therefore we reject our null hypothesis of data being the white noise, so the data are not distributed independently.

3.2.2 ACF and PACF

We create ACF and PACF plots in this section. These plots enable us to identify the terms AR and MA for ARIMA modeling and to infer information about dependencies. An ACF plot shows the correlation among a time series and its lags. The PACF graphic shows the partial correlation among a time series and its lags which could not be explained through correlations at any lower-order lags. When fitting the ARMA model, one should concentrate on identifying the fewest parameters that could adequately explain the series. The more complicated ARMA models are difficult to understand since adding more parameters increases the model's noise level and raises the standard deviation. As we have already mentioned we follow the work Schotman and Schweitzer (2000) regarding the modeling of inflation by AR(1) process for its transparency with alpha for inflation persistence as the main variable. The results show[1] us that this approach is viable as lag 1 is significant for all countries but more sophisticated models could strengthen the model especially in Turkey case.

3.2.3 Breusch-Pagan test

We conclude the Breusch-Pagan test because one of the assumptions of linear regression is the heteroskedasticity of the error components. Breusch-Pagan (1979) created a Lagrange Multiplier test to check for heteroskedasticity, which

[1] See the Appendix A

according to Zaman (1995) appears to support a wide range of hypotheses. In particulary for linear regression model holds:

$$y_t = x_t'\beta + \epsilon_t$$
$$Var(\epsilon_t) = \sigma_t^2 = f(\gamma_0 + \gamma' z_t) \tag{3.2}$$

For each given smooth function f, Breusch and Pagan provide a test of the null hypothesis $H_0 : \gamma = 0$. We will illustrate it on the Argentina case of ten-year trailing lagged model, as it is further describe in the following section. In the following picture we illustrate the graph of residuals vs fitted values:

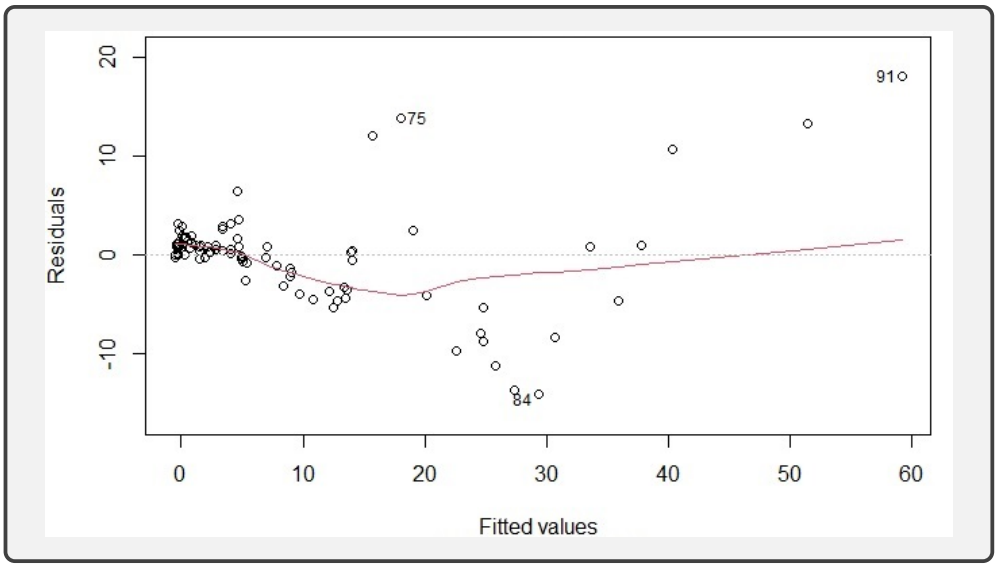

Figure 3.7: Residuals vs fitted values of Argentina lagged model

The graph shows that there are several distance data points for higher fitted values, which may indicate that as values increase, variance likewise increases, indicating heteroscedasticity. The p-value for the Breusch-Pagan test is

$$p =< 2.22e^{-16}$$

Hence we can reject the null hypothesis that the data are homoscedastic, and we must employ a general linear model to evaluate the effectiveness of the linear regression model. We obtain similar results for other countries.

3.2.4 Dickey-Fuller test

We conclude the Dickey-Fuller to test the stacionarity of the time series. We draw information from Mushtaq (2011). In the areas of the economy and finance, many time series exhibit trend tendencies or non-stationarity of the mean. Asset values are prime examples. At the start of the 1970s, this topic created a lot of discussion. Granger and Newbold (1974) introduced the idea that data on macroeconomics often incorporates stochastic patterns along with the idea that this data is described via unit root. Additionally, they suggest that including such factors in econometric models could result to spurious regressions. Since the entire set of regression results may be inaccurate, checking for stationarity is essential. For stationarity, Dickey and Fuller (1979, 1981) creates a rigorous test. Their test's key finding was that determining non-stationarity is the same as determining if a unit root exists. For the testing let us consider AR(1) model:

$$Y_t = \sigma Y_{t-1} + \epsilon \tag{3.3}$$

By subtracting the Y_{t-1} from both sides we got the following:

$$\Delta Y_t = \gamma Y_{t-1} + \epsilon \tag{3.4}$$

where $\gamma = \sigma - 1$ Two alternative versions are used by Dickey and Fuller, constant only and constant and the time trend:

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \epsilon \tag{3.5}$$

$$\Delta Y_t = \alpha + \beta_t + \gamma Y_{t-1} + \epsilon \tag{3.6}$$

The following hypothesis is being tested via t-statistics which is given by formula below:

$$H_0 : \gamma = 0$$

$$H_1 : \gamma < 0$$

$$t = \frac{\hat{\gamma}}{SE(\hat{\gamma})}$$

If t calculated is greater than the critical value given by Dickey-Fuller distribution we do not reject our null hypothesis. The results are in the following table: [2]

[2]We used augmented Dickey-Fuller test to obtain more precise results.

Table 3.1: Dickey-Fuller Test

	Arg (1)	Arg (2)	Turkey (1)	Turkey (2)	Japan (1)	Japan (2)
3; ret	-2.66; 0.2984	-1.69; 0.449	-3.24; 0.085	-2.03; 0.317	-3.02; 0.153	-2.71; 0.0811
3; exp	-2.16; 0.5036	1.285; 0.990	-0.476; 0.982	-1.052; 0.678	-3.48; 0.0466	-3.59; 0.01
3; lag	-0.75; 0.964	2.133; 0.990	-0.720; 0.966	-1.003; 0.695	-3.49; 0.0456	-3.60; 0.01
5; ret	-3.39; 0.0592	-2.07; 0.301	-3.00; 0.162	-2.13; 0.278	-2.71; 0.281	-2.26; 0.227
5; exp	0.684; 0.990	2.90; 0.99	-0.589; 0.976	-1.84; 0.392	-3.12; 0.112	-2.96; 0.0443
5; lag	3.61; 0.990	3.94; 0.99	-0.917; 0.948	-1.75; 0.425	-3.14; 0.105	-2.97; 0.043
10; ret	2.241; 0.99	3.16; 0.99	-3.50; 0.0465	-3.84; 0.01	-1.59; 0.742	0.515; 0.985
10, exp	1.41; 0.99	3.62; 0.99	-2.548; 0.346	-4.72; 0.01	-3.25; 0.0842	-1.184; 0.631
10; lag	4.23; 0.99	4.82; 0.9900	-3.36; 0.0668	-5.31; 0.01	-3.24; 0.086	-1.163; 0.639

The rows contain various time series that we are testing: returns, predicted inflation, and lagged inflation over intervals of 3,5 and 10 years, respectively. In the columns are respective countries and there are two different tests concluded. The (1) is the Dickey-Fuller test with drift and trend and (2) is Dickey-Fuller test with drift. Every cell contains two values, the first one is test statistic value and the second one is the p-value.

Regarding the case of Argentina, the null hypothesis of non-stationarity cannot be dismissed for all time series based on at least one of the performed tests. In Turkey, the null hypothesis can be rejected for non-stationarity using the p-value for a ten-year trailing returns and lagged inflation. However, for all other cases in Turkey, the null hypothesis cannot be rejected. For Japan, the null hypothesis can be rejected for all time series using a three-year horizon, although the test for the returns time series is relatively weak. Therefore, caution is necessary when using this data. However, for all other time series in Japan, the null hypothesis cannot be rejected.

3.2.5 Johansen cointegration test

We are unable to reject the null hypothesis that our data are non-stationary for most of the time-series and therefore we are unable to utilize linear regression without first testing for cointegration of the time series, due to the risk of spurious regression. Johansen (2012) states that Granger (1981) introduced cointegration in econometrics due to the prevalence of nonstationarity of the random walk type among macro variables, along with a discernible tendency towards co-movement. When we refer to spurious regression, we indicate a statistical model with completly misleading statistical evidence. Therefore we employ Johansen cointegration test. According to Dwyer (2015), the enhanced Dickey-Fuller test can be thought of as a multivariate generalization of the

Johansen test. The generalization is the search for unit roots in linear combinations of variables. When there are more than two variables, it is possible to estimate all cointegrating vectors using the Johansen test and estimation approach - maximum likelihood. There exist two tests, namely the trace test and the maximum eigenvalue test, which are used for testing cointegration. The initial Johansen test serves as a test statistic for both of these tests and is used to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration. However, the alternative hypotheses for both tests are different.The maximum eigenvalue test scrutinizes whether the highest eigenvalue is equivalent to zero in comparison to the alternative hypothesis that the next highest eigenvalue is zero. The trace test determines whether the rank of the matrix equals r_0.

Tables (3.2),(3.3) and (3.4) present the outcomes of the trace test, using the same notation as in table (3.1). The results indicate that, for all relevant cases, we can reject the hypothesis of r=0 at a significance level of at least 5%. Additionally, for most cases, we cannot reject the hypothesis of $r \leq 1$ at a 5% significance level. Therefore, it is reasonable to use linear regression on our data, as for example Engle and Granger (1987) claims that when conducting a linear least squares regression on two cointegrated time series, the resulting estimation of their connection is typically very accurate.

Table 3.2: Johansen cointegration test, Argentina

	3, exp	3, lag	5, exp	5, lag	10, exp	10, lag	Test values
r<=1	4.77	6.34	10.66	9.91	2.13	6.76	7.52; 9.24; 12.97
r=0	21.52	24.34	37.31	32.52	37.32	39.34	17.85; 19.96; 24.60

Table 3.3: Johansen cointegration test, Turkey

	3, exp	3, lag	5, exp	5, lag	10, exp	10, lag	Test values
r<=1	2.36	2.38	8.57	8.67	9.21	10.76	7.52; 9.24; 12.97
r=0	19.82	20.96	25.41	26.81	59.52	51.46	17.85; 19.96; 24.60

Table 3.4: Johansen cointegration test, Japan

	3, exp	3, lag	5, exp	5, lag	10, exp	10, lag	Test values
r<=1	6.01	4.94	3.99	4.00	2.88	2.91	7.52; 9.24; 12.97
r=0	24.10	26.53	31.88	31.97	30.81	31.05	17.85; 19.96; 24.60

Chapter 4

Methodology

In this chapter we will examine mathematical models that we will be using to determine the relationship between inflation and stock returns. In literature many advanced models were used, but there is a consensus in Campbell et al.(1997), that when we model inflation as AR(1) process and therefore actual stocks return as ARMA(1,1) process that such dynamics are empirically relevant for stock returns. After modeling of expected inflation we are able to determine whether there is a link between stock prices and expected inflation by linear regression.

4.1 Linear regression

As we have already discussed in chapter Empirical Framework (2.2) linear regression is one of the techniques used in literature to explore the link between stock returns and inflation. In this section we will mathematically define linear regression and its assumptions. Based on James, Witten, Hastie and Tibshirani (2021) assuming that there are p different predictors, the multiple linear regression model has the following structure:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_p X_p + \epsilon \tag{4.1}$$

and where β_j quantifies the link between that variable and response and X_j is representing the jth predictor. We can interpret β_j as the average effect on variable Y of unitary increase in X_j assuming holding all other predictors unchanged.

4.1.1 Assumptions of linear regression

Ayinde, Apata and Alaba (2012) states that few fundamental assumptions guide the formulation of the linear regression model. Regressors are presumed to be non-stochastic and independent among other things. Also assuming independence, constant variance, and independence from the regressors for the error terms. When all these traditional assumptions are true, the assumptions of the linear regression model are met, the Ordinary Least Square (OLS) is recognized to have several optimal features of an estimator, such as it is linear, unbiased and efficient. In some situations these assumptions are not true. As a result, numerous techniques for estimating the model parameters have been created. Because their regressors are frequently produced by stochastic processes outside of their control in the business, economic, and social sciences, the assumption of non-stochastic regressors is not always satisfied. Several authors, such as Fomby et al.(1984) have provided scenarios and examples where the non static assumption may be broken and have also talked about the effects this will have on the OLS estimator when it is used to estimate the model parameters. They concluded that even though the OLS estimator is not BLUE, it is still unbiased and has the lowest variance if the regressors are stochastic and independent of the error components.

In Chartterjee, Hadi and Price (2000) notes that multicollinearity results from the premise of independent regressors being broken. Strongly connected regressors may render the interpretation of the regression coefficients invalid because the regression model's underlying presumption has been broken. As long as multicollinearity is imperfect, the regression coefficients estimates produced by the OLS estimator are still unbiased, but the regression coefficients may have significant sampling errors that have an impact on the inference and forecasting generated by the model. In the paper Akinwande, Dikko and Samson (2015) is noted that a small amount of multicollinearity isn't always a major issue. Serious multicollinearity, however, is a significant issue because it theoretically causes the variance of the regression coefficients to skyrocket, making them unstable. The harder it is to comprehend the coefficients, the more variance they have. Ayinde, Apata and Alaba (2012) concludes that in all amounts of multicollinearity, the OLS estimator consistently outperforms and rivals the maximum likelihood and Cochrane Orcut estimators at low and occasionaly moderate levels of autocorrelation.

4.1.2 Usefulness of linear regression

In this subsection we want to provide evidence that linear regression is not outdated and its usage can be reasonable. Boyd, Levine, and Smith (2001) looked at the relationship between inflation and financial development using three distinct forms of regression analysis. To quantify the independent partial connection between inflation and financial development, they first performed straightforward linear regressions that controlled for other economic parameters related to financial development. Second, they included breakdowns in the relationship between inflation and financial development, denoting distinct shifts in the slopes and intercepts. This method took into consideration any threshold effects brought on by inflation rates going above specified thresholds. In order to determine whether these nonlinear models more effectively explained the data, they replicated the first set of regressions but replaced the inflation rate with two nonlinear transformations of inflation, especially the inverse inflation rate and the exponential function of inflation. Jaffe and Mandelker (1976) utilized linear regression to examine how well equities work as an inflation hedge using the following model:

$$R_{mt} = \beta_0 + \beta_1 I_t + \epsilon_t$$

where I is the rate of inflation over month t and R_{mt} is the return on the market portfolio (the Fisher index) in month t. In James, Witten, Hastie and Tibshirani (2021) notes that linear regression is still effective and popular statistical technique. Also, it provides a suitable starting point for more advanced techniques; many more neat statistical learning techniques can be thought of as extensions or modifications of linear regression. In the paper Cogoljević, Gavrilović, Roganović, Matić and Piljan (2018) is examined the factors that impact inflation by analyzing the gaps in current research. The impact of the consumer price index, monetary aggregates, discount rate, and exchange rate on inflation is examined using multiple regression analysis. The following model is utilized:

$$CPI = a_0 + a_1 PPI + a_2 ER + a_3 ES + a_4 M + a_5 NI + \epsilon_t$$

using the variables of (PPI) Producer Price Index, (ER) Euro-National Currency Exchange Rate, (M) Broadest Monetary Aggregate in Use, (ES) National Banks Discount Rates, and (NI) Net Income.

Linear regression is also commonly used in other research fileds such as in Rath, Tripathy and Tripathy (2020) in which new active cases of coronavirus disease pandemic is predicted. They conclude that linear and multiple linear regression provide remarkable accuracy.

4.2 Generalized regression

Because homoscedasticity is one of the assumptions of the linear regression and our data are heteroscedastic, the the results of linear regression model could be inaccurate. In section (3.2.3) we present reasoning concerning the difference in volatility. This chapter makes use of Green's (2002) work. Each observation is given a weight of 1/n by least squares, but if variance is not equal, some observations may be more illuminating than others. For instance, based on our data, we can observe that with increasing inflation error term variance increases. We cannot estimate the variance of estimates using

$$Var[\hat{\beta}] = s^2(\mathbf{X}'\mathbf{X})^{-1} \tag{4.2}$$

which is employed in most testing statistics if following equation does not hold

$$Var[\epsilon] = \sigma^2\mathbf{I} \tag{4.3}$$

Therefore we also employ generalized regression model to verify our linear regression model results.

4.2.1 Assumptions of generalized regression

We reduce the linear regression homoscedasticity and no correlation across the observations assumptions, but we maintain the uncorrelated error term assumption. We assume the following error term variance in generalized regression:

$$Var[\epsilon] = \sigma^2\mathbf{\Omega} = \begin{bmatrix} \sigma_1^2 & 0 & \dots & 0 \\ 0 & \sigma_2^2 & \dots & 0 \\ & & \dots & \\ 0 & 0 & \dots & \sigma_n^2 \end{bmatrix} \tag{4.4}$$

The model's unbiassness is unaffected, but it is losing effectiveness. To generalized regression function effectively, the following assumptions must hold:

$$plim_{n\to\infty}((\mathbf{X}'\mathbf{X}/n) = \mathbf{Q}$$

$$plim_{n\to\infty}((\mathbf{X}'\mathbf{Q}\mathbf{X}/n)$$

are both finite positive definite matrices. If this holds we get the following:

$$\sqrt{n}(\hat{\beta} - \beta) \xrightarrow{d} N[0, \sigma^2(\mathbf{X}'\mathbf{X})^{-1}(\mathbf{X}'\mathbf{\Omega}\mathbf{X})(\mathbf{X}'\mathbf{X})^{-1}] \tag{4.5}$$

As we can see from (4.5), since $\sigma^2\Omega$ is unknown, we must estimate it in order to estimate the $Var[\beta|\mathbf{X}]$, which is essential to general regression estimation. We will examine two potential solutions in further detail: the White estimator and the Newey-West estimator. In White (1980), under very general conditions such as existence of positive finite constants δ and Δ such that, for all i holds:

$$E(|\epsilon_i^2|)^{1+\delta} < \Delta$$

which ensures that that the error variances are uniformly bounded, is shown that estimate of $1/n\sum_{i=1}^{n}\sigma_i^2 x_i x_i'$ can be constructed followingly:

$$1/n\sum_{i=1}^{n}\epsilon_i^2 x_i x_i'$$

Based on the least square estimate and following estimation of the covariance matrix of $\hat{\beta}$, we may draw the appropriate conclusions without knowing the specifics of the type of heteroscedasticity:

$$\widehat{Var}[\hat{\beta}] = \frac{1}{n}(\frac{1}{n}\mathbf{X}'\mathbf{X})^{-1}(\frac{1}{n}\sum_{i=1}^{n}\epsilon_i^2 x_i x_i')(\frac{1}{n}\mathbf{X}'\mathbf{X})^{-1}$$

Newey and West (1987) presented a new type of consistent estimators that generate positive semidefinite matrices through a specific process. The method involves calculating weighted sums of estimated autocovariances of cross-products of residuals and instruments. The authors emphasized the significance of allowing the bandwidth, i.e., the number of autocovariances utilized, to increase with sample size at an appropriate rate for a given kernel to ensure consistency.

In their paper Pek, Wong, and Wong (2018) explains that when using the generalized linear model, we can relax one of the assumptions of linear regression, namely, the distributional assumption of normality placed on the error term:

$$\epsilon_i \sim N(0, \sigma^2) \tag{4.6}$$

where σ^2 represents the errors unknown variance. Based on Ng and Cribbie (2017) the Gaussian, gamma, and inverse Gaussian distributions are three probability distributions from the exponential family that may be described for continuous responses. However, specifying any of these exponential distributions entails making assumptions about the error distribution and the relationship between the mean and variance. There are three key parts to generalized linear models: The first structural component defines the linear combination of predictors as follows:

$$\beta_0 + \beta_1 X$$

The second component of the generalized linear model involves a random component, which is determined by a distribution family and assumes a specific mean-variance relationship in the error distribution, based on the predictors in the model. The third component is a link function that relates the expected value of the response to the structural component by transforming it.

The link function in a generalized linear model is represented as: $\eta = g(\mu)$, where μ signifies the expected values of the response variable, η represents the transformed values, and $g(\mu)$ is the function used for transformation. If the link function is properly specified, the relationship between the response variable and the predictor variables becomes linear. Some commonly used link functions include the identity function ($\eta = \mu_i$), log function ($\eta = \log_e \mu_i$), and inverse function ($\eta = \mu_i^{-1}$).

4.2.2 Usefulness of generalized regression

An extended regression model is described in the study by Wei, Dash, Gao, and Gunluk (2019) as a potent tool for supervised learning. With regard to the McCullagh and Nelder (1989) proposed generalized linear models, they specifically examine the usage of rule ensembles, which are linear combinations of decision rules. With this method, complex interactions between input data and output variables can be modeled more flexibly for a variety of applications, including classification, regression, and survival analysis. The model can capture

non-linear correlations and interactions between features that may be ignored by simpler models by combining numerous decision rules.According to Myers, Montgomery, Vining, and Robinson (2012), generalized linear model enables us to fit regression models for univariate response data that adhere to the exponential family, a very broad distribution. Ng and Cribbie (2017) recommends generalized linear models as an appropriate modeling technique under specific circumstances of non-normality and heteroscedasticity. GLMs are capable of utilizing all relevant data to model the relationships between variables and can accommodate non-normal distributions, such as the gamma probability distribution, for continuous responses. The selection of a particular distribution implies assumptions concerning the error distribution and the connection between the mean and variance. In the case of the gamma distribution, the variance function expresses the mean-variance relationship, as the distribution models non-negative data that is positively skewed. This method assumes that the variances are proportional to the square of the means. By relaxing the assumptions of normality and homoscedasticity, GLMs provide greater flexibility for modeling the relationships between variables in various situations.

4.3 Autoregressive process

In this section we will be following the work of Davidson and MacKinnon (2004). The first-order autoregressive process, or AR(1) process, is among the most straightforward and widely applied stochastic processes. AR (p) process can be written in following form:

$$y_t = \gamma + \rho_1 y_{t-1} + \rho_2 y_{t-2} + ... + \rho_p y_{t-p} + \epsilon_t \tag{4.7}$$

where we assume $\epsilon_t \sim IDD(0, \sigma_\epsilon^2)$ this assumption give us that ϵ_t innovations are homoskedastic and uncorrelated. We obtain AR(1) model by plugging in p=1. AR(1) process is stationary when $|\rho_1| < 1$.

4.3.1 Usefulness of AR(1) process

In Davidson and MacKinnon (2004) is noted that AR(1) process is by far the most used autoregressive process. In Schotman and Schweitzer (2000) is AR(1)

process used for generating of inflation because of its transparency as already noted in the literature review by following way:

$$\pi_{t+1} = \mu + \alpha(\pi_t - \mu) + \eta_{t+1}$$

According to Campbell et al. (1997), empirical data with a longer time horizon are generally consistent with the persistent AR(1) alternative model. It also explores the ramifications of expected return fluctuations, which have a significant impact on stock prices and make them far more volatile than they would be otherwise. Honkapohja and McClung (2023) investigates the resilience of average inflation targeting when agents possess incomplete information. Specifically, if the length of the averaging window is not publicly known, the stability of the intended equilibrium state may not be secure under learning. They claim that when prices are extremely sticky and other requirements are satisfied, inflation is not particularly responsive to lags of inflation and, as a result, can be reduced to $\hat{\pi}_t \approx A\hat{\pi}_{t-1}$, with A being somewhat less than 1. In McKnight, Mihailov and Rumler (2020), which focuses on inflation forecasting, is AR(1) model employed for modelling of time-varying trend of inflation.

4.4 Time horizon

Twelve-quarters, twenty-quarters, and forty-quarters trailing inflation and return periods are used in our thesis. Where "trailing returns" refers to the overall return, expressed as a percentage, from the beginning to the end of the period. Yao and Curl (2010), for example, employs a similar approach. When we refer to "trailing inflation," we mean the percentage change in the CPI between the beginning and ending periods as referenced by Blinder (2012).

Chapter 5

Results

5.1 Results of linear regression

In this section we will have a closer look at each result and we will provide description. Based on the results of Schotman and Schweitzer (2000) and Attié and Roache (2009) longer time periods are needed in order of receiving better inflationary hedging properties. In the second paper is claimed that although research on hedging capabilities of stocks is still far from in agreement their findings indicate that for investors who do not have tactical positions in their portfolio, the justification for retaining stocks should be based on a very long-term view. We therefore study time periods of 3, 5 and 10 years of quarterly data. Schwert (1981) notes there is a delay of more than a month between the time the data is collected and the C.P.I. is made public. He attempts to determine whether the stock market reacts when pricing data are obtained or when they are announced by monitoring daily common stock returns. He concludes that the stock market appears to not react to unexpected inflation during the time that the C.P.I. is sampled, which is a few weeks before the announcement date and that the stock market seems to react to unexpected inflation around the time the C.P.I. is announced. Bekaert and Engstrom (2010) states that existing literature emphasizes that at lag 0, the projected inflation-to-current equity premium connection is in fact negative. Yet, the relationship between anticipated inflation and anticipated future equity premiums swiftly shifts in favor, and the total of all these factors also favorably affects anticipated inflation. As a result, we employed two models—one that employs lag 1 inflation and the other that uses expected inflation based on the AR(1) model-for each time

period. On the axis we have cumulative returns and inflation in the hundreds of percents.

5.1.1 Argentina

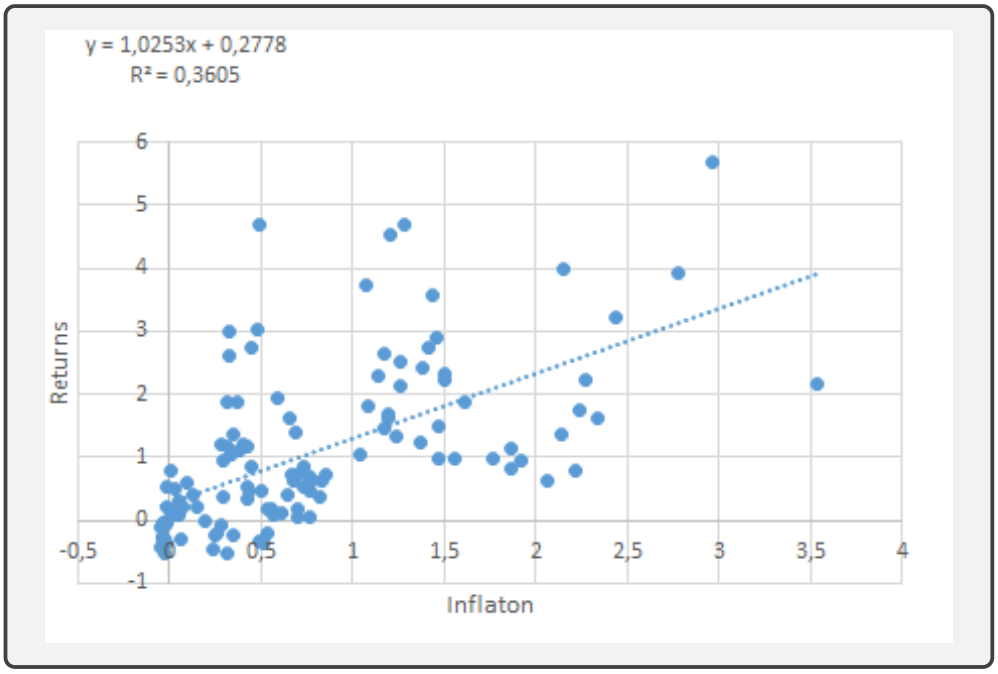

Figure 5.1: Argentina 3 years horizon, 1 lag model

Figure (5.1) displays a 119 data point linear regression model. The three-year trailing data is used to describe returns and inflation. One lag inflation is used to obtain the inflation. Its 1.025 coefficient indicates a favorable link between inflation and stock prices. The fact that the coefficient is both positive and equal to one further supports the idea put out by Fischer (1930). With fewer data points for inflation values farther away, we can see that the majority of the data are clustered near to the origin of the coordinate axis. This number demonstrates that we at least partially account for data volatility, even though using more than one variable in the linear regression model will probably produce a higher R^2 than ours. Usage of R^2 in regression analysis is commented in Helland (1987) that it is imperative to exercise caution when interpreting R^2. However, he finds it difficult to completely renounce the statistic. In Chicco, Warrens and Jurman (2021) findings show that the coefficient of determination R^2, which does not have the interpretability restrictions of MSE, RMSE, MAE, and MAPE and is more informative and useful. Therefore, they advise using

R-squared as the de facto standard metric to assess regression analyses across all scientific fields.

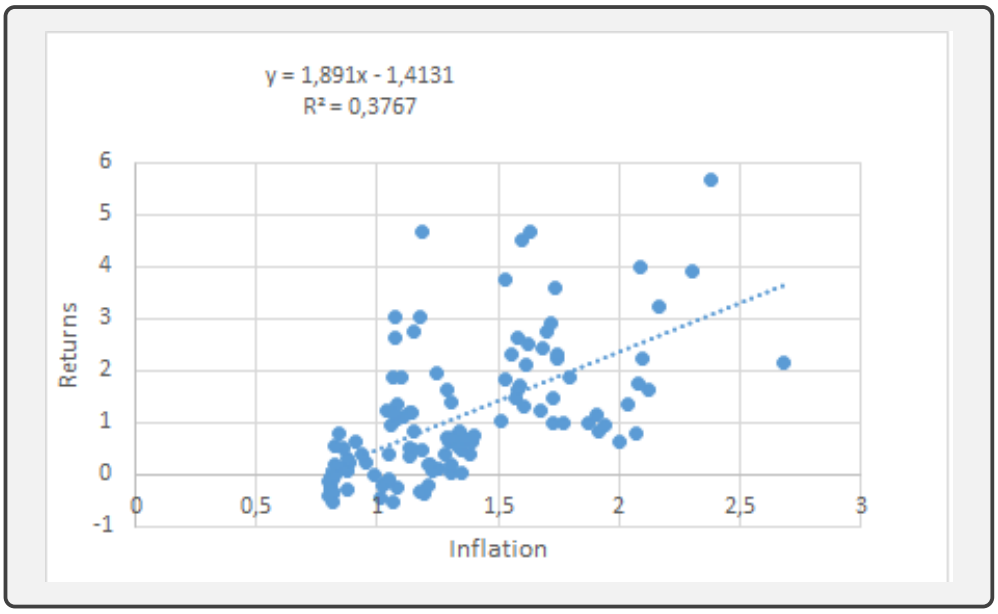

Figure 5.2: Argentina 3 years horizon, AR(1) model

Figure 5.2 displays a 119 data points linear regression model. The three-year trailing data is used to describe returns and inflation. Following AR(1) model is used for obtaining the inflation:

$$\pi_{t+1} = 9.4327 + 0.4516(\pi_t - 9.4327) + \eta_{t+1} \tag{5.1}$$

with standard errors 4.1326 and 0.0772 for the coefficient and mean of AR(1) process respectively.

The 1.891 coefficient indicates a positive link between inflation and stock prices. The fact that the coefficient is significantly higher than 1 would support that stocks are superior hedge Afees, Umar and Lateef (2020). As we can see, the inflation data are more compressed when using the AR(1) model than when using the lagged model, but the R^2 is about the same.

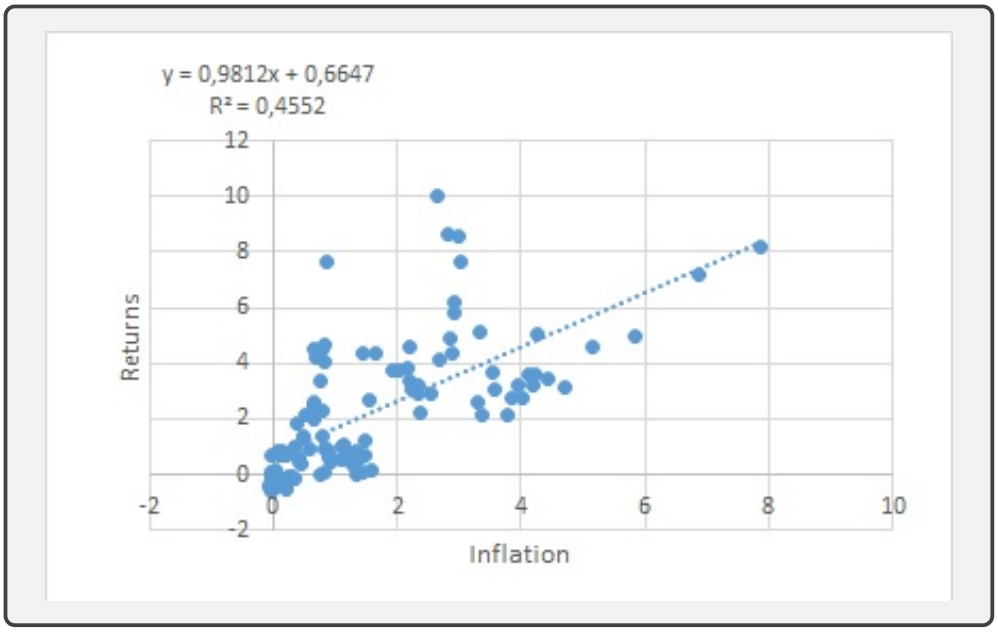

Figure 5.3: Argentina 5 years horizon, 1 lag model

A linear regression model with 111 data points is shown in Figure (5.3). For the sake of describing returns and inflation, utilize the five-year trailing time frame. The inflation is calculated using one lag inflation. The 0.9812 coefficient suggests that inflation and stock prices have a positive relationship. The assumption that equities constitute a complete hedge is further supported by the coefficient's being both positive and equal to one. So, when employing the lag model, the relationship between stock prices and inflation is virtually the same for time horizons of three and five years. As can be seen, $R^2 = 0.4552$ is slightly higher because more volatility, particularly for higher inflation values, is caught.

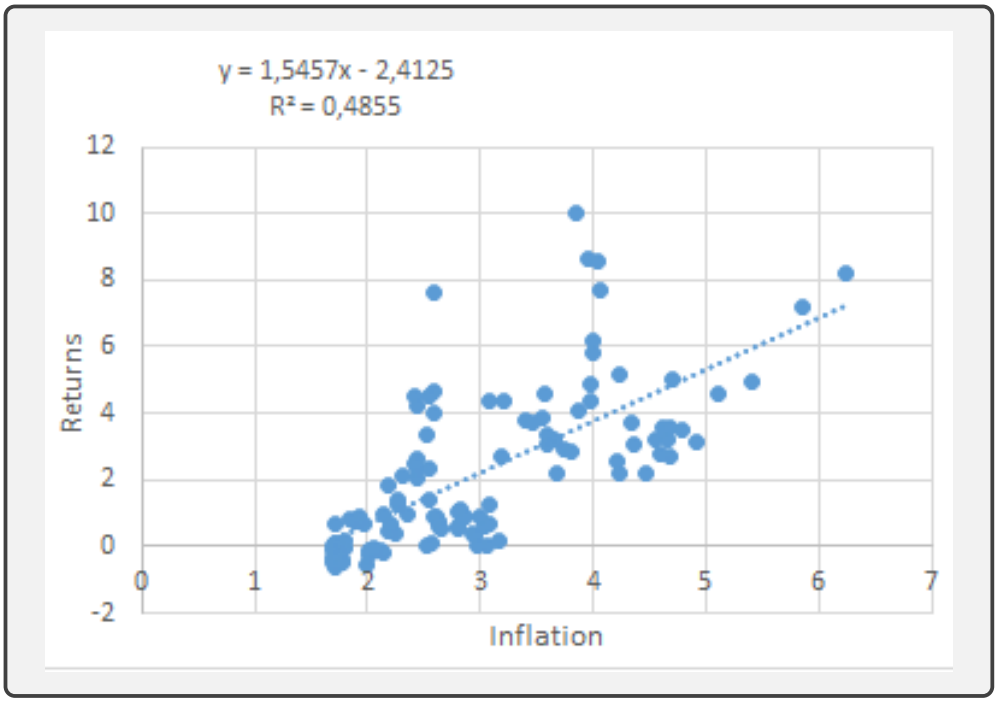

Figure 5.4: Argentina 5 years horizon, AR(1) model

Figure (5.4) displays a linear regression model with 111 data points. For returns and inflation, a trailing interval of five years is employed. The AR(1) model is used to compute the inflation rate (5.1). The 1.5457 coefficient implies a favorable correlation between inflation and stock prices. As we can see, the R^2 increases when compared to 3 year models and is approximately comparable to that in the lag model scenario, which is consistent with Schweitzer's findings (2000). As we can see, the biggest uncaptured volatility occurs during the 400% cumulative inflation. Given that there are many outliers for this inflation, the model can be enhanced by employing a polynomial of order 2 or higher to provide more significant results.

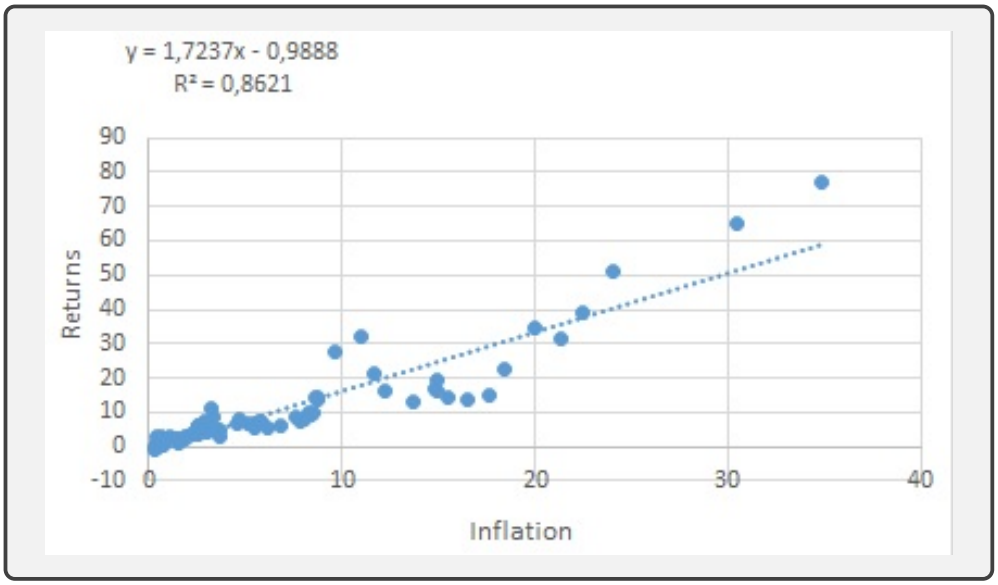

Figure 5.5: Argentina 10 years horizon, 1 lag model

A linear regression model with 91 data points is shown in Figure (5.5). Ten-year trailing data is used for returns and inflation. It is intriguing that the 1.7237 coefficient resembles the 3 years AR(1) model and suggests a positive relationship between stock returns and inflation. As we can see, the $R^2 = 0.8621$ increases dramatically when compared to other models because the model successfully captures the majority of the volatility. We assumed this was because the long-term window smooths out error terms. For the lower two quartiles of inflation, linear approximation is excellent; however, higher polynomial regression would likely better capture the highest cumulative returns for the upper quartiles of inflation.

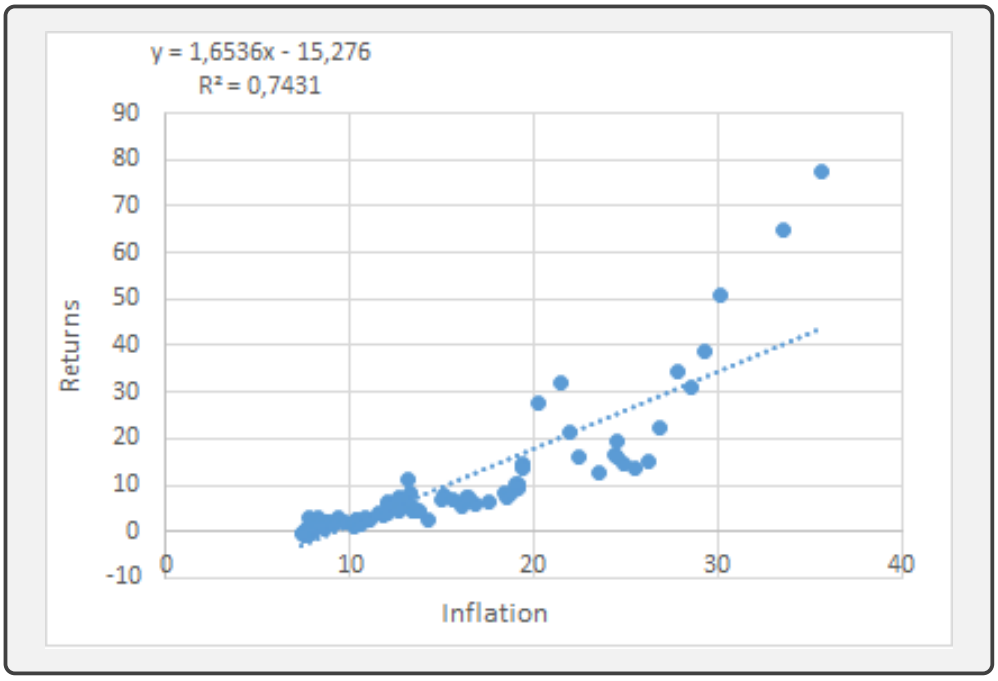

Figure 5.6: Argentina 10 years horizon, AR(1)

Figure (5.6) presents a linear regression model with 91 data points. Returns and inflation are calculated using ten-year trailing data. As the number of distant data points reduced, we can see that the R^2 value was substantially greater than for other AR(1) models, but it was also smaller than for the lagged model, which is interesting because in earlier models, the R^2 value was practically same for AR(1) and lagged model. The linear model performs admirably for lower inflation rates, much like the lagged model, but for higher inflation values, we can observe an almost exponential trend line. The premise that there is a substantial positive correlation between stock returns and inflation during ten-year intervals is supported by the regression coefficient 1.6536.

5.1.2 Turkey

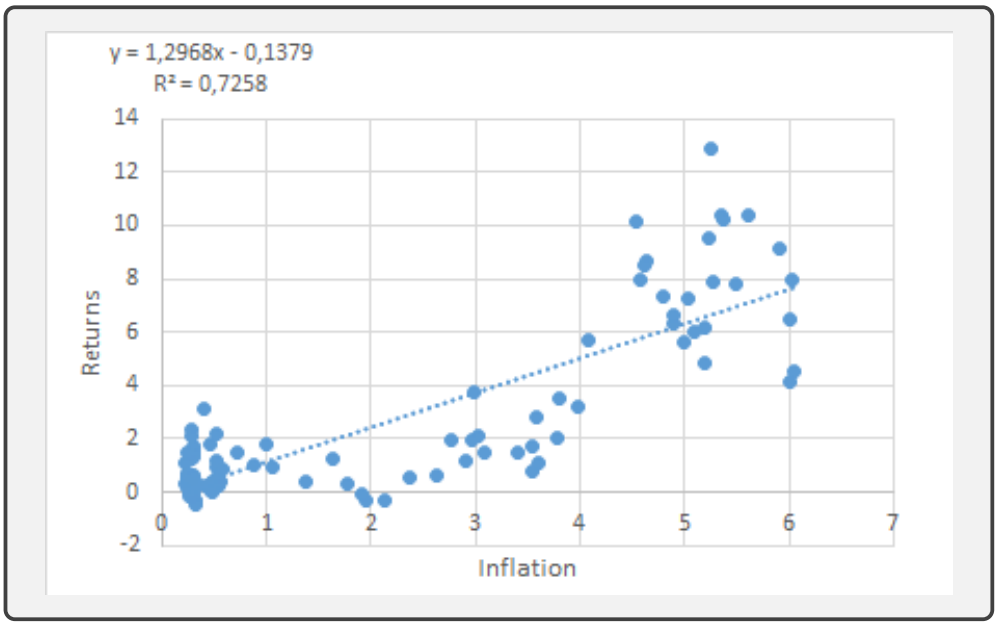

Figure 5.7: Turkey 3 years horizon, 1 lag model

A linear regression model in Figure (5.7) with 119 data points uses a trailing three-year period to describe returns and inflation. One lag inflation is used to calculate the inflation. The 1.2968 coefficient indicates that inflation and stock prices have a strongly positive association, and it is greater than in the case of Argentina for a three-year, one-lag model. As can be observed, the coefficient of determination, $R^2 = 0.7258$, is nearly twice as large as in the case of Argentina. The main difference, in our opinion, is that in Argentina's case higher cumulative returns were quite frequently around 300% for relatively small cumulative inflation between 50% and 150%. On the other hand, this isn't the case in Turkey's case, although we can observe some non-linear behavior for the highest inflation data points.

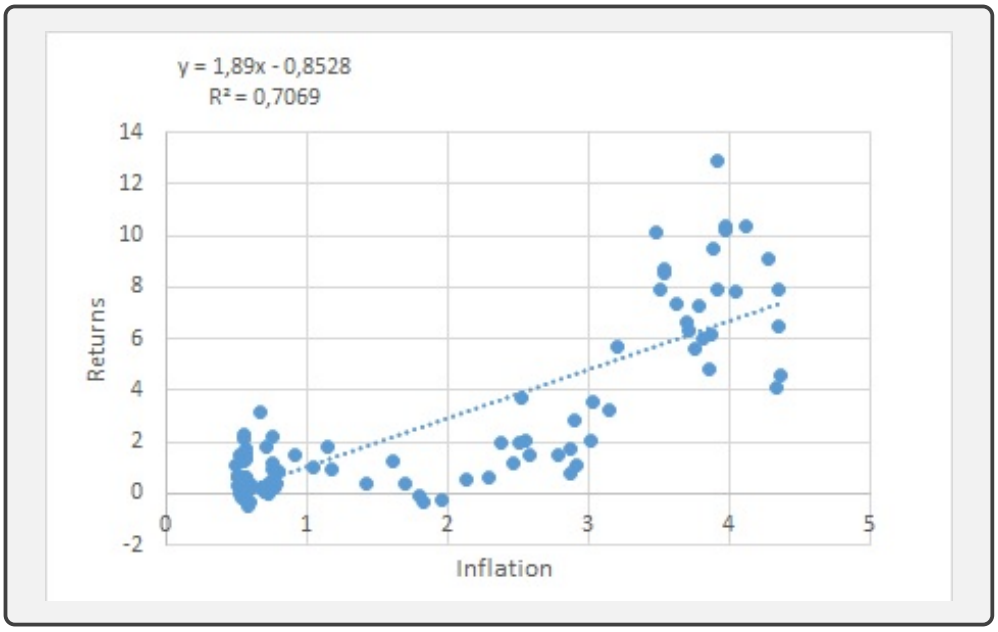

Figure 5.8: Turkey 3 years horizon, AR(1)

A linear regression model with 119 data points is shown in Figure (5.8). For the sake of describing returns and inflation, utilize the three-year trailing timeframe. The AR(1) model is used to calculate inflation as follows:

$$\pi_{t+1} = 8.0583 + 0.721(\pi_t - 8.0583) + \eta_{t+1} \tag{5.2}$$

The standard errors 1.5158 and 0.0599 for the coefficient and mean of AR(1) process respectively. As we can see the standard error of mean of the AR(1) model is much smaller than for Argentina model.

The 1.89 coefficient suggests that inflation and stock prices have a strongly positive relationship. The AR(1) three years model for Argentina produced identical coefficient results, which is an intriguing finding because it supports the idea that high inflationary countries share a relationship between stock returns and inflation. We can observe that the R^2 for the Turkey data is substantially greater than it was for Argentina, which we have already observed for the lagged model.

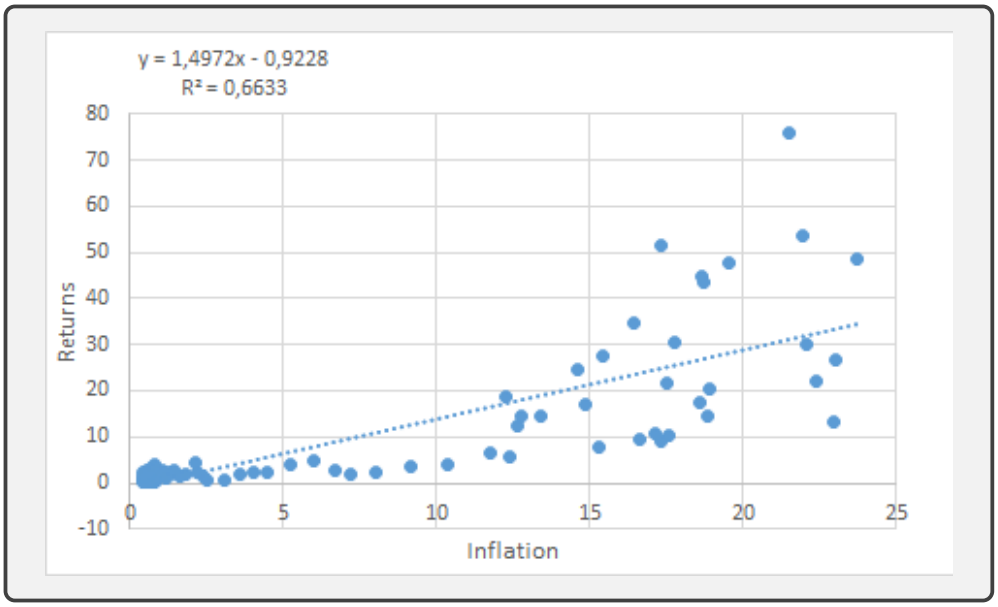

Figure 5.9: Turkey 5 years horizon, 1 lag model

Figure (5.9) displays a linear regression model with 111 data points. Use a trailing five-year period of time to describe returns and inflation. The 1.4972 coefficient indicates a positive correlation between inflation and stock prices. In other words, when using the lag model over a trailing 5-year data, the relationship between stock prices and inflation in Turkey is essentially the same as when using the AR(1) model over a trailing 10-year frame in Argentina. As can be seen, Turkey's R^2 value ($R^2 = 0.6633$) is higher than Argentina's which is consistent with the results for a three-year period. However, it is interesting to note that R^2 dropped in comparison to the three-year period, defying the idea that longer periods would result in more statistically significant models. Although we think a second order polynomial model might increase the coefficient of determination, we believe based on the R^2 value that this model is sufficient to determine whether the link is positive.

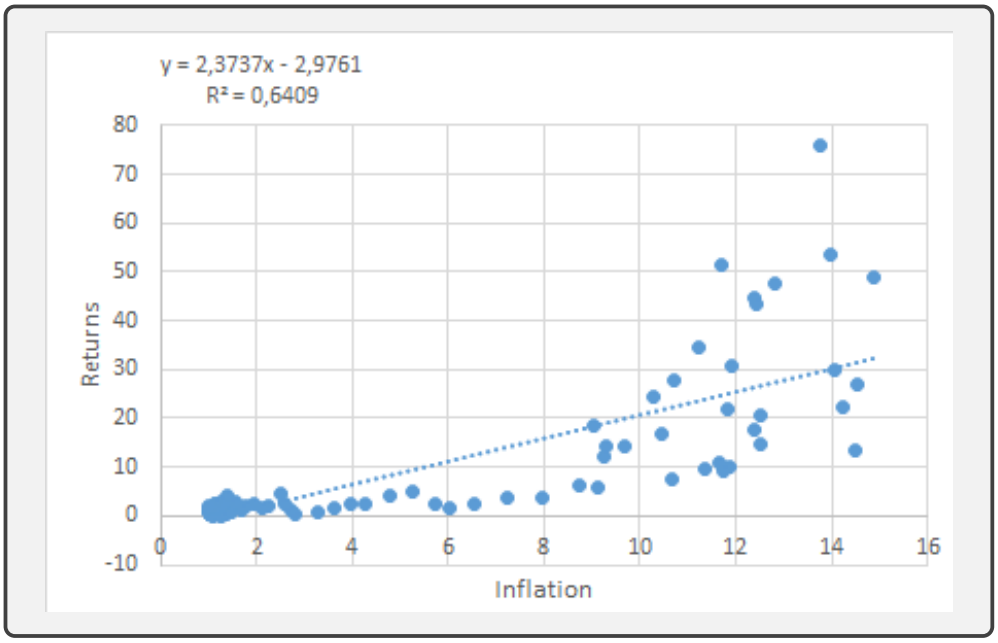

Figure 5.10: Turkey 5 years horizon, AR(1)

In Figure (5.10), a linear regression model is shown, based on 111 data points and employing a trailing data of five years for both returns and inflation. The inflation rate is computed using the AR(1) model (5.2), which tends to produce higher coefficients than the lag model, all else being equal. The coefficient of 2.3737 is noted as the largest among previous models, indicating a strong relationship between returns and inflation. The fact that returns are much larger than inflation for the highest inflation data could be seen as contradicting the Fisher hypothesis, but it also suggests an even stronger relationship between the two variables. The R^2 value of 0.6409 is similar to that of the lag 1 model for this time period, and there is also a decline in R^2 over a three-year time period.

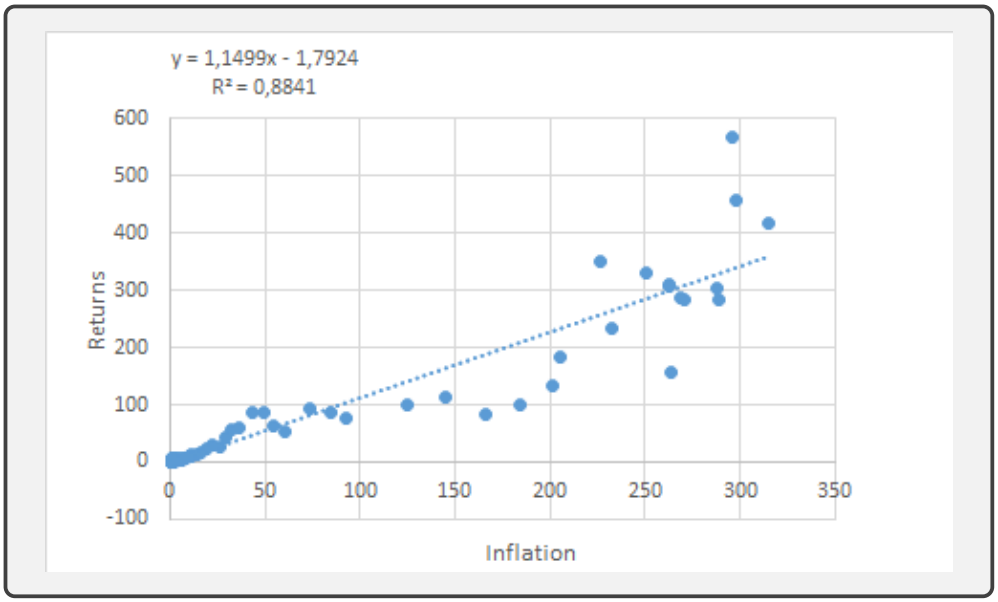

Figure 5.11: Turkey 10 years horizon, 1 lag model

Figure (5.11) displays a linear regression model comprising of 91 data points. The returns and inflation values are computed using ten-year intervals. The linear model exhibits an impressive coefficient of determination value of 0.8841, which is the highest among all the models analyzed. This suggests that the linear model effectively captures the underlying volatility of the majority of data points. It is noteworthy that the 10-year lagged model for Argentina also demonstrates a similar coefficient of determination. This is intriguing because most of the data points for Argentina are concentrated near the origin of the coordinate axis, which does not hold for Turkey case. The Fischer hypothesis is supported by the relationship between stock returns and inflation, which in our model is measured by the model's slope, in our model is equal to 1.1499. However, this value is significantly lower than for a lagged model with a 5-year horizon.

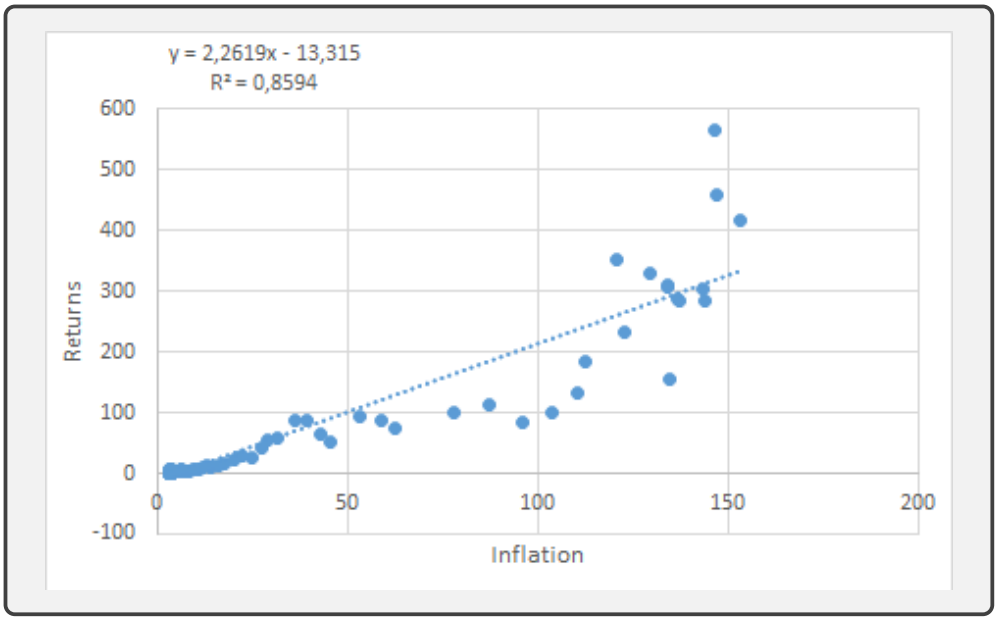

Figure 5.12: Turkey 10 years horizon, AR(1)

Figure (5.12) exhibits a linear regression model that comprises of 91 data points, with returns and inflation values computed using ten-year trailing data. The slope of the linear curve is determined to be 2.2619, which is considerably greater than the lagged model and has a similar trend as the five-year lagged model. Moreover, the coefficient of determination is also high for this model, implying that it provides a good fit to the data. However, it is worth noting that some may argue that a second-order polynomial curve could capture the data's volatility even better. Furthermore, the cumulative inflation values for Turkey are observed to be much higher than those for Turkey, except for the outliers that were filtered out in the Argentina case.

5.1.3 Japan

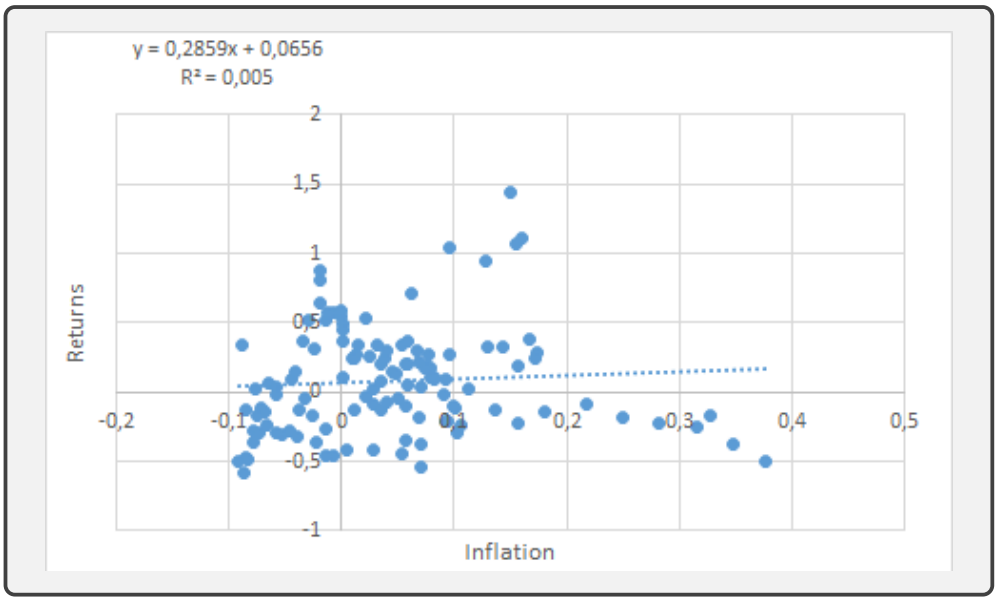

Figure 5.13: Japan 3 years horizon, 1 lag model

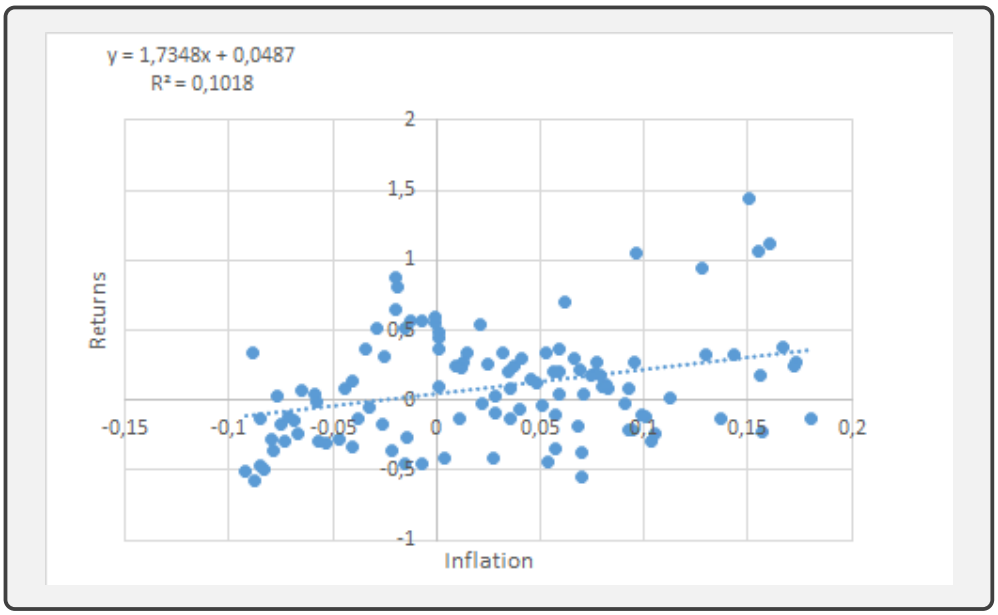

Figure 5.14: Japan 3 years horizon, 1 lag model, from 1992

Figure (5.13) depicts a linear regression model utilizing 120 data points, employing a trailing three-year period to explain returns and inflation. One lag inflation is incorporated to calculate the inflation. The obtained R^2 value of 0.005 is significantly lower than those observed in other countries, indicating

that the model captures very little volatility and fails to indicate a substantial link. We postulate that this is due to the presence of data points with inflation higher than 0.2 but negative returns, most of which are from 1990 and 1991, as evidenced in figure (5.14), where we conducted a similar regression but excluded these data points. We discuss the reasoning why the data from 1990-1991 can have different structure than other data points. The resulting R^2 value of 0.1018 is considerably higher, though still quite low. In the second graph, we observe a similar link of 1.891 to Argentina's 3-year horizon, AR(1) model.

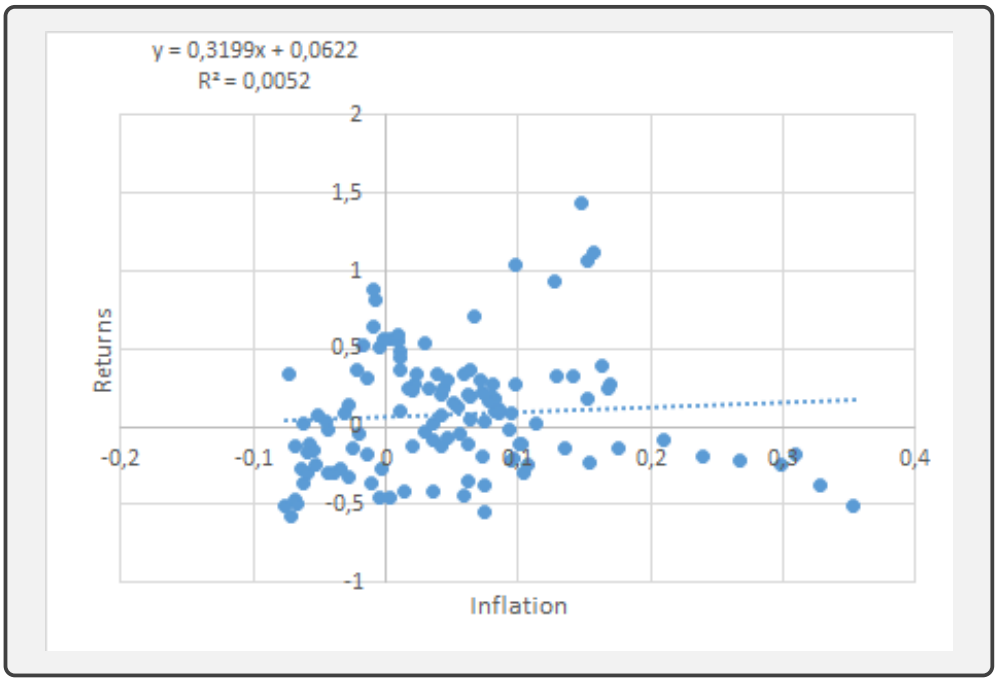

Figure 5.15: Japan 3 years horizon, AR(1) model

We use an AR(1) model for inflation modeling in Japan, just as we do for other countries:

$$\pi_{t+1} = 0.9414 + 0.9160(\pi_t - 0.9414) + \eta_{t+1} \tag{5.3}$$

The mean of the autoregressive model for Japan is noticeably smaller than that of other countries, which aligns with Japan's deflationary period. Additionally, the coefficient is nearly 1, indicating that the results obtained from the lagged and AR(1) models are similar, as demonstrated in figures (5.13) and (5.15).

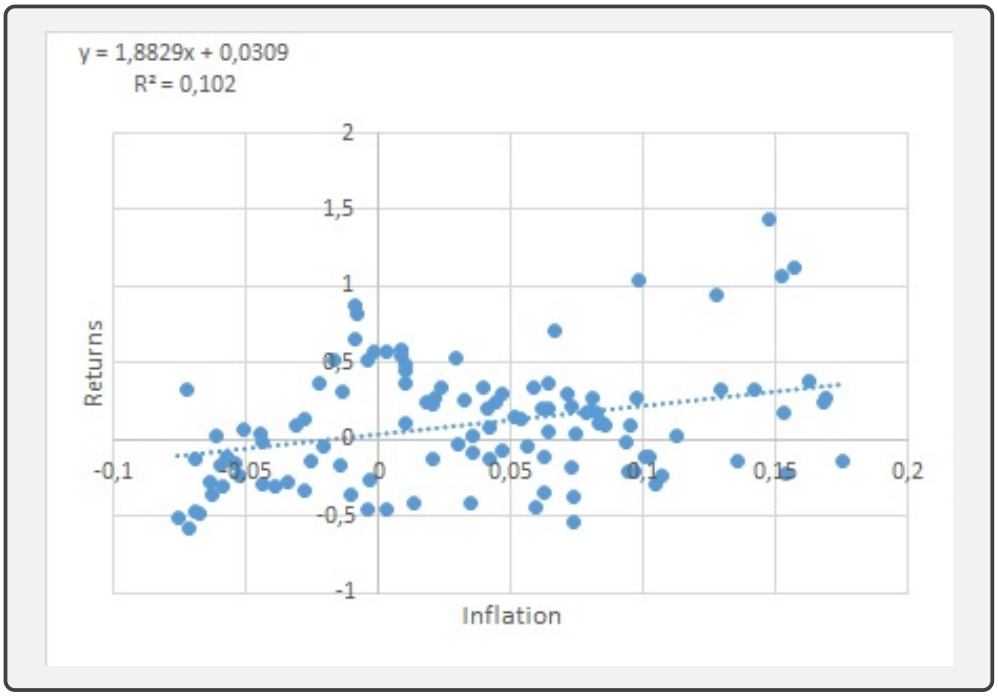

Figure 5.16: Japan 3 years horizon, AR(1) model, from 1992

The model depicted in figure (5.16), which begins in 1992, follows a similar approach as the one in (5.14), with the difference being that we use the expected inflation calculated using an AR(1) model. The coefficient of determination R^2 remains unchanged in terms of the results compared to the lagged model, with a change from 0.005 to 0.1018, and for the expected model, the change was from 0.0052 to 0.102. We can see that majority of volatility of the data is being not captured by our model.

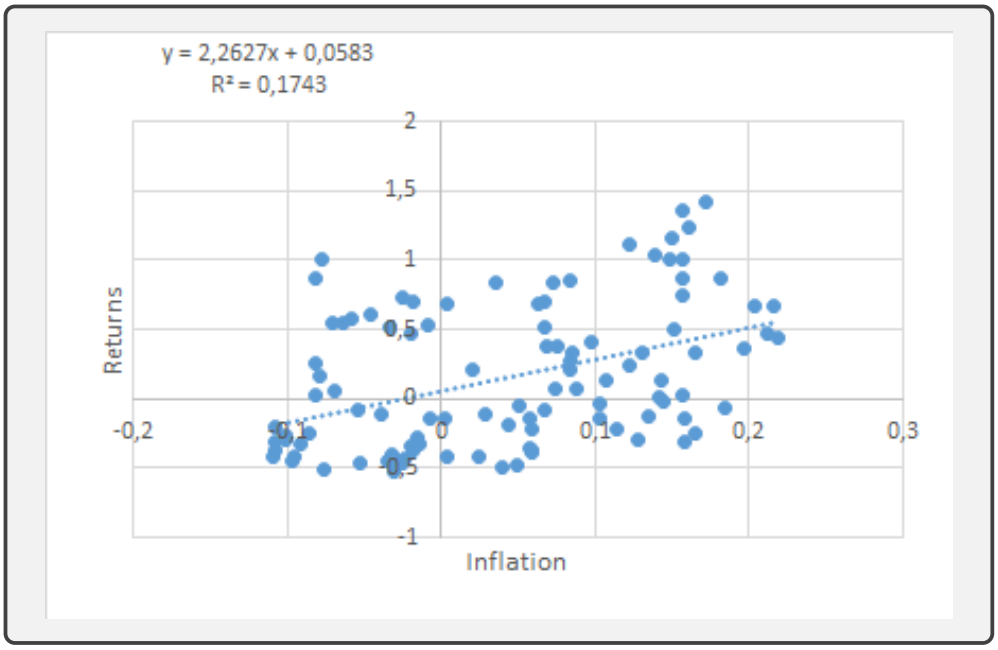

Figure 5.17: Japan 5 years horizon, 1 lag model, from 1992

Figure (5.17) displays a linear regression model consisting of 105 data points. For the same reasons as for the 3 years models we will utilize data from 1992. The R^2 value of 0.1743 indicates that the model captures a greater amount of volatility than the three-year model, but it still falls short in terms of accurately capturing volatility. The coefficient reveals a positive correlation between inflation and stock prices, which is largely attributed to the significant number of data points with an inflation value of -0.1 and negative returns. The dataset also contains a higher frequency of these data points groups, suggesting that the results are inconclusive and that threshold regression could be implemented to yield more conclusive results.

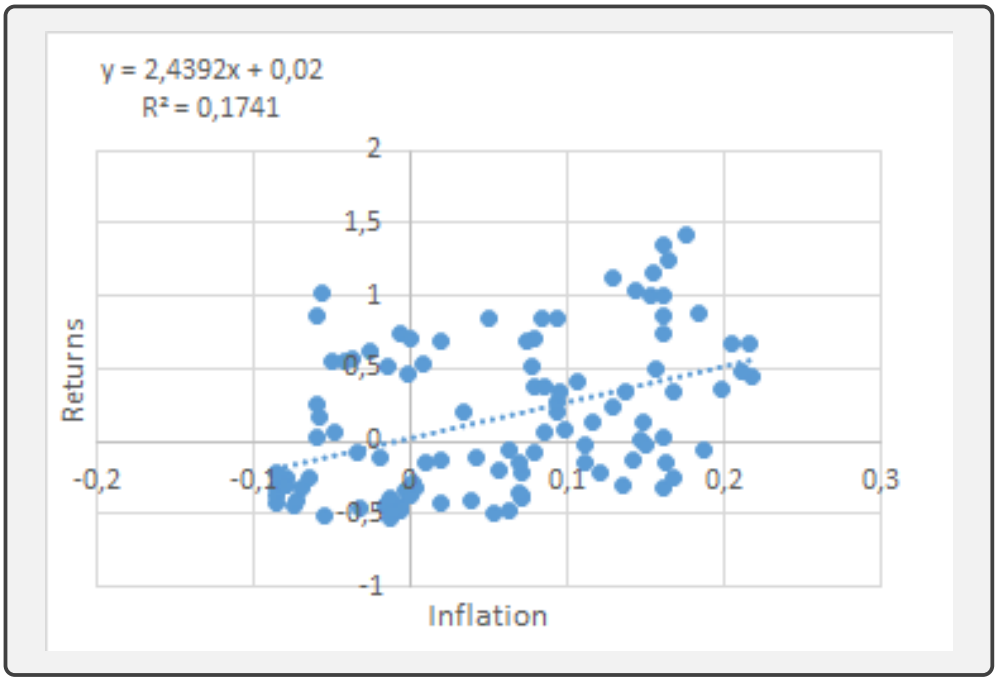

Figure 5.18: Japan 5 years horizon, AR(1), from 1992

Figure (5.18) displays results that are nearly identical to those of the lagged model, which is unsurprising given that the AR(1) model employed a coefficient that is close to 1. The coefficient for the relationship between inflation and returns is greater than that of the lagged model, which aligns with the findings of other AR(1) models.

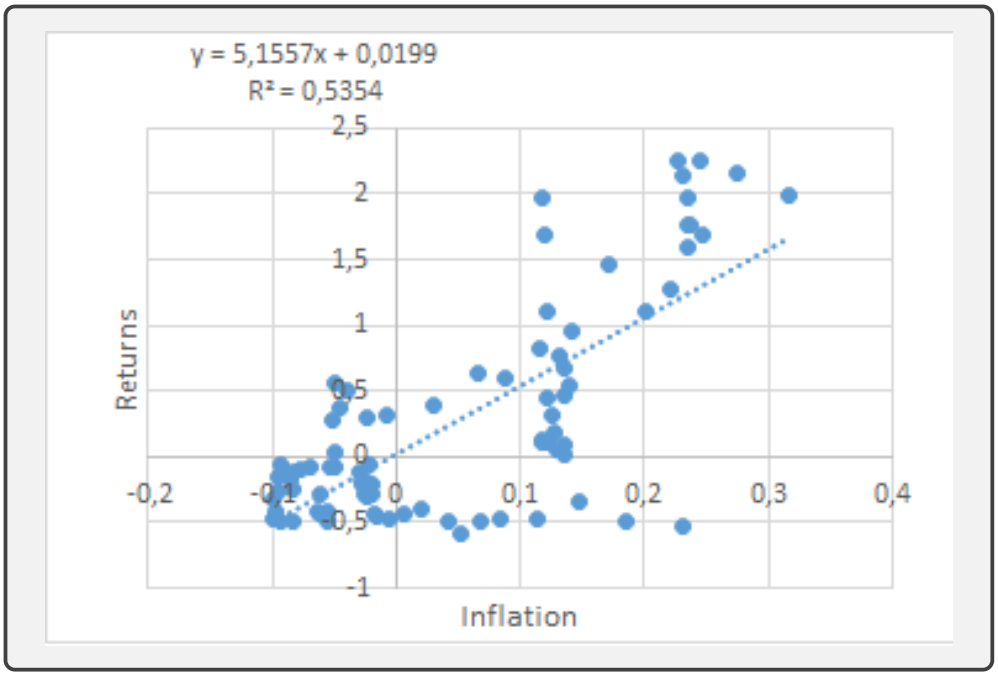

Figure 5.19: Japan 10 years horizon, 1 lag model, from 1992

The results of the ten-year model are presented in Figure (5.19), and we observe a considerable increase in R^2 compared to the three-years and five-years models. This is the first Japanese model graph that captures a substantial portion of the underlying data's volatility. However, outliers persist, particularly data points with negative returns but positive inflation. Figure (5.20) addresses this issue by filtering out data points starting from the year 1994, resulting in an impressive R^2 of 0.7273, indicating that the model captures the majority of inflation. The coefficient is notably higher than that of the Turkey or Argentina case, which we attribute to the fact that even a small trailing inflation of 25% during the period leads to significantly higher returns. We can see that for the model using the expected inflation based on the AR(1) model we acquired almost the same results similarly to the 3 and 5 years models. Regarding the figure (5.21) we can see the same patterns as for other models when using the expected model on the data from 1992.

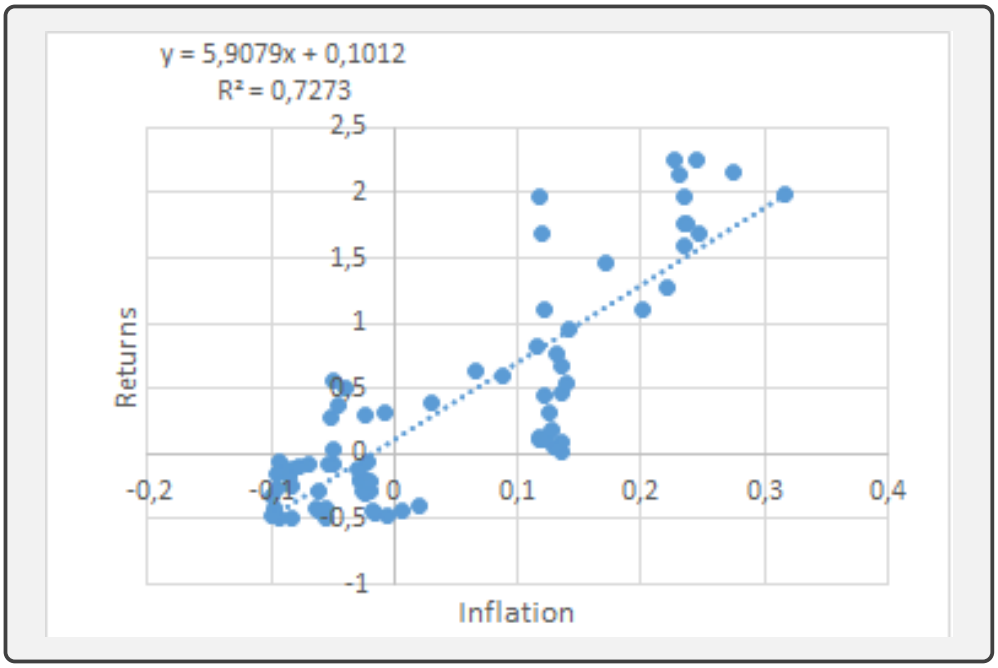

Figure 5.20: Japan 10 years horizon, 1 lag model, from 1994

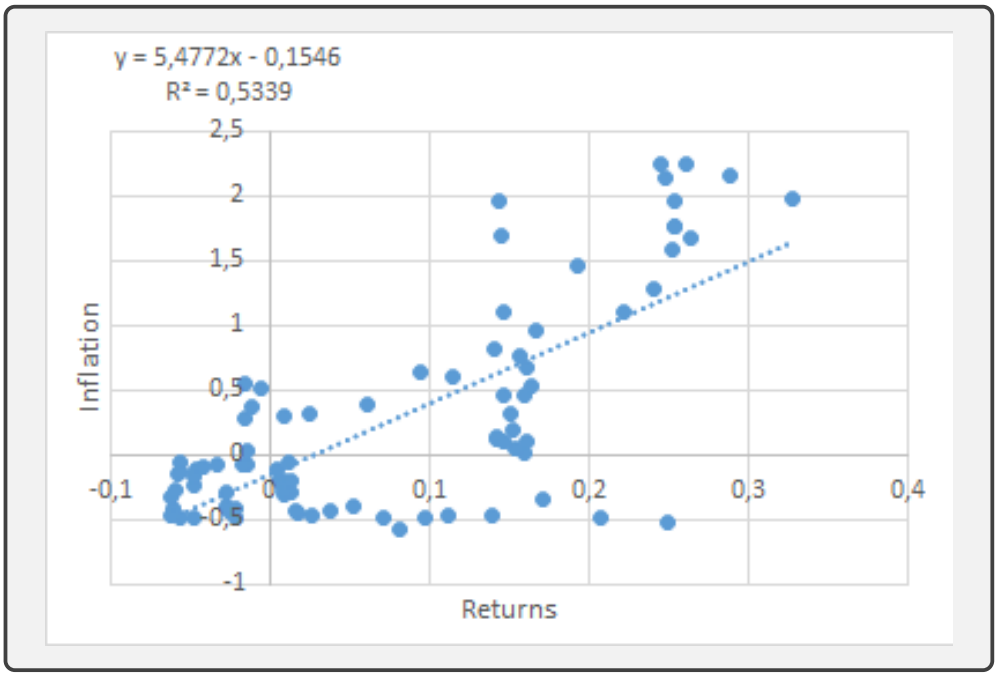

Figure 5.21: Japan 10 years horizon, AR(1), from 1992

5.2 Results of generalized regression

In this section, we finalize the generalized regression method to address the issue of overweighting of data points with higher volatility. The key findings are presented in a table below, which also provides a more structured representation of the results obtained through linear regression as compared to the previous section.

Table 5.1: Overall results

	LR link	LR R^2	LR p-value	GR link	GR R^2	GR p-value
Arg 3; lag	1.03	0.36	5.28e-13	1.29	0.41	1.57e-12
Arg 3; exp	1.89	0.38	1.151e-13	2.18	0.44	3.28e-14
Arg 5; lag	0.98	0.46	4.7e-16	1.44	0.52	2.32e-15
Arg 5; exp	1.55	0.49	2.2e-16	1.85	0.56	2e-16
Arg 10; lag	1.72	0.86	2.2e-16	1.50	0.87	2e-16
Arg 10; exp	1.65	0.74	2.2e-16	1.11	0.85	2e-16
Tur 3; lag	I.30	0.73	2.2e-16	1.06	0.72	2e-16
Tur 3; exp	1.89	0.71	2.2e-16	1.53	0.70	2e-16
Tur 5; lag	1.50	0.66	2.2e-16	1.16	0.79	2e-16
Tur 5; exp	2.37	0.64	2.2e-16	1.73	0.78	1.95e-13
Tur 10; lag	1.15	0.88	2.2e-16	1.06	0.93	2e-16
Tur 10; exp	2.26	0.86	2.2e-16	1.57	0.91	2e-16 [1]
Jap 3; lag	0.29	0.00	0.4441	0.47	0.01	0.228
Jap 3; exp	0.32	0.01	0.4319	0.52	0.01	0.217
Jap 5; lag	0.69	0.03	0.08552	1.09	0.04	0.0101
Jap 5; exp	0.76	0.03	0.08119	1.19	0.04	0.00966
Jap 10; lag	1.80	0.12	0.0007016	2.95	0.24	2.53e-08
Jap 10; exp	1.94	0.12	0.000618	3.14	0.24	2.45e-08
Jap 3; lag*	1.73	0.10	0.0005707	1.88	0.11	0.000183
Jap 5; lag*	2.26	0.17	9.391e-06	2.11	0.16	4.08e-05
Jap 10; lag*	5.16	0.54	1.8e-15	4.15	0.50	1.59e-12
Jap 3; lag**	2.21	0.15	5.46e-05	2.30	0.15	2.71e-05
Jap 5; lag**	2.86	0.25	1.801e-07	2.55	0.21	7.02e-06
Jap 10; lag**	5.91	0.73	2.2e-16	4.96	0.68	2e-16

Table (5.1) provides a summary of the results from both linear and generalized regression analyses for all the time series that were used. Notably, for Japan, we have included time series starting from 1992, indicated by a single asterisk, and from 1994, indicated by two asterisks.

Our calculations reveal that in Argentina, the relationship between inflation and stock returns ranges from 0.98 to 1.89 in the case of linear regression. Moreover, we observed that the R^2 increases for longer time horizons, with a

[1] The generalized regression model and linear regression model were calculated in the R software. We used GLM with the setting family=Gamma.

3-year trailing model capturing over a third of the data volatility. In the case of generalized regression, our results confirm a positive relationship between inflation and stock returns, similar to linear regression, but with different coefficients. Notably, the R^2 values for generalized regression are similar to those for linear regression. The linear regression models for Turkey show positive coefficients ranging from 1.15 to 2.37, which suggest a more robust positive link between inflation and stock returns compared to Argentina. Additionally, the R^2 value for Turkey is noticeably higher. In the case of generalized regression models, the coefficients range from 1.06 to 1.73, and the R^2 value is notably higher for the five-year horizon. This is illustrated in the figure below[2], where we can observe that the extremely high returns for high inflation are not given excessive weight, unlike in the linear regression model.

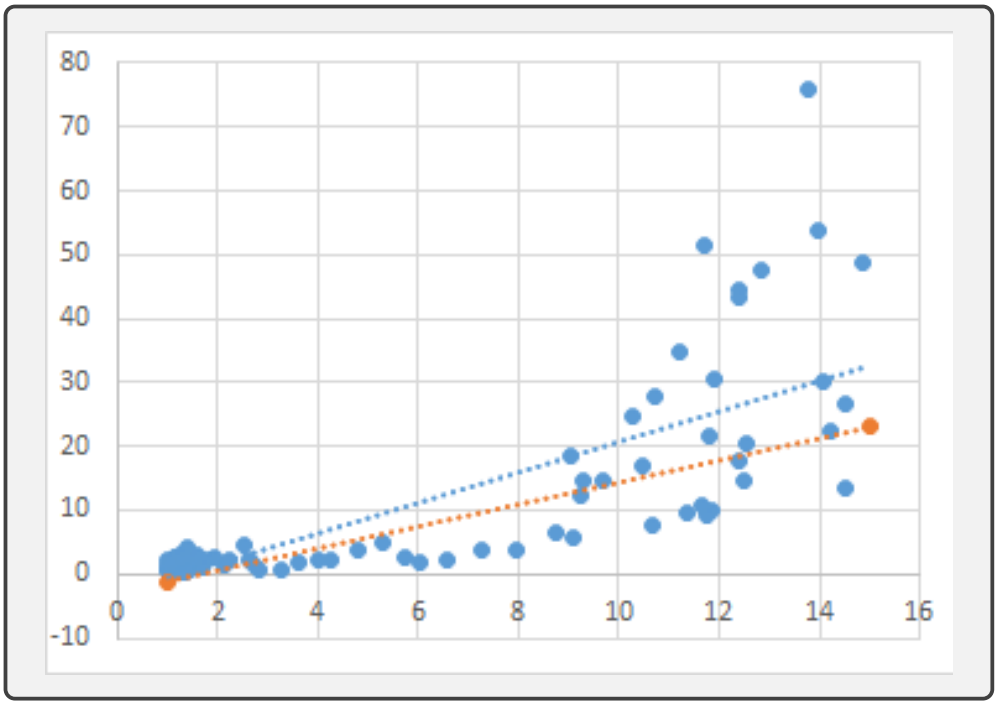

Figure 5.22: GR and LR model, Turkey 5 years, AR(1)

The results for Japan from 1990 are inconclusive as we can see it that the R^2 is lower or equal to 0.12 which is not enough. We can also see that the p-value is for the three and five years models too high, so the model is not statistically significant either. The generalized regression provides better results and for the

[2]To enable better comparison, the intercept from the linear regression model is also utilized in the generalized regression. The blue dot line is result for linear regression and orange for generalized regression

10 years model we can derive some information from the model, but we still do not capture a lot of volatility as we demonstrate it on the following figure:

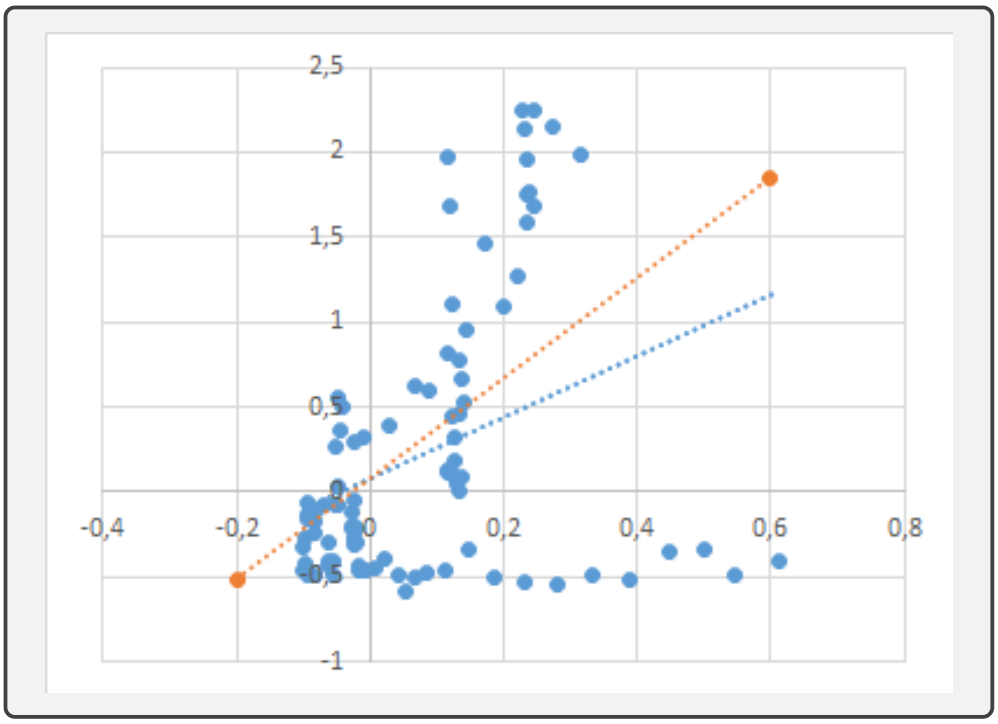

Figure 5.23: GR and LR model, Japan 10 years, 1 lag model

As discussed earlier, the problematic data pertains to the years 1990-1993. Models that commence from 1994 onwards display the highest R^2 values. It is noteworthy that linear regression produces higher R^2 values than generalized regression for these models. Our conjecture is that the Lost Decade is the reason for this trend. Edward and Fumio (2000) have highlighted that the Japanese economy performed poorly during the 1990s, with per capita GDP growing at a rate of only 0.5 percent annually between 1991 and 2000. In contrast, the United States witnessed an annual growth rate of 2.6 percent during the same period, causing Japan to fall behind the leading industrial nation after making steady progress for 35 years. Several factors, such as ineffective fiscal policies, the liquidity trap, reduced investment resulting from excessive investment during the late 1980s and early 1990s economic bubble, and issues with financial intermediation, have been proposed to account for this decline. We believe that by excluding data points primarily influenced by the Lost Decade (1990-1994), we can obtain more meaningful models. When starting the Japan models from 1992, we observed a coefficient of determination ranging from 0.10 to 0.54. However, when we began the models from 1994, we captured even more volatility,

resulting in R^2 values ranging from 0.15 to 0.73. Despite this, the coefficients obtained for Japan were significantly higher than those obtained for Argentina and Turkey. Interestingly, the coefficients obtained for Japan when starting the models from 1990 were more consistent with other countries results.

5.3 Limitations and improvements of the research

Although our study has certain limitations, such as the possibility of other variables affecting the relationship between inflation and stock prices, such as government policies aimed at combating inflation or interest rates set by central banks, we are confident that our research has demonstrated a positive link between inflation and stock prices in Argentina and Turkey, and that stocks can be used as a hedge against inflation. Additionally, while other methods, such as cointegrated VAR models, can be used to study the link between two cointegrated time series, we believe our model was adequate for determining whether the link between inflation and stock returns is positive or negative for each studied country.

Chapter 6

Conclusion

The primary objective of this thesis is to investigate the relationship between inflation and stock prices in selected countries, and determine if acquiring stocks can serve as a hedge against inflation. To achieve this goal, both linear and general regression models were employed, and the coefficient of determination was calculated to evaluate the level of captured volatility. The study analyzed the stock returns of each country using their major stock index, and the Consumer Price Index was utilized to analyze inflation. A minimum of three time series of trailing returns and inflation were examined for each country, consisting of three-year, five-year, and ten-year periods.

The financial data we used in our regressions faced several challenges, such as non-stationarity, which required us to examine the cointegration of the time series to prevent our results from being spurious. Additionally, since the error term's variance assumption was violated, we utilized generalized regression to account for this issue. It is worth mentioning that even when applied to cointegrated data, linear regression has limitations, but in our case, we believe that it is a suitable choice, given the simplicity of the results and the options available to us.

We observed a strong positive relationship between inflation and stock returns in Argentina, with a magnitude of almost 1 or greater for all time periods. This suggests that stocks can provide complete protection against inflation in this particular context. Additionally, the linear model indicated an increase in volatility as the time period lengthened. Turkey produced similar results, with an even stronger correlation between stock prices and returns. The generalized regression model accurately captured almost all of the volatility in this scenario. Unfortunately, models focusing on Japan did not perform as well in

terms of capturing volatility. For data starting from 1990, it is difficult to draw any conclusions regarding the hedging benefits of stocks against inflation. The generalized model provided slightly more significant results for the ten-year period, suggesting a positive association, but it remains uncertain since more than two-thirds of the volatility remains unexplained. However, these findings could be reversed if we use data from later periods, as discussed in the results section.

In summary, the main contribution of this thesis is providing evidence that supports a positive relationship between inflation and stock prices in countries with high inflation rates, a topic that had been a subject of debate in the literature. However, the results for Japan, which is an example of a deflationary country, were not significant. Therefore, we suggests that a broader analysis of the relationship between stock returns and inflation be conducted for countries with lower inflation rates.

Bibliography

Akinwande, M. O., Dikko, H. G., Samson, A. (2015). Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis. Open Journal of Statistics, 05(07), 754–767.

Alper, C. E. (2001). The Turkish Liquidity Crisis of 2000: What Went Wrong. Russian East European Finance and Trade, 37(6), 58–80.

Ang, A., Brière, M., Signori, O. (2012). Inflation and Individual Equities. Financial Analysts Journal, 68(4), 36–55.

Attié, A. P., Roache, S. K. (2009). Inflation hedging for long-term investors. International Monetary Fund, Finance Department.

Ayinde, K., Apata, E. O., Alaba, O. O. (2012). Estimators of Linear Regression Model and Prediction under Some Assumptions Violation. Open Journal of Statistics, 02(05), 534–546.

Barr, D. G., Campbell, J. Y. (1997). Inflation, real interest rates, and the bond market: A study of UK nominal and index-linked government bond prices. Journal of Monetary Economics, 39(3), 361–383.

Beckerman, P. (1995). Central-Bank 'Distress' and Hyperinflation in Argentina, 1989–90. Journal of Latin American Studies, 27(3), 663-682.

Bekaert, G., Engstrom, E. (2010). Inflation and the stock market: Understanding the "Fed Model". Journal of Monetary Economics, 57(3), 278-294.

Blinder, A. S. (2012). Revisiting monetary policy in a low-inflation and low-utilization environment. Journal of Money, Credit and Banking, 44, 141-146.

Bodie, Z. (1976). Common stocks as a hedge against inflation. The Journal of Finance, 31(2), 459–470.

Boudoukh, J., Richardson, M. (1993). Stock returns and inflation: A long horizon perspective. American Economic Review, 83(5), 1346-1355.

Boyd, J. H., Levine, R., Smith, B. D. (2001). The impact of inflation on financial sector performance. Journal of monetary Economics, 47(2), 221-248.

Branch, B. (1974). Common Stock Performance and Inflation: An International Comparison. The Journal of Business, 47(1), 48–52.

Brandt, M. W., Wang, K. Q. (2003). Time-varying risk aversion and unexpected inflation. Journal of Monetary Economics, 50(7), 1457–1498.

Breusch, T. S., Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. Econometrica, 47(5), 1287–1294.

Cagan, Phillip, (1972), Common Stock Values and Inflation—The Historical Record of Many Countries, p. 1-10 in , Supplement to NBER Report Thirteen, National Bureau of Economic Research, Inc.

Cogoljević, D., Gavrilović, M., Roganović, M., Matić, I., Piljan, I. (2018). Analyzing of consumer price index influence on inflation by multiple linear regression. Physica A: Statistical Mechanics and its Applications, 505, 941-944.

Chatterjee, S., Hadi, A.S. and Price, B. (2000) Regression Analysis by Examples. 3rd Edition, Wiley VCH, New York.

Davidson, R., MacKinnon, J. G. (2004). Econometric theory and methods (Vol. 5, pp. 189-196). New York: Oxford University Press.

Dickey, D. A., Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series With a Unit Root. Journal of the American Statistical Association, 74(366), 427–431.

Dickey, D. A., Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49(4), 1057–1072.

Diewert, W. E. (1998). Index Number Issues in the Consumer Price Index. The Journal of Economic Perspectives, 12(1), 47–58.

Dwyer, G. P. (2015). The Johansen tests for cointegration. White Paper, 516.

Eldomiaty, T., Saeed, Y., Hammam, R., AboulSoud, S. (2020). The associations between stock prices, inflation rates, interest rates are still persistent: Empirical evidence from stock duration model. Journal of Economics, Finance and Administrative Science, 25(49), 149-161.

Engle, R. F., Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251–276.

Fama, E. F. (1981). Stock Returns, Real Activity, Inflation, and Money. The American Economic Review, 71(4), 545–565.

Fama, E. F. (1983). Financial intermediation and price level control. Journal of Monetary Economics, 12(1), 7-28.

Fama, E. F., French, K. R. (2002). Testing Trade-Off and Pecking Order Predictions about Dividends and Debt. Review of Financial Studies, 15, 1-33.

Fisher, I. (1930). The Theory of Interest. Macmillan.

Fomby, T. B., Hill, R. E., Johnson, S. R. (1984). Advanced Econometric Methods. In Springer eBooks. Springer Nature.

Franco Modigliani Richard A. Cohn (1979) Inflation, Rational Valuation and the Market, Financial Analysts Journal, 35:2, 24-44.

Frederic F. Clairmont. (2001). Dilemmas of Imperialism: Enfeebled Dollar. Economic and Political Weekly, 36(45), 4262–4264.

Granger, C. W. J., Newbold, P. (1974). Spurious regressions in econometrics. Journal of Econometrics, 2(2), 111–120.

Granger, C. W. J. (1981). Some properties of time series data and their use in econometric model specification. Journal of Econometrics, 16(1), 121–130.

Greene, W.H. (2002) Econometric Analysis. 5th Edition, Prentice Hall, Upper Saddle River, 802.

Gultekin, N. B. (1983). Stock Market Returns and Inflation: Evidence from Other Countries. The Journal of Finance, 38(1), 49–65.

Hassani, H., Yeganegi, M. R. (2020). Selecting optimal lag order in Ljung–Box test. Physica A: Statistical Mechanics and its Applications, 541, 123700.

Hayashi, F., Prescott, E. C. (2002). The 1990s in Japan: A lost decade. Review of Economic Dynamics, 5(1), 206-235.

Honkapohja, S., McClung, N. (2023). On robustness of average inflation targeting. Available at SSRN 4021712.

Hossain, M., Rafiq, F. (2011). Asset Price Bubble and Banks: The Case of Japan. The Bangladesh Development Studies, 34(1), 23–38.

Jaffe, J. F., Mandelker, G. (1976). The "Fisher Effect" for Risky Assets: An Empirical Investigation. The Journal of Finance, 31(2), 447–458.

James, G. M., Witten, D., Hastie, T., Tibshirani, R. (2021). Tree-Based Methods. Springer Texts in Statistics, 327–365. Johansen, S. (2012). The Analysis of Nonstationary Time Series Using Regression, Correlation and Cointegration.

Manzetti, L., Dell'aquila, M. (1988). Economic Stabilisation in Argentina: The Austral Plan. Journal of Latin American Studies, 20(1), 1-26.

McCullagh, P. and Nelder, J.A. (1989) Generalized Linear Models. 2nd Edition, Chapman and Hall, London.

McKnight, S., Mihailov, A., Rumler, F. (2020). Inflation forecasting using the New Keynesian Phillips Curve with a time-varying trend. Economic Modelling, 87, 383-393.

Mushtaq, R. (2011). Augmented Dickey Fuller Test. Augmented Dickey Fuller Test by Rizwan Mushtaq:: SSRN.

Myers, R. H., Montgomery, D. C., Vining, G. G., Robinson, T. J. (2012). Generalized linear models: with applications in engineering and the sciences. John Wiley Sons.

Ng, V. K. Y., Cribbie, R. A. (2016). Using the Gamma Generalized Linear Model for Modeling Continuous, Skewed and Heteroscedastic Outcomes in Psychology. Current Psychology, 36(2), 225–235.

Newey, W. K., West, K. D. (1987). Hypothesis testing with efficient method of moments estimation. International Economic Review, 777-787.

Pek, J., Wong, O., Wong, A. C. (2018). How to address non-normality: A taxonomy of approaches, reviewed, and illustrated. Frontiers in psychology, 9, 2104.

Rath, S., Tripathy, A., Tripathy, A. R. (2020). Prediction of new active cases of coronavirus disease (COVID-19) pandemic using multiple linear regression model. Diabetes Metabolic Syndrome: Clinical Research Reviews, 14(5), 1467-1474.

Salisu, A. A., Ndako, U. B., Akanni, L. O. (2020). New evidence for the inflation hedging potential of US stock returns. Finance Research Letters, 37.

Salisu, A. A., Raheem, I. D., Ndako, U. B. (2020). The inflation hedging properties of gold, stocks and real estate: A comparative analysis. Resources Policy, 66, 101605.

Schotman, P. C., Schweitzer, M. (2000). Horizon sensitivity of the inflation hedge of stocks. Journal of Empirical Finance, 7(3-4), 301–315.

Schwert, G. W. (1981). The adjustment of stock prices to information about inflation. the Journal of Finance, 36(1), 15-29.

Siegel, J. J. (1998). Stocks for the Long Run (2nd ed.). McGraw-Hill

WEI, C. (2010). Inflation and Stock Prices: No Illusion. Journal of Money, Credit and Banking, 42(2-3), 325–345.

Wei, D., Dash, S., Gao, T., Gunluk, O. (2019). Generalized linear rule models. In International Conference on Machine Learning (pp. 6687-6696). PMLR.

Yao, R., Curl, A. L. (2011). Do market returns influence risk tolerance? Evidence from panel data. Journal of family and economic issues, 32, 532-544.

Zaman, A. (1995). Inconsistency of the Breusch-Pagan Test. Journal of Economic and Social Research, 2(1), 1-11.

Appendix A

Additional things

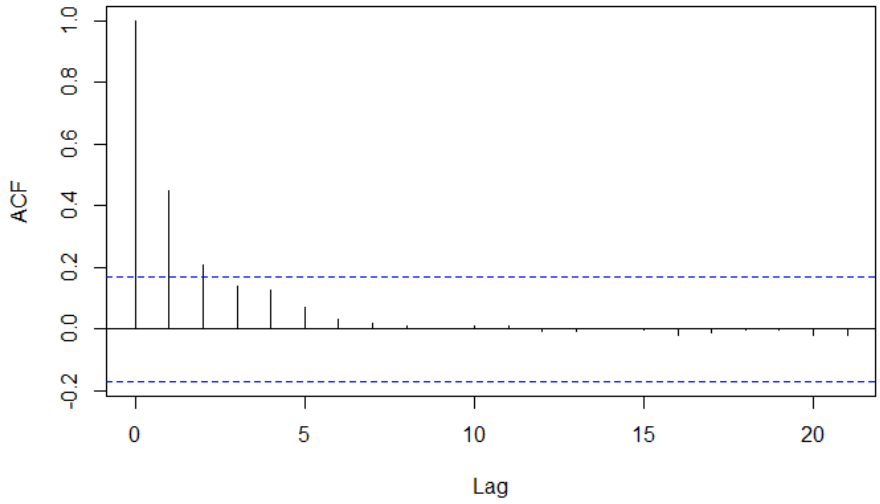

Figure A.1: ACF of Argentina inflation

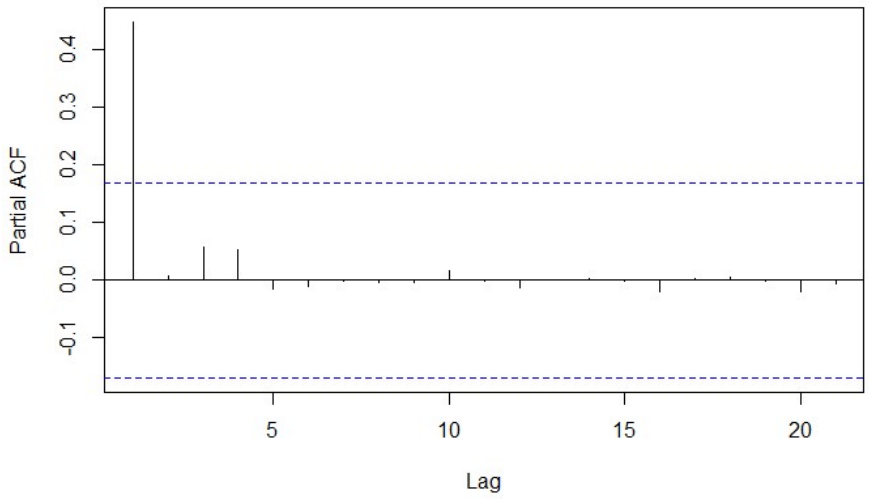

Figure A.2: PACF of Argentina inflation

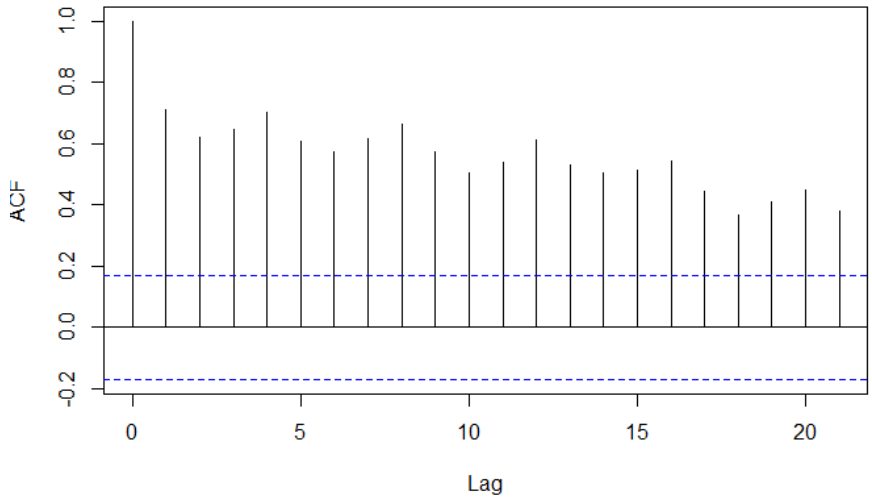

Figure A.3: ACF of Turkey inflation

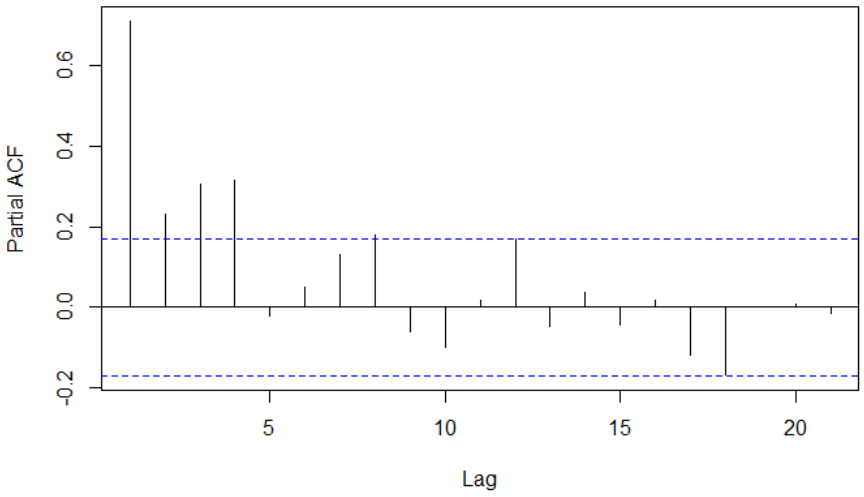

Figure A.4: PACF of Turkey inflation

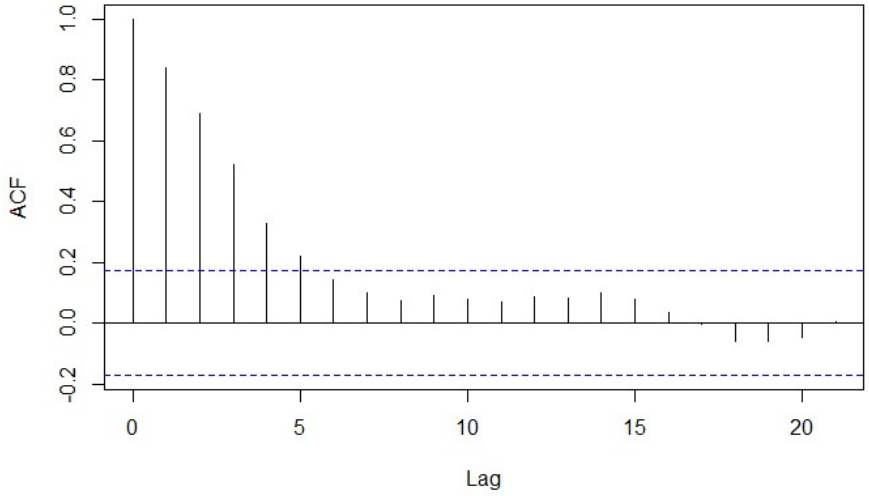

Figure A.5: ACF of Japan inflation

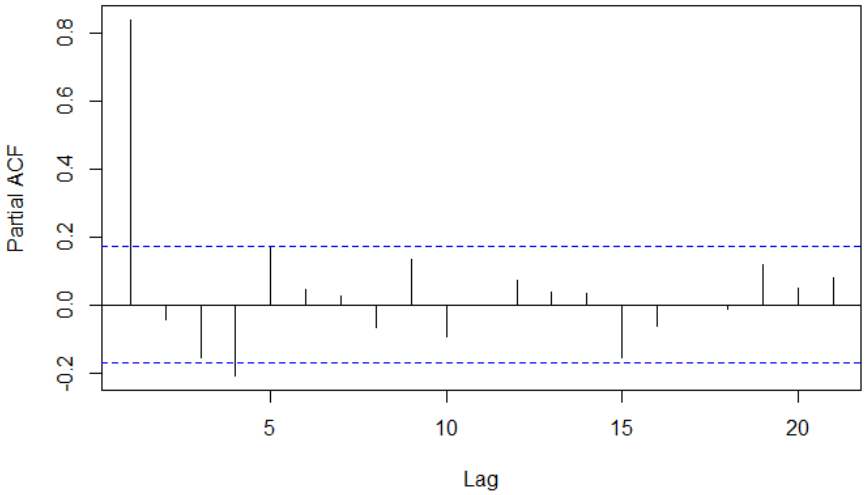

Figure A.6: PACF of Japan inflation