Does the Fisher Hypothesis Hold in Sweden? An Analysis of Long-Term Interest Rates under the Regime of Inflation Targeting

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ABSTRACT

This paper examines the validity of the Fisher hypothesis in Sweden by analyzing inflation expectations and long-term interest rates from January 1993 to February 2015 under a regime of inflation targeting. The Fisher hypothesis holds for the maturities of 2, 3, 4, 5, and 7 but not 10 years. The results show that changes in inflation expectations move in the same direction and degree as nominal long-term interest rates for the maturities of 2, 3, 4, 5, and 7 years. This can primarily be attributed to the credibility of the inflation-targeting framework in Sweden for the last 20 years and the success it has achieved in locking inflation expectations into the target range within these maturities. In the maturity of 10 years, this credibility has never been as certain.

Keywords: Fisher Hypothesis, Inflation Targeting, Long Term Interest Rates

1. INTRODUCTION

According to Fisher (1931), the expected rate of inflation will be reflected in the nominal interest rates, with real interest rates holding constant. This is known as the Fisher hypothesis. In order for it to hold, the nominal interest rate must move one-to-one with the expected rate of inflation. This paper examines the validity of the Fisher hypothesis in Sweden by analyzing inflation expectations and long-term interest rates from January 1993 to February 2015 under a regime of inflation targeting. This paper can be distinguished from previous work in that it analyzes long-term interest rates in the maturities of 2, 3, 4, 5, 7, and 10 years from the introduction of inflation targeting policy. Long-term swap rates are used because they are closely connected with benchmark interest rates for long-term lending.

There are several reasons to investigate the validity of the Fisher hypothesis by analyzing long-term interest rates in connection with monetary policy. Sweden adopted an inflation targeting policy in January 1993 when the Riksbank announced that it would target a rate of inflation within 2%±1% after 1995. Monetary policy can influence both inflation and interest rates, which in turn influence general economic activity. If the Fisher hypothesis holds, this implies that changes in inflationary expectations do move in the same direction and degree as the nominal long-term interest rates. This means that real

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long-term interest rates are stable. This gives corporations an incentive to make commitments and plan their investment because real long-term interest rates are a very important factor in investment decision making. This can primarily be attributed to the credibility of the inflation-targeting framework and the success it has achieved in locking inflation expectations into the target range.

There are no consistent conclusions as to the analysis of the Fisher hypothesis. Results differ depending on the countries, periods, and interest rates under consideration. Hawtrey (1997) and Mitchell et al. (2007) analyze the hypothesis in connection with the monetary policy of inflation targeting. Hawtrey (1997) finds that while the Fisher effect is not established prior to the 1980s financial deregulation in Australia, there is subsequent evidence (following deregulation) that the relationship was restored. Mitchell et al. (2007) conclude that the long-run Fisher hypothesis cannot be confirmed in its strictest form in South Africa, but changes in inflation expectations do move in the same direction as the nominal long-term interest rate. This suggests that monetary policy has an influence on the real long-term interest rate, which has positive implications for general economic activity, thus confirming the credibility of the inflation targeting framework.

Other than these two studies, the following works analyze the Fisher hypothesis; Atkins (1989), Atkins and Chan (2004), Badillo et al. (2011), Berument (1999), Berument and Jelassi (2002), Berument et al. (2007), Bonham (1991), Carneiro et al. (2002), Granville and Mallick (2004), Hawtrey (1997), Herwartz and Reimersans (2011), Inder and Silvapulle (1993), Ito (2009), MacDonald and Murphy (1989), Mishkin(1992), Moosa and Kwiecien (2002), Payne and Ewing (1997) , Tsong and Lee (2011), Tsong and Lee (2013), Yu (1997), Wallace and Warner (1993), Woodward (1992), and Wong and Wu (2003) . Cooray (2003) provides a survey for the Fisher hypothesis.

Atkins (1989) conducts the Engle and Granger cointegration test using the Consumer Price Index (CPI) and 90-day interest rates in the US and Australia from 1953 through 1971. He finds that the Fisher hypothesis holds for both. He also conducts the Granger causality test to find the impact of CPI on nominal interest rates. Atkins and Chan (2004) find support for the hypothesis that both the nominal interest rate and inflation in Canada are stationary around a deterministic trend with two breaks. Their results indicate that there are three regimes in the relationship between interest rates and inflation.

Badillo et al. (2011) infer that there is a full Fisher effect, as found by Westerlund (2008), for a panel of Organization for Economic Cooperation and Development (OECD) countries. However, if we explicitly introduce the common factors in the Fisher equation, the CupBC and CupFM estimators of the slope parameter on inflation are significantly lower than unity, which implies the existence of a partial Fisher effect. Berument (1999) assesses the effect of expected inflation and inflation risk on interest rates within the Fisher hypothesis framework. Using UK quarterly data from 1958 through 1994, he concludes that both the expected inflation and the conditional variability of inflation positively affected the UK three-month Treasury bill rate.

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Berument et al. (2007) test the validity of the Fisher hypothesis for the G7 countries as well as 45 developing economies. The Fisher relation holds in all the G7 countries, but in only 23 of the developing countries. There is a positive and statistically significant relationship between interest rates and inflation uncertainty for 6 of the G7 and 18 of the developing countries, while the relationship is negative for 7 of the developing countries.

Berument and Jelassi (2002) find evidence for the Fisher hypothesis in 16 of 26 countries. It is also likely that the Fisher hypothesis holds more for the developed than the developing countries in their sample. The Fisher hypothesis cannot be rejected for 9 out of 12 developed and for 7 out of 14 developing countries. Bonham (1991) utilizes the Engle and Granger cointegration test using three-month Treasury bills and CPI in the US from 1955 through 1986. He concludes that the Fisher hypothesis holds for the US.

Carneiro et al. (2002) analyze monthly data for the period 1980 through 1997 for three countries with a recent history of chronic high inflation; Argentina, Brazil, and Mexico. A cointegration analysis provides evidence of a stable long-run equilibrium relationship between nominal interest rates and the inflation rate for Argentina and Brazil. Granville and Mallick (2004) use annual data over a long time horizon from 1900 through 2000 for the UK. They conclude that the cointegrating relationship between the two variables suggests a significant long-run equilibrium with a positive coefficient of more than one during the stated period.

Ito (2009) concludes that the Fisher hypothesis holds in the interest rates of 2, 3, 4, 5, 7, and 10 years only in the period from October 1987 through June 1991 when the monetary policy of the Bank of Japan was tightening. Inder and Silvapulle (1993) use the Engle and Granger cointegration test to compare bankers' acceptance rates and CPI in Australia and conclude that the Fisher hypothesis does not hold.

MacDonald and Murphy (1989) conduct the Engle and Granger cointegration test using three-month Treasury bills and CPI in the US, Canada, UK, and Belgium from 1955 through 1973. They find that the Fisher hypothesis is effective in all these countries. They divide their sample into two. The first subsample is from 1955 through 1973 (second quarter), which is a fixed exchange regime. The second is from 1973 (third quarter) through 1986. They conclude that the Fisher hypothesis holds in the US and Canada in the first subsample, but the validity of the hypothesis cannot be found in any of the four countries in the second.

Mishkin (1992) resolves the issue of why a strong Fisher effect occurs only during certain periods and not others. There is no empirical evidence for a short-run Fisher effect in which a change in expected inflation is associated with a change in interest rates, but some evidence does support the existence of a long-run Fisher effect in which inflation and interest rates have a common stochastic trend when they exhibit trends. These results indicate that a strong Fisher effect will appear only in samples where there are trends in the inflation and interest rates. Mitchell-Innes et al. (2007) conclude that the short-run Fisher hypothesis does not hold during the relevant period under the inflation targeting

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monetary policy framework in South Africa.

Moosa and Kwiecien (2002) examine the viability of using short-term interest rates to forecast inflation as implied by the Fisher hypothesis. They demonstrate, using quarterly data for OECD countries and allowing for seasonality in the inflation rate, that it is possible to obtain a model with a high degree of forecasting accuracy and efficiency. Payne and Ewing (1997) examine the Fisher hypothesis for nine less-developed countries. They conclude that it holds only in Malaysia, Pakistan, and Sri Lanka.

Tsong and Lee (2011) show firstly that due to the higher power obtained by the inclusion of covariates, the test can overwhelmingly reject the unit root null for the 16 industrialized countries. The empirical results of Tsong and Lee (2013) for six OECD countries suggest that although the nominal interest rate and inflation move together in the long run, the cointegrating coefficients between the two variables display an asymmetric pattern depending on the sign and size of the shocks.

Yu (1997) examines the nominal interest rate using the IS-LM model incorporating the Fisher hypothesis. Eight different interest rates are considered for different sample periods ending in 1993. He concludes that the Fisher hypothesis holds only for the federal fund and AAA bond rates. Wallace and Warner (1993) test the Fisher hypothesis using 3-month Treasury bills, 10-year Treasury bonds, and CPI. They conduct the Johansen cointegration test and conclude that the Fisher hypothesis does not hold from 1953 through 1979.

Woodward (1992) tests the Fisher hypothesis using inflation-indexed securities to obtain direct data of inflation expectations and real interest rates. He concludes that the coefficients on the expected rate of inflation are approximately equal to one. Wong and Wu (2003) find more support for the Fisher hypothesis when the model is estimated by an instrumental variables estimation method using long-horizon data than by ordinary least squares (OLS) using short-horizon data.

2. DATA

2.1. Expected Rate of Inflation

As described by Ito (2009), some form of distributed lag on past inflation is used as a proxy for inflationary expectations when analyzing the Fisher hypothesis. This approach is found in Gibson (1970). Using the theory of rational expectations pioneered by Muth (1961), and the theory of efficient markets advanced by Fama (1970), an alternative approach to model expectations can be developed. This approach is adopted by Fama (1975), Lahiri and Lee (1979), and Levi and Makin (1979).

With the incorporation of these theories into the Fisher hypothesis, methods examining the time series properties of the variables can be developed. These methods are used by Ito (2009), MacDonald and Murphy (1989), and Wallace and Warner (1993). Woodward (1992) uses inflation-indexed securities to obtain direct data of inflation expectations and real interest rates. Sweden issues inflation-indexed Government Bonds, but the liquidity

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of the market and the accumulation of historical data are not enough.

This paper uses the method of Wallace and Warner (1993) to construct a proxy for inflation expectation. They point out that if inflation rates in the past have been unit root processes, innovation will influence the change of rates in the future. When $E_t(\pi_{t+j})$, defined as the expected rates of inflation (they are j periods forward based on information at the period t, are random walked,$\pi_{t+1}=\pi_t+\varepsilon_{t+1}$ (ε_{t+1} is an innovation of inflation rates) is established. Here equation (3) is established as for the expected rate of inflation at the time of j.

$$E_t(\pi_{t+j}) = \pi \quad (3)$$

Accordingly,π_t defined as the realized rates of inflation at the time t, denotes the expected rates of inflation in future. Thus, the realized rates of inflation are used as a proxy for inflation expectation after confirming that they are unit root processes. This paper uses the annual changes (inflation rate) of the CPI released by Statistics Sweden.

3.2 Nominal Interest Rate

As for nominal interest rates, Swedish interest rate swaps of 2, 3, 4, 5, 7, and 10 years are used from January 1993 to February 2015 on a end of month basis. The rates are averages of the bid and offer rate. These data are provided by Datastream.

The market for interest rate swaps has grown exponentially since the 1990s. According to a survey by Bank for International Settlements (BIS), the notional outstanding volume of transactions of interest rate swaps amounted to 461,281 billion US dollars at the end of December 2013 as described in BIS (2014).Figures 1 shows the data of CPI (annual changes) and the 5- and 10-year interest rates.

3. METHODOLOGY

3.1 Unit Root Test

It is necessary to check if the data used in this paper contain unit roots because empirical analysis from the mid-1980s through the mid-1990s shows that data such as interest rates, foreign exchange, and stocks are nonstationary, Therefore, the Phillips/Perron (PP) test and the Kwiatowski/Phillips/Schmidt/Shin (KPSS) test are used. The PP test defines the null hypothesis as “unit roots exist” and the alternative hypothesis as “unit roots do not exist.” Fuller (1976) provides the table for the PP test. The KPSS test defines the null hypothesis as “unit roots do not exist” and the alternative hypothesis as “unit roots exist.” Firstly, the original data are checked to see if they contain a unit root. Next, the data with first difference are analyzed to see if they have a unit root to confirm that the data are a I (1) process. The same method is used in Ito (2009).

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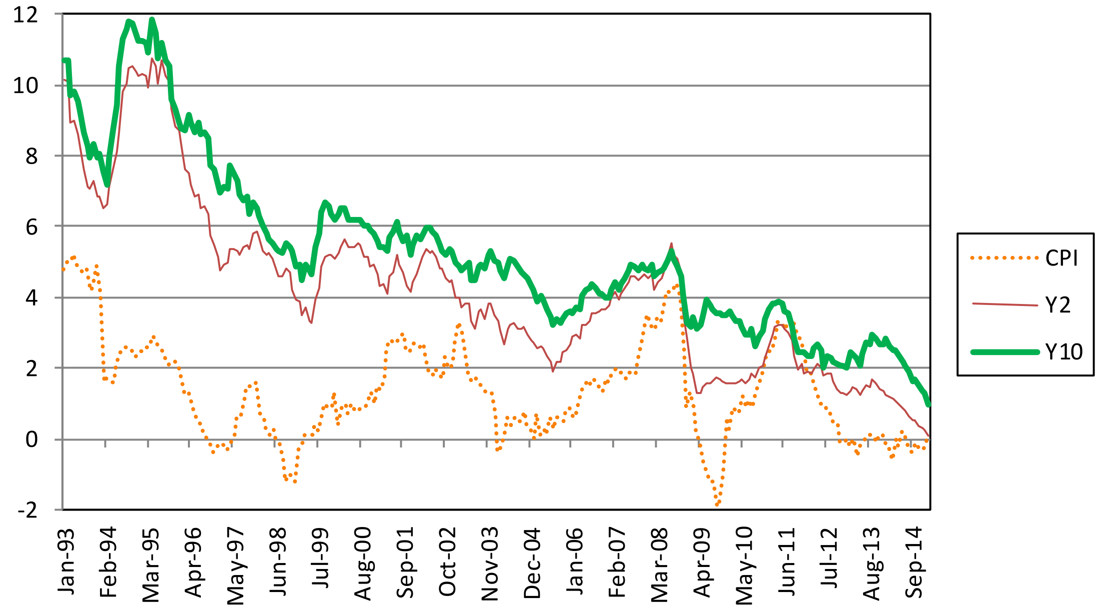
% Figure 1 CPI and Long Term Interest Rates



Notes: Sample period is from January 1993 to February 2015.
CPI is inflation rate.
Y2 and Y10 are swap rates of 2 years and 10 years.
Data source is Datastream.

3.2. Cointegration Test

A cointegration framework is presented to analyze the relationship between the nominal interest rate and the expected rate of inflation. Nonstationary time series vary widely with their own short-run dynamics, but their linear combination can sometimes be stationary such that they show comovement with long-run dynamics. This is called cointegration by Engle and Granger (1987). In the test of the Fisher hypothesis using cointegration, equation (1) is estimated by OLS to find if the residual contains a unit root.

$$i_t = \alpha + \beta\ E_t(\pi_{t+j}) + u_t \qquad (1)$$

i_t = nominal interest rates $E_t\ (\pi_{t+j})$ = expected rate of inflation

When series i_t and $E_t\ (\pi_{t+j})$ are both nonstationary I (1), they are said to be in a relationship of cointegration if their linear combination is a stationary I(0). The cointegration relationship between i_t and $E_t\ (\pi_{t+j})$ implies that nominal interest rates and the expected rate of inflation move together in a long-run equilibrium.

In addition to testing whether nominal interest rates and expected inflation rates have a cointegration relationship, the cointegration vector (1,−1), β in equation (1), is checked using the method of dynamic OLS (Stock and Watson, 1993). Equation (2) is used to test if $\beta = 1$ can be rejected. $\Delta Et\text{-}j(\pi_{t+j-i})$ are the lead and lag variables of the expected inflation rates. If $\beta = 1$ cannot be rejected, the nominal interest rates change to a degree equivalent

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to the expected inflation rates. The cointegration vector test is only conducted on a pair of samples when they have a cointegration relationship. The same method is used in Ito (2009).

$$i_t = \alpha + \beta E_t(\pi_{t+j}) + \sum_{i=-p}^{p} b_i \Delta E_{t-i}(\pi_{t+j-i}) + u_t \qquad (2)$$

The Fisher hypothesis holds when the expected inflation rates and nominal interest rates are in both a cointegration and one-to-one relationship.
The methods for testing the Fisher hypothesis can be summarized as follows:
(1) Test data if they are I (1) by unit root tests.
(2) Conduct the cointegration test on pairs of data confirmed to be I (1).
(3) Conduct the cointegration vector test on pairs of data confirmed to be in cointegration.

4. RESULTS

4.1 Unit Root Test

The results of the PP test and the KPSS test on the original data do not eliminate the possibility that the original data have unit roots because all results of the PP test (with and without trend) and the KPSS test (lag 4) show nonstationarity. The results are shown in Tables 1 and 2. Before reaching a conclusion, data with the first difference need to be checked to see if they have unit roots. If they are confirmed as not having unit roots, the original data are considered to be I (1).

Table 1
PP Unit Root Test Results (Original Series)

Variable	Without Trend	With Trend
CPI(t)	−2.865	−2.808
Y2	−1.707	−2.337
Y3	−1.529	−2.353
Y4	−1.422	−2.372
Y5	−1.357	−2.340
Y7	−1.334	−2.441
Y10	−1.411	−2.489

Notes:
* indicates significance at the 5% level.
5% critical values are −2.89 (without trend) and −3.45 (with trend).

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Table 2
KPSS Unit Root Test Results (Original Series)

	Lag = 4		Lag = 12	
Variable	Trend Stationary	Level Staionary	Trend Stationary	Level Staionary
CPI(t)	0.167*	0.478*	0.109	0.235
Y2	0.331*	3.451*	0.157*	1.705*
Y3	0.328*	4.204*	0.155*	1.744*
Y4	0.332*	4.280*	0.160*	1.770*
Y5	0.344*	4.337*	0.165*	1.788*
Y7	0.379*	4.406*	0.181*	1.811*
Y10	0.422*	4.58*	0.199*	1.826*

Notes:
* indicates significance at the 5% level.
5% critical values are 0.146 (trend stationary) and 0.463 (level stationary).

According to the results of the PP and KPSS tests on the data with first difference, the data are considered not to have unit roots. The results are shown in Tables 3 and 4. It can be concluded that all the data used for the analysis are I (1). Thus, it is appropriate to use nonstationary time series models.

Table 3
PP Unit Root Test Results (First Differenced Series)

Variable	Without Trend	With Trend
⊿CPI(t)	−14.156*	−14.177*
⊿Y2	−11.903*	−11.916*
⊿Y3	−11.840*	−11.847*
⊿Y4	−12.289*	−12.294*
⊿Y5	−12.685*	−12.691*
⊿Y7	−13.133*	−13.138*
⊿Y10	−13.404*	−13.410*

Notes:
* indicates significance at the 5% level.
5% critical values are −2.89 (without trend) and −3.45 (with trend).

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Table 4
KPSS Unit Root Test Results (First Differenced Series)

	Lag = 4		Lag = 12	
Variable	Trend Stationary	Level Staionary	Trend Stationary	Level Staionary
⊿CPI(t)	0.053	0.072	0.048	0.064
⊿Y2	0.043	0.063	0.037	0.054
⊿Y3	0.038	0.051	0.036	0.047
⊿Y4	0.037	0.046	0.035	0.044
⊿Y5	0.036	0.044	0.036	0.043
⊿Y7	0.036	0.044	0.037	0.044
⊿Y10	0.037	0.049	0.038	0.050

Notes:
* indicates significance at the 5% level.
5% critical values are 0.463 (trend stationary) and 0.146 (level stationary).

4.2 Cointegration Test

Interest rates in all maturities except for 10 years are in a relationship of cointegration with the expected rate of inflation. However, the 10-year interest rate is not. The results of the cointegration test show that interest rates in the maturities of 2, 3, 4, 5, and 7 years move together with the expected rate of inflation in a long-run equilibrium. The results are shown in Table 5.

Table 5
Cointegration Test Results

Variable	Test Statistics
CPI −Y2	−4.269*
CPI −Y3	−4.203*
CPI −Y4	−4.101*
CPI −Y5	−3.988*
CPI −Y7	−3.829*
CPI −Y10	−3.660

Notes:
* indicates significance at the 5% level.
5% critical value is −3.7809 from MacKinnon (1991).

The tests of the cointegration vector are conducted on all pairs of data except for the 10-year interest rate. As for the cointegration vector test, $\beta = 1$ cannot be rejected for all maturities. The results show that all the maturities except for the 10-year interest rate are in a one-to-one relationship. The results are shown in Table 6. From the tests of cointegration and the cointegration vector, it can be concluded that the Fisher hypothesis holds for the maturities of 2, 3, 4, 5, and 7, but not 10 years.

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Table 6
Cointegration Vector Test Results

Variable	β	Modified SE	Modified t Value
Y2	1.209	2.238	0.933*
Y3	1.198	2.192	0.705*
Y4	1.172	2.224	0.077*
Y5	1.134	2.243	0.027*
Y7	1.073	2.243	0.033*

Notes:
* means that $\beta = 1$ cannot be rejected since modified t value is smaller than 5% critical value (1.96).

5. CONCLUDING REMARKS

The purpose of this paper is to examine the validity of the Fisher hypothesis in Sweden by analyzing long-term interest rates from January 1993 to February 2015 under the regime of an inflation targeting policy. The Fisher hypothesis holds in the maturities of 2, 3, 4, 5, and 7, but not 10 years. The results of this paper partially support those of Hawtrey (1997) and Mitchell et al. (2007) who analyze the validity of the Fisher hypothesis under a regime of inflation targeting.

The results imply that changes in inflation expectations do move in the same direction and degree as the nominal long-term interest rates in the maturities of 2, 3, 4, 5, and 7 years. In these cases, real long-term interest rates are stable. This can be primarily attributed to the credibility of the inflation-targeting framework over a period of almost 20 years and the success it has achieved in locking inflation expectations into the target range within these timeframes. However, in the maturity of 10 years, this credibility has never been as certain as in the shorter periods. Thus, it can be concluded that the Riksbank has been almost successful in stabilizing inflationary expectations and real interest rates. This study can be extended into multiple-country analyses of countries operating inflation targeting.

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