The Swedish inflation rate and stock market returns: does the Fisher effect exist?

Time-series regression analysis of the connection between inflation rate and stock market returns within the Swedish context between 1990-2021.

Adam Malmén & Anton Persson

Abstract:

In Sweden the annual inflation rate raised in September 2021 above the Sveriges Riksbank inflation target of two percent annually, which has been the central bank's inflation target since 1995. This created a discussion regarding if the repo interest rate should be increased from currently zero percent. The repo interest rate affects the general interest rate level in the country and when interest rate decreases investors tend to re-allocate their capital towards more riskier assets such as stocks. Previous research has shown that there is a negative correlation in the short-term but possibly a positive correlation in the long-term between stock market return and inflation rate. Thus providing some explanation of stocks acting as a hedge against inflation in the long-term. Furthermore, earlier research has argued that the presence of the Fisher effect depends on country and economic context. By using monthly Swedish stock market return and inflation rate measured by Swedish CPI, this thesis examines if there is any significant evidence for the so-called Fisher effect within the context of the Swedish stock market. Using lagged and lead inflation rates as independent variables, four regressions are tested. The results suggest only a negative relationship between stock market return and inflation rate lagged three months at the 10% significant level. The coefficients for the other lagged and lead inflation rates are found insignificant. In conclusion, the findings present no evidence that the Fisher effect exists at 5% significance level in the Swedish stock market.

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1. Introduction

This first section gives an introduction to the framework for this thesis. First follows a short presentation on the economic background behind the thesis. Later follows a shorter introduction on the subject of inflation and interest rates, while a short discussion on the so-called Fisher effect. The purpose and source of inspiration for the thesis is then declared and lastly follows the structure of the thesis.

1.1 Background

The Sveriges Riksbanks yearly inflation targeting is 2.0 percent, but it usually experiences fluctuations where it can be lower or higher than the target for different years (Sveriges Riksbank, 2018a). Inflation rate in Sweden is measured by the consumer price index with fixed interest rate called CPIF[3] (Sveriges Riksbank, 2020). SCB measured the annual inflation rate in Sweden in September 2021 to be approximately 2.8 percent, i.e. 0.8 percentage units above the Sveriges Riksbanks goal for the yearly inflation rate, and approximately 3.1 percent in October 2021 (SCB, 2021a; SCB, 2021b; Wikén, 2021). The inflation rate is affected by central banks through monetary policy, where one of their main policies is to decide the short-term interest rate yield on treasury bills called 'repo' interest rate. As inflation now tends to increase above 2.0 percent annually there is a need for further understanding how the inflation rate will affect stock market returns in the future. A recent[4] debate has emerged on how the Sveriges Riksbank should either raise or leave the 'repo' interest rate at zero but eventually they decided to not change it (Julin, 2021) with the forecast that the inflation will settle back in the coming year[5] (Israelsson & Nilsson, 2021; Julin, 2021). The 'repo' interest rate is more or less proportional to the level of interest rate yields in one country and therefore it affects investors' yield. Following this argument, when interest rates are low, investors tend to seek higher yields elsewhere, usually in more riskier assets such as the stock market.

Fisher (1930) argued that *"No problem in economics has been more hotly debated than that of the various relations of price levels to interest rates"* (p. 399). Even though this statement has been in a published work for almost a century, one could argue that this still holds. Fisher summarizes his hypothesis about inflation rate and interest rates in what has been known as

[3] Consumer price index with fixed interest rate
[4] Of November 2021
[5] 2022

the so-called Fisher effect. This effect has been investigated within the academic context in a vast magnitude. Nevertheless, there is still a need to further investigate how this relationship holds in a more contemporary context, while also examining the context outside of the United States, United Kingdom and other countries referred to as 'big economies'.

Bodie et al. (2014) argue that the *Fisher hypothesis* and its effect have been empirically investigated and discussed throughout the academic literature with mixed results and conclusions. Bodie et al. (2014) point out that the Fisher hypothesis might be difficult to confirm due to the effect of fluctuations in both real and nominal interest rates. Nevertheless, there is a need to investigate how the relationship between inflation and stock market return is panned out in the Swedish context. Through the previous research there seems to be some discrepancy regarding empirical results. Therefore one might argue that this study is of importance and interest, while also adding a more contemporary context.

The aim of the study conducted is to investigate if the so-called *Fisher effect* exists in the context of the Swedish stock market. The Fisher effect states that nominal rate of return is affected by the expected inflation rate (Austin & Dutt, 2016). Furthermore, the study should emphasize the general relationship between inflation and the stock market. By investigating if the Fisher effect is present in the examined context, one might argue that there is a possibility to further be able to discuss whether investors are able to hedge against inflation fluctuations when investing in stocks.

1.2 Purpose

Inflation is according to Graham (2003) *"an investor's worst enemy"* (p. 102) and, Bampinas and Panagiotidis (2016) states that "*inflation erosion is one of the most important economic risks for consumers and investors alike"* (p. 390). Therefore, hedging against inflation is something very attractive. Several studies regarding this topic and the Fisher effect have been conducted, but these are not in the Swedish context.

The purpose of this thesis is to investigate if present, lagged and lead inflation rate has any effect on the Swedish stock market index through time-series regression analysis. Thus, possibly providing answers to if the Fisher effect exists or not.

1.3 Inspiration for the thesis

This thesis gets its inspiration from what Firth (1979) employed when examining the relationship between stock market returns and inflation using the Fisher effect in the U.K. His study uses three regression models with stock market return as dependent variable and different combinations of inflation rate as independent variable such as including past, present and expected inflation rate as lags. These lagged and lead inflation rates represent expected inflation for analyzing the Fisher effect. Firth (1979) used monthly data spanning the time period of 1935-1976, as well as yearly data between 1919-1935.

As Firth (1979) argues, if the Fisher effect exists there should be a perfect relationship between the return on the market portfolio and the expected rate of inflation. Firth's (1979) result illustrates that there are some hedges against inflation in the stock market. Also, he found that the coefficients in the regression models consisting of lagged values of inflation rate were negatively correlated but not significant with the stock market returns. However, a study referred to by Firth (1979) conducted by Jaffe and Mandelker (1976) suggests that there is at least some violation of the efficient market hypothesis where the investor can utilize public data to predict stock market returns in an American context. The main findings of Firth´s (1979) study is that the U.K. stock market gave some hedge against inflation and argumentation followed that his findings differed from other studies on the topic.

1.4 Structure of the thesis

As the background and context have been presented above, what follows is a guide for the rest of the thesis. The second section presents the theoretical framework for this study, as well as a declaration of the previous research on the subject. In the third section the methodology and the econometric framework of the thesis is presented, which is then followed by the fourth section in which a declaration of the data used in the empirical analysis will be presented. In the fifth section the results are presented, which is then followed by the sixth section containing summary and conclusions.

2. Literature

In this section the necessary literature is presented for this thesis. The theoretical framework is built upon a literature review spanning a time period 1930-present, providing evidence and drawbacks with stocks as a hedge against inflation. Then the section continues with a presentation of previous research done within the topic.

2.1 Theoretical framework

The theoretical framework will complement the following previous research as a foundation to understand and be able to conduct a deeper analysis. The presented theory is efficient market hypothesis, price level increase (i.e. inflation rate) and the Fisher effect.

2.1.1 Efficient market hypothesis

The efficient market hypothesis is key for understanding prices on markets decided by supply and demand, e.g. the stock market. Rationally, stock prices should be reflected by known information (Bodie, 2014). This implies that any new information should cause them to change. If it is possible to predict the stock market, for investors with all available information, that would be evidence of inefficiency. This is summarized as "the notion that stocks already reflect all available information is referred to as the efficient market hypothesis" (p. 351). The efficient market hypothesis can be exploited through an opportunity called arbitrage. This is an investment that yields profits without taking any risk because there is an imbalance in the market. But the efficient market should make sure this opportunity does not appear in the first place.

2.1.2 Price level change - Inflation rate

According to Gottfries (2013) inflation is measured by the change from one period to the next in terms of price levels on the same goods and services. This way of measuring inflation is usually summarized in an index called consumer price index (CPI). Consumers use money obtained from their wage to buy these goods and services. Thus, inflation has an apparent connection to money.

If everything else is kept constant and the quantity of money increases so should inflation (Gottfries, 2013). However, in the real world this ceteris paribus condition is usually not fulfilled resulting in other variables such as production and money velocity also affecting inflation. Notably, money growth and inflation is only positively correlated to a certain extent where low money growth tends to not be correlated at all with inflation.

Gottfries (2013) explains that the main objective for central banks around the globe is to have price stability, which implies low inflation rates between 2 and 4 percent. Increasing inflation rate makes the same amount of money buy less goods or services, in general this means all consumers become poorer.

2.1.3 The Fisher effect

The Fisher hypothesis is explained by Jaffe and Mandelker (1976) as; *"…the nominal interest rate fully reflects the available information concerning the possible future values of the rate of inflation"* (p. 447). Thus, one could assume that investors are fully compensated for inflation expectations (Firth, 1979). As discussed by Hasan (2008), within efficient markets the Fisher hypothesis states that nominal rates of return on a given asset consists of both the expected real rate of return as well as the expected inflation. Thus the Fisher equation is derived in its approximative form as;

$r = i - \pi^e$, which can be rewritten as $i = r + \pi^e$ (Gottfries, 2013. p. 104)

where *r* denotes real interest rate, *i* denotes nominal interest rate and π^e denotes expected inflation rate. According to Austin and Dutt (2016), a version of the Fisher equation can be expressed as

$Expected\ \ Nominal\ Rate\ of\ Return\ =\ \alpha\ +\ \beta Expected\ inflation$ (p. 336)

where Austin and Dutt (2016) argues that if this relationship is expected to hold over long periods of time the above equation can be interpreted in a more algebraic way. An algebraic explanation of how to extract the Fisher equation is given in Hasan (2008), and is followed neatly below[6];

$$i = r + \pi^e \Leftrightarrow sr_t = E(i_t^e | I_{t-1}) + E(\pi_t | I_{t-1}),$$

[6] Equations and notations found on page 7-9 is derived by Hasan (2008), page 689-690

where *E* before parentheses notes for *Expected*, also referred to as average. sr_t is denoted as stock return at time t. Thus, the *Stock market return at time t* denotes the *expected nominal rate of return.* Hasan (2008) denotes I_{t-1} as *information given at time t-1,* i.e. all important information given at time t-1 that will affect expected rate of return as well as expected inflation.

Taking expectations of both parentheses on the right hand side will give that;

$E(i_t^e|I_{t-1}) = i^c + u_t$, and as Hasan (2008) explains, this is due to the assumption that expected real returns are constant over time, thus i^c is constant and u_t is assumed to be a normally distributed error term.

$E(\pi_t|I_{t-1}) = \pi_t + v_t$ follows the assumption that individuals rationally form their inflation expectations, where Hasan (2008) points out that expectations of inflation are to be unbiased predictors of present, actual inflation. Thus this represents present actual inflation at time t and v_t is a normally distributed error term.

If then these two equalities are substituted into the first equation, then the following equality below must hold;

$$sr_t = E(i_t^e|I_{t-1}) + E(\pi_t|I_{t-1}) = i^c + u_t + \pi_t + v_t.$$

If then i^c is constant;

$$i^c + u_t = \alpha + u_t$$

and given that stock return is the dependent variable, inflation must be the independent variable, thus; $\pi_t + v_t = \beta\pi_t + v_t$

$sr_t = \alpha + u_t + \beta\pi_t + v_t$ and summing the error terms gives; $u_t + v_t = \varepsilon_t$

$sr_t = \alpha + \beta\pi_t + \varepsilon_t$

This equation given by Hasan (2008) neatly explains how the stock return and inflation rate relationship is connected and how one can measure it empirically. This equation follows the lines of Firth (1979) where both authors examine the rate of return and how this is affected by inflation rate.

In a large part of the literature it is emphasized that if the Fisher effect is evident within the investigated economic environment then the estimated regression coefficient is equal to one, $\beta = 1$, and individuals who are investing in stocks ought to be compensated fully for anticipated inflation rates (Firth, 1979; Nelson, 1976; Hasan, 2008; Luintel & Paudyal, 2006). Furthermore, as argued in the literature; if $\beta = 1$ then one would have a uniform, complete hedge against inflation (Austin & Dutt, 2006; Al-Khazali, 2004), and as argued by Austin and Dutt (2006); if $\beta > 0$ then there ought to be some form of hedge for investors against inflation - although not a complete hedge.

2.2 Previous research

There have been several previous studies and empirical analysis similar to this thesis purpose. Some of which will be presented during this section. It is important to distinguish older research from more recent since the econometric method has developed over time.

2.2.1 Previous empirical studies on the Fisher effect

The Fisher effect has been of interest to previous research, and within the literature one will find both consistent and inconsistent results. In the seventies, Jaffe and Mandelker (1976), Nelson (1976) and Firth (1979) examined the subject and argued that an effect exists but results were not consistent.

Jaffe and Mandelker (1976) found that there was a negative relationship in the fifties, sixties and early seventies when comparing rates of stock return and inflation. But over a longer period of time these two variables were in a positive relationship, and they also suggested that the negative estimates were possibly due to a market inefficiency. Jaffe and Mandelker (1976) used monthly data from January 1953 to December 1971, with estimated results from this time period that were large, negative and statistically significant. This was further complemented with yearly data spanning from 1876 to 1970, with estimated results that were smaller in magnitude, and had a positive sign on the coefficient of inflation. However, the results using yearly data spanning a longer time period did not generate any statistically significant results. Specifically, Jaffe and Mandelker (1976) estimated a model with inflation rate lagged for three months, where the estimated model showed a large, negative coefficient on the lagged inflation, which were statistically significant. The estimated R^2 for this model was low[7], but due to the fact that the estimated coefficient were significant, Jaffe and Mandelker (1976) argued that earlier data on inflation could be used as a prediction for estimating stock market returns.

Nelson's (1976) findings suggest that there is a negative relationship between rates of return and inflation - taking into account both anticipated inflation and unanticipated inflation - and Nelson (1976) therefore argued that this effect was not in accordance with the Fisher effect. While Firth's (1979) findings were presented in section 1.3 above, just to clarify, these findings suggested that there is some form of evidence for the Fisher effect within the British context - although Firth (1979) points out that these findings often resulted in statistically insignificant results.

In a more contemporary context, Hasan (2008) draw inspiration from studies done in the seventies[8] and results suggested that there is a positive relationship between stock market returns and inflation rate for a time period of 36 years, using monthly data spanning the period of January 1968 - December 2003, thus arguing for a hedge against inflation when investing in stocks. Using a simple regression model where stock market returns were regressed on inflation rates, Hasan (2008) estimated that inflation had a positive effect on stock market returns. These estimates were statistically significant at the 1% level. Furthermore, including interest rate in the model estimated, Hasan (2008) found that interest rate had a negative effect on stock returns while the estimated coefficient for inflation was ≈ +1 at the 5% level of significance. Thus arguing that the findings were in accordance with the Fisher hypothesis. Hasan (2008) argues that his findings suggest that the Fisher effect exists in the UK stock market when examining data from the given time period, and that investing in stocks provides a good hedge against inflation.

[7] 0.033

[8] E.g Firth (1979)

On the contrary, the findings from Al-Khazali (2004) suggest that there is a negative relationship between inflation and common stock returns when investigating countries in and around the pacific basin[9], which then contradicts the Fisher hypothesis and the hedge against inflation. Al-Khazali (2004) argues that one of the studies' implications was that there might be some form of mismatch between available information about future inflation rates, which then interplays with the assumption of an efficient market, which thus might erode the possibility for an efficient market - where stock prices are not adjusted fully to incorporate future inflation - and thus affecting the possibility for investors to comprise a portfolio based on the markets given information, in which stocks are a hedge against future inflation (Al-Khazali, 2004).

Furthermore, Al-Khazali (2004) discusses that inflation rates in the pacific basin does not seem to affect stock returns in a vast majority, thus arguing that inflation rates, present and expected, might not be a thorough indicator to predict stock market returns. Al-Khazali (2004) also points out that the results did not suggest consistent results for all countries, thus rejecting the hypothesis that the Fisher hypothesis existed within the investigated context.

2.2.2 Stock market as a hedge against inflation

Bodie (1976) suggests that common stocks can be used as a hedge against inflation. If successful, this means reducing real return uncertainty based on uncertainty in price level change. For this to be true, common stocks also need a better risk-reward relationship than all different assets. The argument for hedging is that a nominal change in inflation rate should give an equal change in rate of stock market return. Also, physical capital is real value and should be independent of inflation rate. Bodie´s (1976) study however resulted in a negative correlation between stock market return and inflation in the short-run. Thus, if investors would like to hedge against inflation it is only possible by going short.

Fama and Schwert (1977) studied if it is possible to hedge against inflation rate based on change in CPI on different asset types. When examining common stock returns they found a negative relationship between inflation rate and stocks during 1953-1971. Interestingly, all other assets examined such as real estate, bonds and treasury bills did however provide some hedge against inflation. They conclude by stating that "*the existence of the [negative] relationship is nonetheless anomalous*" (p. 145). There are several studies that find this

[9] Mostly Asian countries, see Al-Khazali (2004) for more details on countries

negative relationship between stock market returns. For example, in the U.S. stock market (Geske & Roll, 1983; Jaffe & Mandelker, 1976; Nelson, 1976) and in general not associated with any country (Gultekin, 1983).

There have been more recent attempts to resolve the evidence of short-run negative correlation by studying long-run relationships (Bampinas & Panagiotidis, 2016). These attempts used an approach with regression and cointegration analysis. The result from these studies suggest that there is a positive long-run relationship instead. Meaning that owning stocks gives a hedge against inflation. This means that in the long-run the stock market returns have outperformed inflation rate providing a hedge. The long-run is more appropriate since investors should have long-term agendas. More specifically, there are stocks with certain characteristics giving stronger hedge against inflation than a market index. The industry with the best hedge against inflation was energy followed by materials and consumer staples (Bampinas & Panagiotidis, 2016).

2.2.3 Inflation, interest rate and stock market return

Fisher (1930) was the first one to study the relationship between price changes (inflation/deflation) and interest rate. He found that the correlation between these two variables were +0.7 for, at that time, important industrial countries such as England, Germany and the U.S. The intuitive explanation given is that when experiencing inflation the lenders tend to want higher interest rates as a compensation for decreasing purchasing power in the future of their money. Campbell and Ammer (1993) found that the variance of excess stock market return is mainly explained by changes in the expectation of future excess stock returns. They conclude that long-run predictions of the real interest rates are not explaining these changes. But there is a short-term relationship between decreased interest rate and increase in stock market prices.

Cash is usually called risk free, because of its high liquidity. But when facing inflation a cash position can decrease in terms of purchasing power. In particular if hyperinflation occurs. According to Anarkulova, Cederburg and O'Doherty (2021) when comparing real and nominal risk-free assets this suggests that investment in stocks are a great way to reduce the effect of inflation. Considering the long-run, an investor might actually be lowering their risk by investing heavily in the stock market. However, the presence of other assets providing a hedge against inflation must also be taken into account when considering this option. Anarkulova et al. (2021) also points out that even in the long-run, spanning 30 years for their study, the market can underperform. Actually, they estimate a 12.1% probability for a 30 year long investment could reduce in value compared with the inflation.

2.2.4 Inflation targeting

Inflation targeting is defined through a central bank or other regime having an explicit quantitative inflation target, an operating procedure for reaching the target and transparency together with accountability (Svensson, 1998). Heenan, Marcel and Roger (2006) argues that when a regime/central bank is given this duty of inflation targeting they must also be given the authority to set policies which influences the inflation rate. According to Fazio, Tabak and Cajueiro (2015) inflation targeting is only helpful for countries to decrease inflation rate during the first years after policy change and for long-run expectations. Thus highlighting the importance of regimes/central banks being able to create policies freely. In summary the central banks conditions to fulfilling inflation targeting is given by Heenan et al. (2006) as:

1. Deliver price stability.
2. Measureable inflation targets.
3. Prediction of future inflation considering broad information.
4. Increased transparency for reaching the inflation target through monetary policy.

The Schwartz hypothesis from 1995 is a traditional perspective which states that implementing inflation targeting creates better forecasting of future returns, thus also improves financial performance (Fazio et al, 2015). However, Fazio et al. (2015) also states that when central banks only focus on reducing the inflation rate they are missing the banking system and increasing the risk of high asset prices in the economy. This could in the future lead to financial crises and bubbles, which probably was the necessary foundation of the great recession during 2007-2008.

Fazio et al. (2015) argues that inflation targeting decreases uncertainties about inflation rate now and in the future. Their study suggests that empirical evidence explains that countries with inflation targets of approximately three percent annually have not experienced deflation to the same extent compared to countries without inflation targets. Nevertheless, when keeping everything else constant, low inflation rate should reduce financial instability.

Evidence is provided for this in their result, where "*countries that adopt inflation targets have, on average, less fragile [commercial] banks*" (p. 81).

A policy for central banks to reach the inflation targets is the short-term interest rate (Fazio et al, 2015). Decreased interest rate makes the investors less risk averse because they need to find sufficient return somewhere else. Thus investors tend to re-allocate their capital to risky assets such as stocks. Gottfries (2013) argues that a central bank can change the money supply to affect the interest rate in the short-run. This is due to the fact that prices are usually referred to as sticky in the short-run. In the long-run however the money supply will affect the inflation rate but keep production constant. Rigobon and Sack (2004) conducted a study on price changes considering effects from monetary policy. Their results suggest a negative relationship between monetary policy and stock prices. Monetary policies were conducted through changing the short-term interest rate. In 1995 Sweden began with inflation targeting at two percent annually which could have an impact on other macroeconomic variables (Sveriges Riksbank, 2018a).

3. Methodology

This section presents a description of the methodology for the conducted literature section and the empirical analysis. The first part describes the theoretical framework and literature review that were carried out. The second part describes the econometric framework including hypotheses.

This thesis uses a quantitative approach to the research field. Bell, Bryman and Harley (2019) describes quantitative research as the process of finding a measure and/or count to social phenomenons and their relationship. The logic is deductive and follows a linear process, which is rarely found in reality. Firstly, the thesis gave a brief introduction to the background information of the topic, followed by the purpose and its accompanying research question. Secondly, elaboration of theory was conducted through a literature review. This established a foundation for the theoretical framework from previous research. Thirdly, data was collected for empirical analysis. Lastly, the data was analyzed based on the research question and theoretical framework, and the most important findings were summarized in a conclusion.

3.1 Search process for the previous research and theoretical framework

A literature review is conducted to get a deeper understanding but also to investigate previous research hypotheses. Studying what and how studies have been carried out earlier generates opportunities for this thesis to complement and add knowledge. The literature is mainly collected through online databases and Bell et al. (2019, p. 98) states that "*online databases are the most valuable source of academic journal references*". The databases used in this thesis were SSRN, EBSCO, Scopus and the search engine at the Gothenburg university library together with keywords, separately, and combined into strings. For example, "stock market returns", regression, inflation, "inflation rate", hedge et cetera. Bell et al. (2019) explain EBSCO as an business oriented database growing in popularity and 2019 contained roughly 3000 business journals. Furthermore, the literature review itself provides' a larger amount of relevant literature through the suggested readings in each journal article looked at, both through the given 'previous research' section in each article as well as references. As a complement, the theoretical framework is based upon books, such as academic literature.

3.2 Regression models with hypotheses and robustness test

As mentioned in Bodie (2014), one of the main candidates for tracing out how the economy moves, and in particular the movement in stock prices, is through the usage of time series. The empirical analysis follows the work of Firth (1979) as well as Jaffe and Mandelker (1976) for the first three hypotheses. The fourth model describes the robustness test for the estimated results.

3.2.1 Hypothesis 1

The following equation examines the first hypothesis;

H_0: Lagged, present and lead inflation rate does not affect stock market return.

H_a: Lagged, present and lead inflation rate does affect stock market return.

$$R_{mT} = \alpha_0 + \beta_1\pi_{t+4} + \beta_2\pi_{t+3} + \beta_3\pi_{t+2} + \beta_4\pi_{t+1} + \beta_5\pi_t + \beta_6\pi_{t-1} + \beta_7\pi_{t-2} + \beta_8\pi_{t-3} + \beta_9\pi_{t-4} + \varepsilon_{mT} \qquad (1)$$

Where α provides the constant, that is the intercept of the equation. β is the effect of each independent inflation rate on stock returns. The index on each of the independent variables, i.e. π_t, π_{t-n}, π_{t+n} gives the lead and lagged index.

$R_{mT} = Monthly\ Stock\ market\ return\ at\ time\ t$

$\pi_t = Inflation\ rate\ at\ time\ t$

$\pi_{t\pm n} = Lead/Lagged\ inflation\ rate\ of\ n\ periods\ at\ time\ t$

$\varepsilon_{mT} = Error\ term$

This equation (1) provides answers whether the stock market return is dependent on any of the regression coefficients, i.e. any of the lagged or lead variables in the regression, as well as the present inflation at time t.

3.2.2 Hypothesis 2

The empirical analysis is then continued with a decomposition of the first equation;

H_0: Lagged and present inflation rate does not affect stock market return.

H_a: Lagged and present inflation rate does affect stock market return.

$$R_{mT} = \alpha_0 + \beta_1\pi_t + \beta_2\pi_{t-1} + \beta_3\pi_{t-2} + \beta_4\pi_{t-3} + \beta_5\pi_{t-4} + \varepsilon_{mT} \quad (2)$$

Where α provides the constant in the equation. β is the effect of inflation on stock returns. The index on each of the independent variables, i.e. π_{t-n} gives the inflation rate lagged nth months.

Equation (2) provides answers whether the stock market return is dependent on any of the regression coefficients, i.e. any of the lagged inflation rate variables in the regression as well as present inflation rate at time t.

3.2.3 Hypothesis 3

Next, the empirical analysis investigates the third equation;
H_0: Lagged inflation rate does not affect stock market return.
H_a: Lagged inflation rate does affect stock market return.

$$R_{mT} = \alpha_0 + \beta_1\pi_{t-1} + \beta_2\pi_{t-2} + \beta_3\pi_{t-3} + \beta_4\pi_{t-4} + \varepsilon_{mT} \quad (3)$$

Where α provides the constant in the equation. β is the effect of inflation on stock returns. The index on each of the independent variables, i.e. π_{t-n} gives the lagged index.

Equation (3) provides answers whether the stock market return is dependent on any of the regression coefficients, i.e. any of the lagged inflation rate variables in the regression without the effect of present inflation rate at time t.

3.2.4 Robustness test

The results of the initial regressions on model 1 through 3 suggested that one independent variable was found to be statistically significant at the 10% level. Since these three models included independent variables with both lead and lagged values, the econometric framework was also complemented by a fourth equation. The following equation uses the same theoretical frame as the three equations above, but is somewhat simplified. If the fourth model generates similar estimates as the previous models, this will indicate that the results are trustworthy.

H_0: Inflation rate with three lags does not affect stock market return.
H_a: Inflation rate with three lags does affect stock market return.

$$R_{mT} = \alpha_0 + \beta_1 \pi_{t-3} + \varepsilon_t \quad (4)$$

3.3 Testing for estimation error

To be able to regress on the specified equations above, one must conduct statistical tests for these equations to be precisely and methodologically correctly estimated. Therefore three tests have also been conducted. First, a Dickey-Fuller test for unit root and stationarity were conducted on each variable to be used in the analysis. Second, a Durbin-Watson test statistic was conducted on the awareness that the data might contain serial correlation. Following Wooldridge (2018) argument, testing for serial correlation before testing for heteroskedasticity was performed on the notion that the presence of serial correlation might give false test results when testing for heteroskedasticity. Third, an ARCH test was used to check for heteroskedasticity in the residuals (error terms). If there is evidence of either serial correlation or heteroskedasticity, regressions ought to be made using Newey-West standard errors[10], taking these into account reduces the possibility of dubious regression statistics (Stock & Watson, 2020). The results of the Dickey-Fuller test are presented in table 3 while the results of the Durbin-Watson and the ARCH tests are presented in table 6 as well as in the notes of the regression tables.

3.3.1 Dickey-Fuller test for unit roots and stationarity

If a time series is expected to follow a trend over time there is a need to test its stationarity. A stationary time series will explain a more trustworthy relationship between the dependent variable and the independent variable without being biased. Notably, unit root tests for stationarity were not considered in previous research before the Dickey-Fuller test was first coined in 1979. The Dickey-Fuller test is used to determine if this is the case (Stock & Watson, 2020). To be concrete, the Dickey-Fuller test emphasizes two hypotheses where the null hypothesis is that the data set contains a *unit root*, i.e. non stationary. The alternative hypothesis emphasizes that there is no unit root present in the data set. Thus, rejecting the

[10] Also known as the Newey-West variance estimator. See Stock and Watson (2020) for details

null hypothesis declares that the data set is stationary (Stock & Watson, 2020). According to (Stock & Watson, 2020, p. 586) this can be a presented as:

$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t$

H_0: $\beta_1 = 1$

H_a: $\beta_1 < 1$

This first equation is usually modified for easier interpretation as subtracting outcome variable with one lag, Y_{t-1}, on both sides of the equation, i.e. taking the first difference. Then introduce a new variable $\delta = \beta_1 - 1$:

$\Delta Y = \beta_0 + \delta Y_{t-1} + u_t$

H_0: $\delta = 0$

H_a: $\delta < 0$

Running OLS regression and estimating t-statistics provide answers if the null-hypothesis can be rejected or not. If it is rejected then δ is a negative non-zero numeric coefficient for Y_{t-1}, and the time series is stationary without a unit root.

3.3.2 Durbin-Watson test for serial correlation

The Durbin-Watson test statistic is an appropriate test for serial correlation[11]. The test equation are as follows according to Wooldridge (2018, p. 403);

$$DW = \frac{\sum_{t=2}^{n} (\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^{n} \hat{u}_t^2}$$

The Durbin-Watson statistic will usually be a numeric between 0 and 4, i.e. $0 < DW < 4$, and the Durbin-Watson test statistic usually test the alternative hypotheses, i.e. H_a: $\rho > 0$, while also applying two critical values - a lower bound value, d_L and an

[11] Also referred to as Auto correlation

upper bound value d_U (Cortinhas & Black, 2012; Wooldridge, 2018). According to the literature, a Durbin-Watson test statistic that follows $DW < d_L$ reject the null hypothesis of no serial correlation, $DW > d_U$ fail to reject the null hypothesis and if $d_L < DW < d_U$ then the test fails to provide any answer whether serial correlation exists or not (Wooldridge, 2018; Cortinhas & Black, 2012).

However, Turner (2020) explained that these upper and lower bounds are usually not presented as standard in statistical books, Cortinhas and Black (2012) provide such a table[12], though insufficient for this thesis due to the fact that the number of observations in this table being only $n = 100$. Savin and White (1977) although present some tables for observations up to $n = 200$, which could then be used to estimate upper and lower bounds for the critical Durbin-Watson statistic, but still, since the thesis data set contains 382 observations, none of these tables provide fair enough upper and lower bounds for the Durbin-Watson test.

Wooldridge (2018. p. 404) point out that one can rewrite the equation above such as;

$$DW \approx 2(1 - \hat{\rho}),$$

which then, according to Wooldridge (2018), ought to mean that $\hat{\rho} \approx 0$ would imply $DW \approx 2$. Thus, as the Durbin-Watson statistic tends to 2 this implies less, or non-existing serial correlation. Thus, using the hypothesis testing from Cortinhas and Black (2012, p. 655) as well as Wooldridge (2018, p. 404);

$$H_0: \rho = 0$$

$$H_a: \rho > 0$$

where the null hypothesis declares that no serial correlation is detected in the error terms, and the alternative hypothesis declares that there is positive serial correlation within the error terms. Thus, as according to the discussion above, as the Durbin-Watson statistic tends to two, ρ tends to zero and serial correlation is decreasing or non-significant.

[12] See Cortinhas & Black (2012), Appendix A, Table A.9, page 795-796

3.3.3 Autoregressive conditional heteroskedasticity test

Wooldridge (2018) argues that the presence of heteroskedasticity does not cause any change or bias to the estimates in any form. But what heteroskedasticity might inflict though is invalid standard errors - and thus wrongful significance for estimated coefficients such as invalid T-statistics, F-statistics and P-values. Due to properties surrounding the dynamic forms of heteroskedasticity, Wooldridge (2018) argues to use a Autoregressive conditional heteroskedasticity model, where the conditional variance of the error term is considered. According to Wooldridge (2018, p. 417), the mathematical properties of the ARCH test can be expressed as;

$$E(u_t^2 | u_{t-1}, u_{t-2}, ...) = E(u_t^2 | u_{t-1}) = \alpha_0 + \alpha_1 u_{t-1}^2$$

Which is the *first-order ARCH* model (Wooldridge, 2018). The equation above gives the conditional variance of the error term dependent on previous error terms, and it is conditional only if the exogeneity assumption for the error term holds, i.e. $E(u_t | u_{t-2}, ..) = 0$.

According to Stock and Watson (2020, p. 670) the equation above can be expressed as;

$$E(u_t^2 | u_{t-1}, u_{t-2}, ...) = \sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + ... + \alpha_p u_{t-p}^2$$

making use of both the equation derived in Wooldridge (2018, p. 417), on the left hand side, and the equation derived in Stock and Watson (2020, p. 670) on the right hand side. Thus, assuming the conditional expectation of the squared error term, given past error terms is equal to sigma squared, an ARCH model of order p is obtained. $\alpha_0 ... \alpha_p$ are unknown coefficients of the equation and given that these coefficients are positive while the past lagged error terms are large, then the variance will also be large (Stock & Watson, 2020), and Wooldridge (2018) argues that the variance is a common measure of volatility. Wooldridge (2018) refer to the findings of Engle[13] in 1982 - that larger error terms from previous time periods affected the error terms of the present time period - are compelling enough to see that it is necessary to test for the conditional heteroskedasticity when regressing on time series data.

[13] See Engle (1982) for the full discussion

As is discussed in Sjölander (2011), the ARCH-LM[14] test is the most commonly used test to detect any so-called ARCH effects in the residuals (error term). Thus, when referring to the ARCH test in the results section, this result comes from the conduction of an ARCH-LM test on the regressions. As Sjölander (2011, p. 1021) derive the ARCH-LM model, one can find that this is the same as the regression model above;

$$e_t^2 = \hat{\delta}_0 + \sum_{t=1}^{q} \hat{\delta}_s e_{t-s}^2 + v_t \Leftrightarrow \sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 +...+ \alpha_p u_{t-p}^2,$$

where $e_t^2 = \sigma_t^2$, which implies that $\sigma_t^2 = \alpha_0 + \sum_{t=1}^{q} \alpha_s u_{t-s}^2 + v_t$, thus they are likewise equations. e is the squared error term that is regressed on. Sjölander (2011) argues that the null hypothesis for the ARCH test states that no Autoregressive conditional heteroskedasticity effects are present in the error terms up to order[15] q, which implies that the alternative hypothesis is that there are autoregressive conditional heteroskedasticity effects present in the error term up to order q, i.e.

$$H_0: e_t^2 = 0$$

$$H_a: e_t^2 > 0$$

[14] Where the LM acronym refers to the Lagrange Multipliers (Sjölander, 2011; Engle, 1982)
[15] q = p for the equation to hold correct order

4. Data

In this fourth section the data used during the empirical analysis is presented. The data sources are declared and there is a presentation of how the data was used to calculate both the stock market return for each period as well as how the inflation rate was calculated with the help of Swedish CPI data.

According to Sveriges Riksbank (2018b) the most common way to measure inflation is through the difference in moving 12-month change in price levels measured by CPI. Inflation is defined in general as increase in price level in, usually, within one country and represented in the consumer price index (CPI) (SCB, 2017). In September 2017 Sveriges Riksbank started using the CPI with constant interest rate instead, called CPIF, for calculating the targeted inflation, specifically the interest rate for house loans. The reason for this is based on monetary policies affecting 'repo' interest rate thus affecting CPI. As emphasized by Jaffe and Mandelker (1976), the CPI is the index most representative of what consumers actually pay, therefore the most relevant when investigating the inflation rate and its interaction with the Fisher effect.

Data on inflation rate measured by CPI and Stockholm stock market index OMXS30 were collected from Ekonomifakta.se with references to Macrobond[16] (Armelius, 2021; Holmström, 2021). The data is in monthly frequency and spanning the time period January 1990 to October 2021. This resulted in 382 observations which were later reduced due to the creation of new variables. To conduct the testing of hypotheses, the inflation was lagged and lead four frequencies, i.e. months, backward or forward, and because of problems with non-stationary, serial correlation and heteroskedasticity several tests were conducted, see section 3.3.1 through 3.3.3. It is expected that the indices will fail these tests and thus require manipulation. Hence, the stock market index and CPI returns for time t and observation n. Resulting in the following dataset consisting of:

- Stock market returns, R_{mT} , (OMXS30) as

$$\frac{OMXS30_{index,\, t=n} - OMXS30_{index,\, t=n-1}}{OMXS30_{index,\, t=n-1}} = R_{mT}$$

[16] https://www.macrobond.com/data

- Inflation rate, π_t , (CPI) as

$$\frac{CPI_{index,\, t=n} - CPI_{index,\, t=n-1}}{CPI_{index,\, t=n-1}} = \pi_t$$

Holmström (2021) points out that the stock market has performed well. According to him this is because of the fall in global interest rate yield, increasing investors' willingness to increase riskier investments in stocks to reach sufficient return for their portfolio. There have also been two major stock market crises during the data time period. First, the dot.com crash during the start of the 21th century where the stock market decreased by almost 80 percent. Then, the great recession during 2007-2008 where the stock market decreased by over 50 percent. Lastly, a quicker but not so severe decrease of approximately 30 percent during the covid-19 pandemic in the early 2020.

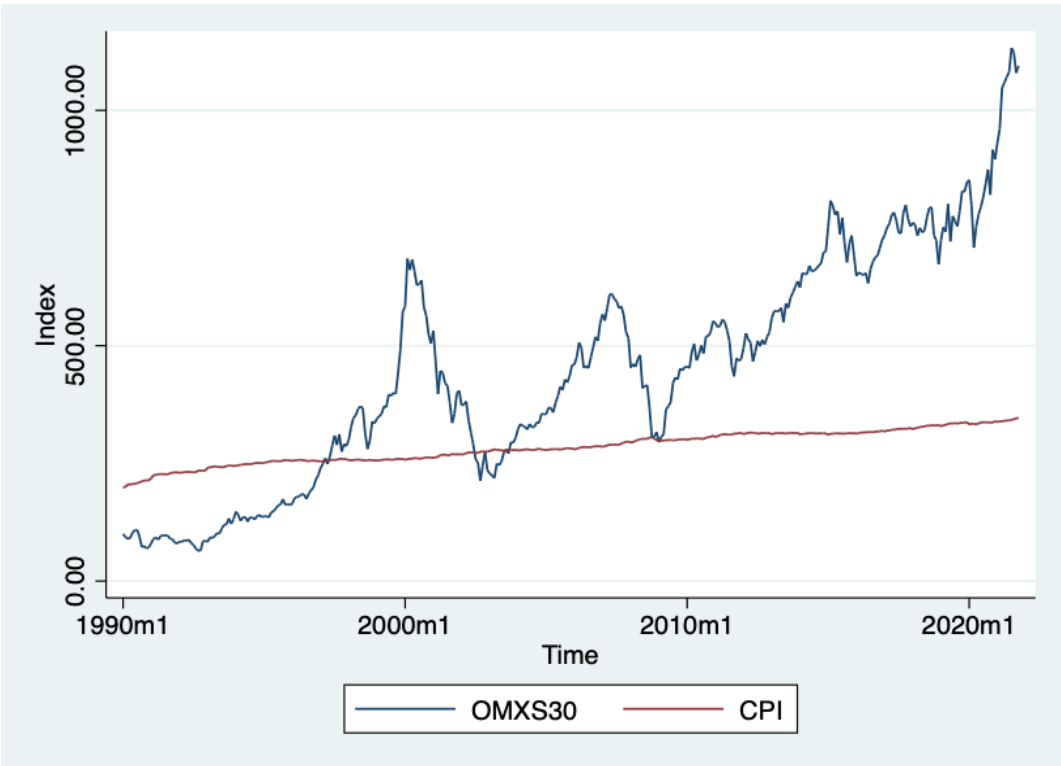

Figure 1. Indices of stock market ("OMXS30", blue) and consumer price ("CPI", red) (Holmström, 2021; Armelius, 2021).

5. Results

In this section, the empirical results are presented, then followed by an analysis and a discussion.

The result is presented through table 1 to 6. In general, the findings in table 4 and 5 show no statistically significant results at the 5% level. However, some coefficients are found to be statistically significant at the 10% level. In table 1 the descriptive statistics for stock market returns and inflation rate are presented.

Table 1: Descriptive statistics for variables stock market return and inflation rate.

Variable	Observations	Mean	Std. dev	Min	Max
Stock market return (R_{mT})	381	0.0081	0.0597	-0.2329	0.3014
Inflation rate (π_t)	381	0.0015	0.0048	-0.0144	0.0279

Notes: First row presents the descriptive statistics for the variable *Stock market return* R_{mT}. The second row presents the descriptive statistics for the variable *Inflation rate* π_t. The columns present the number of observations on each variable contained in the data set, the variables mean value, the standard deviation as well as minimum and maximum values.

Stock market return had on average 0.8 percent return from one month to the next. The risk is represented by the standard deviation at 6.0 percent, notably a low risk-reward relationship for the stock market portfolio at 0.8/6 ≈ 0.13. When examining the table, the largest decrease on the stock market was 23.4 percent and the largest increase was 30.1 percent during one month. In comparison, the inflation rate is not fluctuating as much each month during the given time period. The largest decrease in the inflation rate, i.e. deflation, was 1.4 percent and the largest increase was 2.8 percent during one month. Notably, the stock market return got a larger standard deviation each month due to bigger fluctuations over time compared to inflation rate.

Inflation targeting may have an impact on these fluctuations because the Swedish central bank is constantly working on creating price stability with a low but steady inflation rate. As put forward by Fazio et al. (2015) a well managed inflation targeting should also reduce the financial instability and therefore reduce uncertainties about stock market returns, but this cannot be analyzed in these findings because of no comparison model.

In table 2 correlation between stock market return and inflation rate is presented. The result suggests a small correlation, but it could also be due to errors in the estimates resulting in lower or even no correlation at all.

Table 2: Correlation between stock market return and inflation rate.

	Stock market return (R_{mT})	Inflation rate (π_t)
Stock market return (R_{mT})	1	-0.0961
Inflation rate (π_t)	-0.0961	1

Table 2 suggests a low negative correlation of 0.0961 between stock market return and inflation rate. This is in accordance with previous research, such as Firth (1979) who also found negative correlation.

According to the Fisher effect, when present inflation rate increases this also affects the expected inflation rate resulting in lenders demanding larger yield on their capital. This puts pressure on the short-term interest rate and makes investors re-allocate their capital from stocks to risk-free assets. Fazio et al. (2015) explained the same finding as decreased interest rate tends the investor to behave less risk averse, which is in accordance with Campbell and Ammer (1993) who suggests that investors are affected by expectation of future excess stock market returns. Thus revealing that both stock market return and inflation rate are affected by expectations.

Inflation targeting is mainly conducted through changing the monetary supply which affects the short-term interest rate and thus inflation rate. Rigobon and Sack (2004) is developing this argument further and suggested that monetary policy is negatively correlated with stock prices. This should imply similar results between inflation rate and stock market return, which is confirmed by the result in table 2. As of 1995, the Swedish central bank introduced inflation targeting at two percent annually, this specific inflation target percent might be the answer for the low correlation between stock market returns and inflation as given in table 2.

Before the regression models can be estimated the variables need to be tested for stationarity. In table 3 the result from an unit root-test is presented for both indices and monthly percentage change.

Table 3: Unit root-test for stock market index, stock market return, CPI and inflation rate.

Variable	Observations	Z(t)	Stationarity (at 5 % level)
Stock market index	381	0.287 (0.9767)	No
CPI	381	-2.366 (0.1517)	No
Stock market returns	380	-17.898 (0.000)	Yes
Inflation rate	380	-17.826 (0.000)	Yes

Notes: P-values are presented within the parentheses.
The first two rows give the test statistic for the variables *stock market index* and *CPI.* The MacKinnon Z value is presented on the first row in the third column. The p-value is presented within the parentheses in the third column. As shown in the table, these first two variables are not significant at the 5% level, which proves that they are non-stationary at level.
The last two rows give the test statistic for the variables *stock market return* and *inflation rate.* The MacKinnon Z value is presented on the first row in the third column. The p-value is presented within the parentheses in the third column. As shown in the table, these last two variables are significant at the 5% level, which proves that they are stationary at level.

Neither CPI nor stock market index was stationary at 5% significance level. Both indices are plotted[17] in figure 1 under section 4, which strengthens the view of the variables not being stationary, this is because there is a clear pattern that both indices are increasing with time and includes a trend. It was expected that the indices would not pass the test for stationarity. However, when plotting stock market return and inflation rate in figures 2 and 3 in the appendix it shows more evidence for stationarity. Following this expectation, another Dickey-Fuller test is conducted with the stock market return and inflation rate, and the result in table 3 shows that they both passed the test for stationarity at 5% significance level.

[17] See Figure 1 in section 4

In table 4 the regression output for model 1 through 3 are presented. Overall the results provide no new information regarding how inflation rate can be used for estimating stock market return.

Table 4: Regression results for model 1 through 3.

Inflation rate (π)	**Hypothesis 1** **Model 1**	**Hypothesis 2** **Model 2**	**Hypothesis 3** **Model 3**
Inflation rate with 4 leads	-0.9929 (-1.08)		
Inflation rate with 3 leads	0.4633 (0.58)		
Inflation rate with 2 leads	1.3648 (1.17)		
Inflation rate with 1 lead	0.3321 (0.670)		
Inflation rate	-1.3428 (-1.50)	-1.2745 (-1.36)	
Inflation rate with 1 lag	0.0754 (0.10)	-0.2062 (-0.25)	-0.3239 (-0.41)
Inflation rate with 2 lags	1.0293 (1.31)	0.7673 (0.99]	0.8338 (1.05)
Inflation rate with 3 lags	-1.3331 (-1.58)	-1.2249* (-1.76)	-1.1480* (-1.67)
Inflation rate with 4 lags	-1.2276 (-1.34)	-0.7063 (-0.99)	-0.6357 (-0.92)
Constant	0.0105*** (2.60)	0.0118*** (3.27)	0.0099*** (2.97)
$Adj\ R^2$	0.0189	0.0119	0.0049
$F\ statistic$	0.83	1.02	1.00
Observations	373	377	377

Notes: Equation (1) $R_{mT} = \alpha + \beta\pi_{t+4} + \beta\pi_{t+3} + \beta\pi_{t+2} + \beta\pi_{t+1} + \beta\pi_{t} + \beta\pi_{t-1} + \beta\pi_{t-2} + \beta\pi_{t-3} + \beta\pi_{t-4} + \varepsilon_{mT}$

Equation (2) $R_{mT} = \alpha + \beta\pi_{t} + \beta\pi_{t-1} + \beta\pi_{t-2} + \beta\pi_{t-3} + \beta\pi_{t-4} + \varepsilon_{mT}$

Equation (3) $R_{mT} = \alpha + \beta\pi_{t-1} + \beta\pi_{t-2} + \beta\pi_{t-3} + \beta\pi_{t-4} + \varepsilon_{mT}$

Equation (1): Durbin-Watson statistic (10,373) = 1.9 ≈ 2. ARCH test is rejected, indicating that regression ought to be made with Newey-West standard errors.

Equation (2): Durbin-Watson statistic (6,377) = 1.8 ≈ 2. ARCH test is rejected, indicating that regression ought to be made with Newey-West standard errors.

Equation (3): Durbin-Watson statistics (5,377) = 1.8 ≈ 2. ARCH test is rejected, indicating that regression ought to be made with Newey-West standard errors. Coefficients are presented on the first row, T-Statistics are presented within parentheses on the second row, in each column. $Adj\ R^2$ is not presented by stata when regressing with Newey-West standard errors, thus the values are from the regression made before testing. The coefficients are the same whether regression is made with default standard errors or Newey-West standard errors.
***, **, * - estimates significantly significant at 1%, 5% and 10% level

In model 1, no coefficient is significant at the 5% level, except for the constant. The null-hypothesis cannot be rejected since F statistics is close to zero for the joint significance, which is not unexpected since none of the coefficients are significant at the 5% level. If anything, the result suggests that inflation rate without lags or leads and inflation rate lagged three months is the most reasonable independent variable for estimating stock market return, since they have higher t-values when compared with the rest of the coefficients. However, since these coefficients are not statistically significant at the 5% level, no adequate conclusion can be made.

In model 2, there are no coefficients significant at the 5% level, except for the constant. Inflation rate lagged three months is statistically significant at the 10% level. The result suggests a similar negative relationship with stock market return found when regressing on model 1. The null hypothesis cannot be rejected due to low F statistics for joint significance.

In model 3, the only statistically significant coefficient is inflation rate with three lags, which is still significant at the 10% level, except for the constant. Similar to model 2, inflation rate lagged three months is statistically significant - on the same level, 10% - and that there is a negative relationship with stock market return.

A positive sign on the coefficients is argued to provide some form of information regarding inflation hedging. As mentioned in section 2, when $\beta = 1$ investors are fully hedged against inflation. Thus, following the discussion from previous research, some of the coefficients given in table 4 do suggest that there might be some evidence of a hedge against inflation. For example, in model 1, inflation rate with a two month lag is approximately equal to 1, which would indicate that the relationship is sound, thus almost providing investors with a uniform hedge against inflation. However, as has been pointed out earlier, these positive estimates are not statistically significant, therefore no conclusion can be drawn.

As explained earlier[18], this negative effect has been found during previous studies before (Jaffe & Mandelker, 1976) where findings suggest a negative relationship when examining stock market returns and inflation as well as Nelson (1976) who argued for a non-existing Fisher effect. Given the results presented in table 4, the estimates are somewhat conclusive with the findings of Jaffe and Mandelker (1976), where estimates for lagged and lead inflation showed a somewhat likewise relationship. For example in their[19] study when examining a model consisting of four lagged and lead variables, the coefficient for inflation lagged with three months was negative and the coefficient for present inflation was negative - which is conclusive with the findings in table 4. However, while the coefficient mentioned estimated the same sign, the coefficient for inflation rate lagged one month is negative in Jaffe and Mandelker (1976), which is inconclusive with the findings in table 4. Furthermore, many of the estimates in Jaffe and Mandelker (1976) are found to be statistically significant, while the estimates in table 4 only reach statistical significance at the 10% level.

Firth (1979) also commented on the non-significant coefficients. He argues that these results suggest that investors cannot earn superior returns with the usage of models dependent upon the available inflation rate information. Thus not finding any significant result of the Fisher effect. The negative estimate of the coefficient on inflation rate lagged three months also suggest that investors are not able to hedge against inflation.

Notably, Firth (1979) nor Jaffe and Mandelker (1976) did not test the stationarity of their data sets using an unit root test. Since their studies there have been several studies[20] emphasizing the liability in testing time series models through the regression if they are not stationary. Not conducting this test could neglect both Firth's (1979) as well as Jaffe and Mandelker's (1976) results. Furthermore, if it is possible to predict the stock market return using only inflation rate, this would violate the efficient market hypothesis since all this information is known.

Further distinctions can be made on the low levels of the adjusted R^2 for each of the three models. The low values show that all three models are affected by other variables not explained or integrated in the equation. Therefore one can assume that the stock market return is affected by inflation to a low degree, as is also argued by Jaffe and Mandelker

[18] See section 2.2.1
[19] See Jaffe and Mandelker (1976), page 453, table 3
[20] See section 2.2 Previous research and Hasan (2008) for further discussion

(1976). The adjusted R^2 in table 4 are in line with the R^2 from Firth (1979), although smaller than his[21] R^2.

Since all three models in table 4 have low F-statistics, the null hypothesis is not rejected for any of the first three models presented in section 3, thus resulting in no new information about the relationship between inflation rate and stock market returns. Independent variables of lagged inflation rate for model 1, 2 and 3 are trying to mimic the anticipated inflation rate for a period, i.e. the Fisher effect. The result suggests that there is no statistically significant relationship at the 5% level between stock market returns and anticipated inflation rate. Thus, at the 5% level of significance the Fisher effect cannot be found in the Swedish stock market since 1990. However, at the 10% level of significance the inflation rate lagged three months is significant and negative.

[21] See Firth (1979), table 3

Robustness test for the result in table 4 is conducted using inflation rate lagged three months because it is the most significant independent variable. This model tests for the whole time period between 1990-2021 except for three months. The stock market return is expected to be affected by inflation rate lagged three months similar to previous findings in table 4.

Table 5: Robustness test; inflation rate with three lags on stock market return.

Inflation rate (π)	Default SE	Newey-West SE
Inflation rate with 3 lags (π_{t-3})	-1.0846* (-1.70)	-1.0846* (-1.67)
Constant	0.0099*** (3.11)	0.0099*** (3.13)
$Adj\ R^2$	0.0050	0.0050
Observations	378	378

Notes: Second column shows the regression without *default* standard errors. Third column shows the regression with Newey-West standard errors. Equation (4) $R_{mT} = \alpha + \beta\pi_{t-3} + \varepsilon_{mT}$
Durbin-Watson statistic (2,378) = 1.8 ≈ 2. ARCH test statistic = 0.0343, indicating Newey-West standard errors ought to be used. Both default standard errors and Newey-West standard errors are presented in the table. $Adj\ R^2$ is not presented by stata when regressing with Newey-West standard errors, thus the values are from the regression made before testing. The coefficients are the same whether regression is made with default standard errors or Newey-West standard errors. Coefficients are presented on the first row. T-Statistics are presented within parentheses.
***, **, * - estimates statistically significantly at 1%, 5% and 10% level

From table 5 the following linear equation can be estimated;

$$\widehat{R}_{mT} = 0.010 - 1.085\pi_{t-3}$$

These findings suggest that there is a negative effect of inflation on stock market return, which is conclusive with the previous findings in table 4 where inflation lagged with three months were negative as well as statistically significant at the 10% level for equation 2 and 3. The linear equation suggests that when inflation rate with three lags increases with one percent the stock market return decreases by 1.085 percent.

The results in table 5 are in line with the findings of Jaffe and Mandelker (1976) who estimated a large, statistically significant negative sign on the coefficient of three months lagged inflation rate. While the findings of Jaffe and Mandelker (1976), as well as Nelson (1976), suggested negative coefficients of a larger magnitude, the estimates in table 5 show the same sign but in less magnitude, as well as not being statistically significant at the 5% level.

On the other hand, the estimates in table 5 are only in line with Firth's (1979) estimates related to significance level. Firth (1979) estimated a positive, none statistically significant coefficient on inflation rate lagged with three months when running likewise regressions as found in table 4. Thus, the results in table 4 are in contrast to the ones found in Firth (1979) when addressing the estimated sign, although in line when it comes to statistical significance at the 5% level.

Interpretation of the presented estimates in table 4 and 5 suggests conclusive findings with Jaffe and Mandelker (1976), Nelson (1976) and Al-Khazali (2004) who argue that the negative sign on estimates were inconclusive with the argued Fisher effect, and thus there is no evidence signaling any possible hedge against inflation through investments on the stock market. As is argued by both Al-Khazali (2004) and Jaffe and Mandelker (1976), this could be a sign of inefficient markets, however, due to the weak significance level, no conclusion on this matter can be made. Jaffe and Mandelker (1976) argues that a low R^2 suggest that the estimations are affected by variables not explicitly given in the model. A low R^2, as is the case with model 1 through 4, shows that the stock market returns are determined by a lot more than just present, lagged and lead inflation rates.

With respect to the discussion whether investments on the stock market could be used as a means to hedge against inflation, the presented results above suggest that there is no immediate hedge against inflation in this thirty year perspective. As argued by Arnakulova et al. (2021) it is possible for an investor to lose against inflation even at this long-run perspective[22] however they also argue that in the majority of cases, approximately 90%, an investor will win and thus provide a hedge in this long-run perspective. Bodie´s (1976) study showed a similar negative relationship compared with table 4 and 5, and correlation in table 2. Suggesting that investors may only hedge against inflation by going short.

[22] More than 30 years

Table 6 presents the serial correlation and heteroskedasticity test results for all four models. The tests are conducted to confirm the results reliability. As mentioned in section 3, the tests conducted are the Durbin-Watson and the ARCH-LM test.

Table 6: Tests for serial correlation and heteroskedasticity in the error terms for model 1-4.

Equation	**Durbin-Watson**	**ARCH** **H0: homoscedasticity** **Ha: heteroskedasticity**	**Interpretation**
1	1.85	0.0041	Low, or non significant positive serial correlation, but heteroskedasticity
2	1.83	0.0323	Low, or non significant positive serial correlation, but heteroskedasticity
3	1.84	0.0352	Low, or non significant positive serial correlation, but heteroskedasticity
4	1.82	0.0343	Low, or non significant positive serial correlation, but heteroskedasticity

Notes: Durbin-Watson (DW) under 2 is a sign for positive serial correlation, over 2 is a sign for negative serial correlation, if DW is close to 2 then the assumption of no significant serial correlation is applied. Heteroskedasticity is evaluated through a significance level of 5%. The ARCH column shows the estimated p-value of the test for each equation. If either serial correlation, heteroskedasticity or both are contained in the regression, then estimates are to be re-run using Newey-West standard errors.

The result in table 6 suggests that both models are not experiencing significant serial correlation which means that previous data points do not affect future data points in any serious way. The Durbin-Watson statistic for model 1-4 resulted in approximately two indicating no serial correlation. The ARCH test suggests that there are some forms of heteroskedasticity within the error terms. In figures 4 - 7 in the appendix the residuals vs. fitted values are presented in a graphical format showing no apparent trend for the residuals. The results of the tests suggest that regressions ought to be made using Newey-West standard errors. Thus, the results presented in table 4 and 5 are considered to be reliable.

6. Summary and Conclusion

Here follows a summary of the findings and the presented results. Through these, the thesis is concluded and the purpose is revisited to confirm whether it is fulfilled.

Using historical data on the Swedish stock market index and CPI, this thesis provides evidence whether the Fisher effect exists within the Swedish context during the time period of 1990-2021. Stock market return is estimated by four regression models using different combinations of monthly lagged and lead inflation rate. The findings in this thesis suggest that the results are similar to the previous studies, which show a negative relationship between stock market return and inflation rate with a low, or insignificant level. One of the main differences between earlier (Firth, 1979; Fama & Schwert, 1977; Bodie, 1976; Jaffe & Mandelker, 1976) and more recent studies (Anarkulova et al. 2021; Bampinas & Panagiotidis, 2016; Hasan, 2008) is testing the data for stationarity and unit roots. This thesis follows the earlier econometric framework with the exception of conducting unit root testing.

The results of the four conducted models suggest that only inflation rate lagged three months is statistically significant at the 10% level. The estimates show that there is a negative relationship between inflation rates lagged three months and the stock market returns. All other coefficients estimated are not statistically significant, even at the 10% level, thus providing no conclusive evidence whether they determine stock market returns. Furthermore, the testing of the Fisher effect is mainly dependent on the assumption that lagged and lead inflation rate could be used as an estimate for anticipated inflation rate. Due to the findings of non-significant estimates together with the negative relationship for inflation rate lagged three months, the results suggest that there is no evidence of the Fisher effect within the Swedish stock market during the time period 1990-2021. Thus, these results suggest that the Swedish stock market does not provide any hedge against inflation during this time period.

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Appendix

Plots for Stock Market Return and Inflation

As can be seen in the two figures below, both Stock Market Return and Inflation are stationary after re-calculations, using the equations presented in section 4.

Figure 2. Stock market return 1990-2021 OMXS30 (Holmström, 2021).

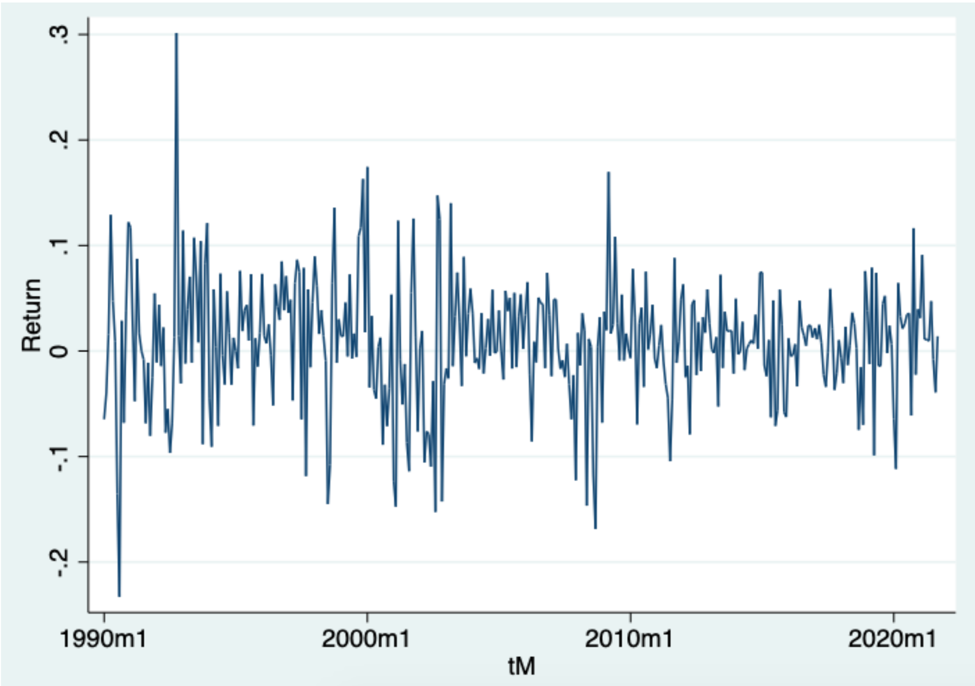
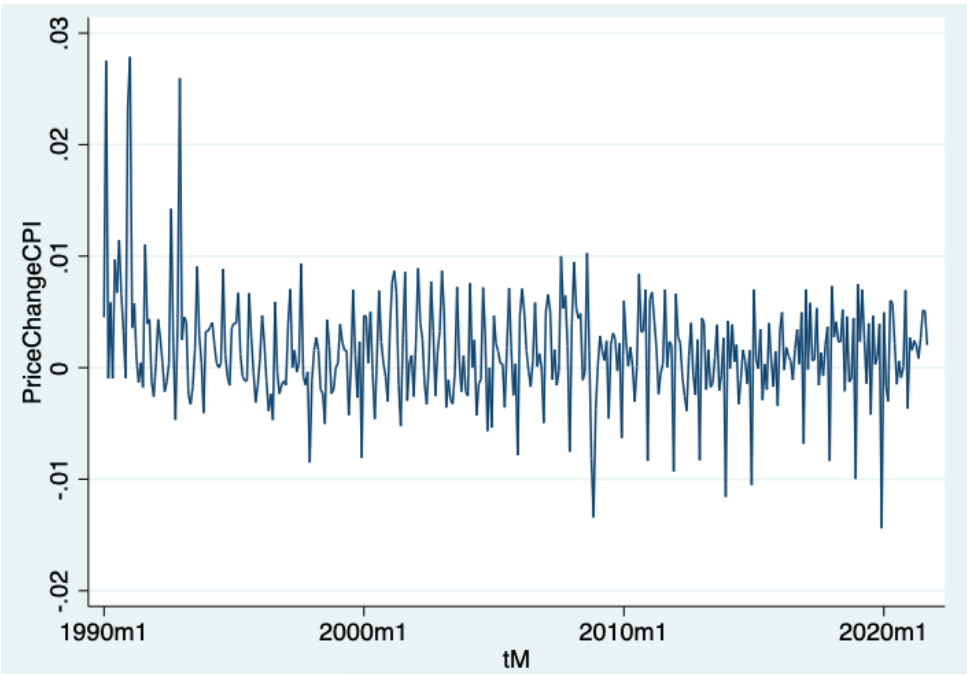


Figure 3. Swedish inflation rate in monthly frequency and CPI return (Aremlius, 2021).



Residual plots for each equation (1-4)

Figure 4. Residuals vs. Fitted values Equation 1

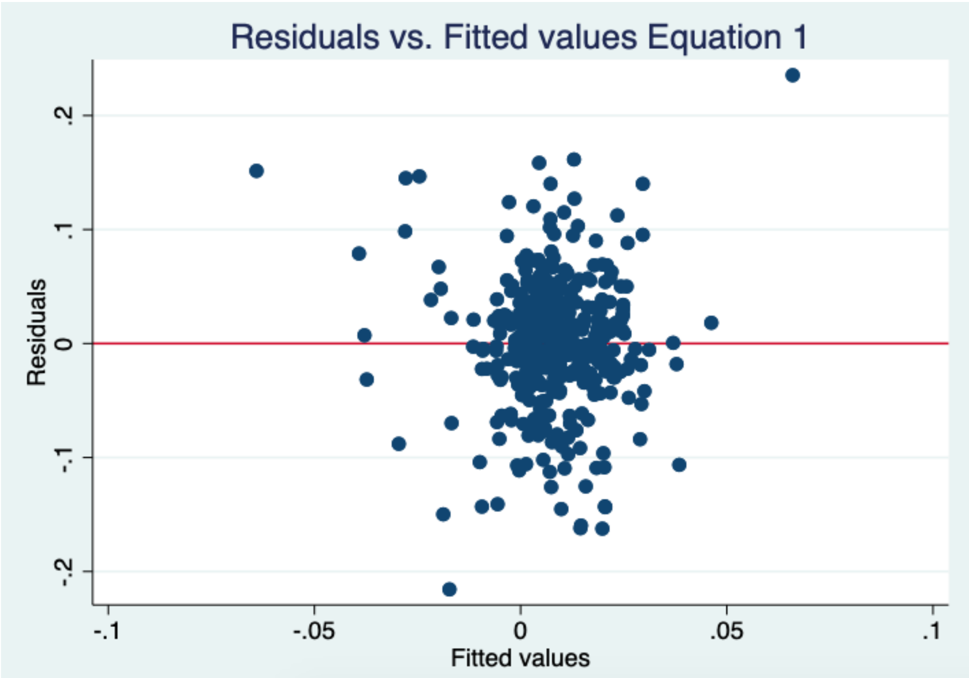


Figure 5. Residuals vs. Fitted values Equation 2

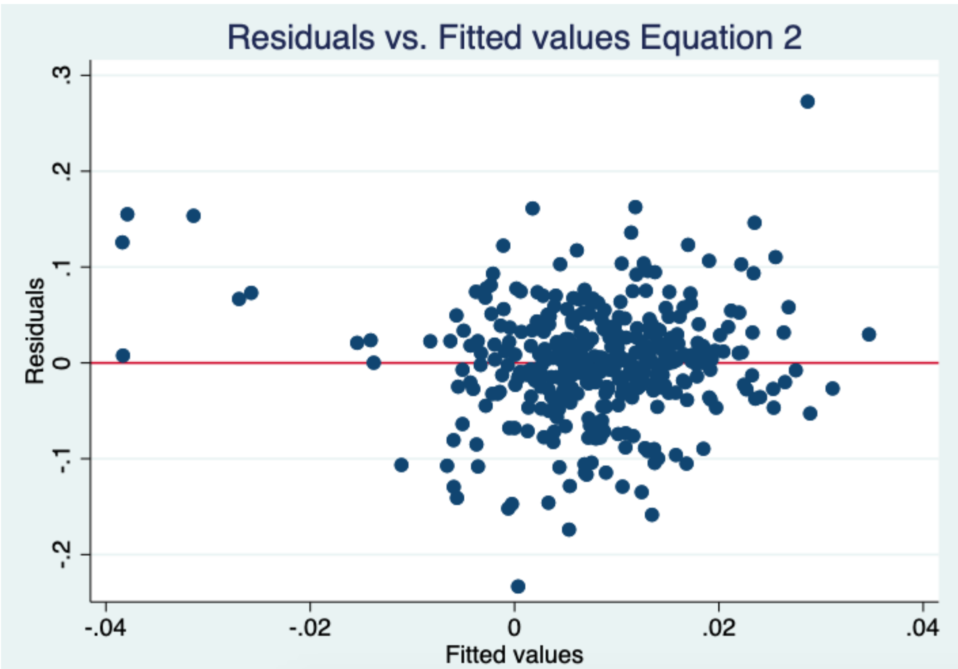


Figure 6. Residuals vs. Fitted values Equation 3

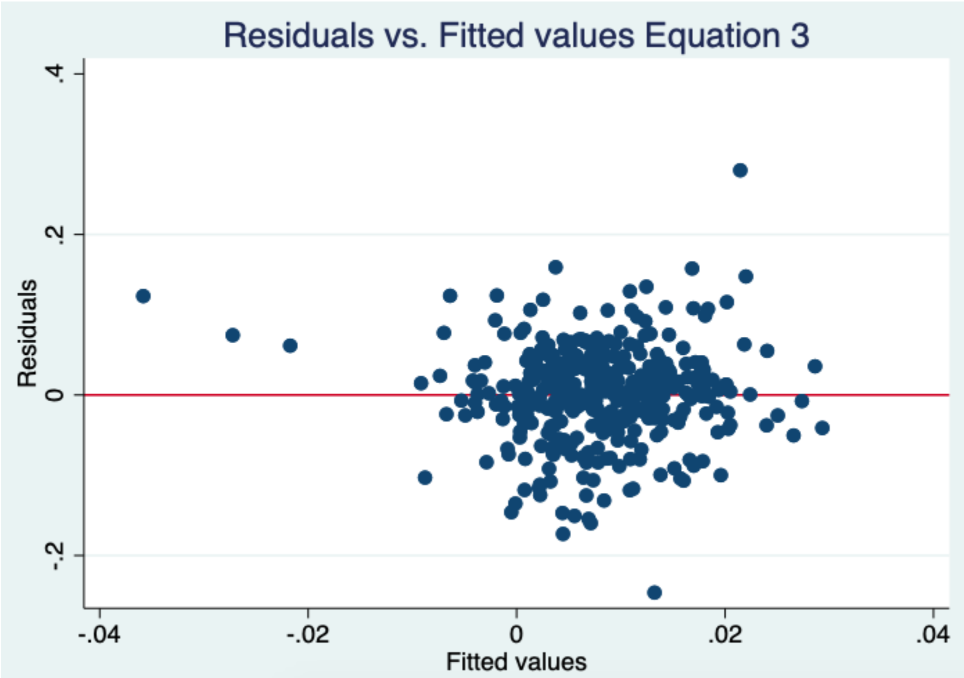


Figure 7. Residuals vs. Fitted values Equation 4