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Bachelor Essay

The nonlinear relationship between inflation and economic growth

A dissection of the threshold level between inflation and economic growth in Sweden between 1971-2017.

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Abstract

A common belief about inflation and economic growth has developed during recent years. This belief is that a “low” and stable inflation rate favors economic growth. The underlying arguments for this are that a low inflation rate create a beneficial playground for all participants. A playground which will meliorate investments and ensure a stability for consumers which in return will give a favorable environment for the economy to thrive. This paper aims to clarify this relationship between inflation and economic growth in Sweden between the period 1971-2017 and thus investigate the co-integration relation between the two variables. Additional test will be conducted to explore a potential threshold level of inflation. This threshold level is defined as the point where inflation starts to harm growth.

Key words

Economic growth, Inflation, Threshold level of inflation, Relationship between inflation and economic growth

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1 Introduction

Economic growth and inflation are two essential variables in macroeconomics. To understand and determine the relationship between these two variables is of great interests for policymakers, authorities, economists and researchers. The ambiguous relationship has generated many debates about the subject and researchers has tried to solve for the relationship both theoretically and empirically. Some agreement exists, that low inflation is positively related with economic growth and the relationship is nonlinear in the long-run. However, according to classical economic theories like Keynesianism and Monetarism, there exists no relationship in the long-run.

Too high inflation is associated with inefficiency and thus creating costs according to Gokal and Hanif (2004). It leads to uncertainty about future profits for investors and irrational decisions by consumers. This results in lower levels of investments and welfare losses, reducing the economic growth. These costs and inefficiencies motivate policies that aims for low and non-volatile inflation. Furthermore, they state that inflation can have a negative impact on a country's competitiveness compared to other countries. This is because inflation makes export relatively more expensive and thus it affects the balance of payments.

But how low should inflation be? One argument against too low inflation is that wages are considered to be rigid downward. Berg (1999) argues that with zero inflation, the only way to adjust to shocks would be to lay-off workers in order to protect profits and reduce costs for the firms. Another argument by Fregert and Jonung (2018) is that with too low inflation, deflation can occur. When rational consumers know that the price level is lower tomorrow than today, they will postpone their consumption, and this will harm the economic growth.

Having stated the possible outcomes of too high or too low inflation, our research questions are; is the relationship between inflation and economic growth negative in the long run? And if so, is it possible to determine a threshold level of inflation in order to avoid disrupting the economic growth? The answer to these questions will vary between different countries, since all countries does not have the same structure and nature. This paper will investigate the relationship between inflation and economic growth in Sweden during the period 1971-2017.

The paper is structed in the following way;
Section 2 contains our theoretical framework of the Keynes and Monetarists vision and thoughts of economic growth and inflation. Section 3 summarizes previous studies in the field. Continuing with section 4 which describes our data and provide descriptive information about the sample. In section 5 we present the methodology of our approach with the results presented in section 6. We round off the paper with discussion and conclusion in section 7 respectively in section 8.

2 Theory

2.1 Keynesianism

This theory was developed by the British economy John M. Keynes in his famous book “The General Theory of Employment, Interest and Money” (1936). Keynes assumed that prices are sticky in the short-run, hence alternations in aggregated demand affects income. Furthermore, he believed that when resources aren’t efficiently allocated, i.e. not operating at the potential level, the government changes the aggregated demand with economic policies. These changes in aggregated demand is done by stimulating consumption and investments via increasing government spending.

The famous Keynesian model consists of two curves, the Aggregated Supply (AS) curve and the aggregated demand (AD) curve, which explains the relationship between economic growth and inflation. This model implies that, in the short-run, the AS-curve is not vertical but instead upwards sloping. This signify, according to Dornbusch et.al (1996), that in the short-run, alterations in aggregated demand affects the price level *and* output. This holds because labor force, monetary and/or fiscal policies and expectations are factors that drive inflation and output in the short run. When the AS-curve is vertical as it is in the long -run, alterations in aggregated demand affects *only* the price level. This is because the alternations are assumed to be smoothen out and the output goes back to its potential level.

Dornbusch et.al (1996) also assumes that aggregated demand and aggregated supply generates an “adjustment path”. At first, the relationship between inflation and economic growth is positive. This can be explained by the time inconsistency problem. Producers believe that the price level of their own merchandise has risen, while the other producers on the market is operating at the same price level as before. But the realism is that the price level overall has indeed increased.

Blanchard and Kiyotaki (1987) argues that the relationship between inflation and economic growth is positive because firms may have agreed on forward contracts. Firms are compelled to increase production, even if the price level has increased, in order to meet the demands that was agreed upon earlier.

Figure (2.1.1) shows how the demand affects the price level and the output in the economy where Y^2 is defined as full production. In theory we can't produce beyond this level. According to Keynes the aggregated demand shows the relation of price and output dependent on the aggregated demand.

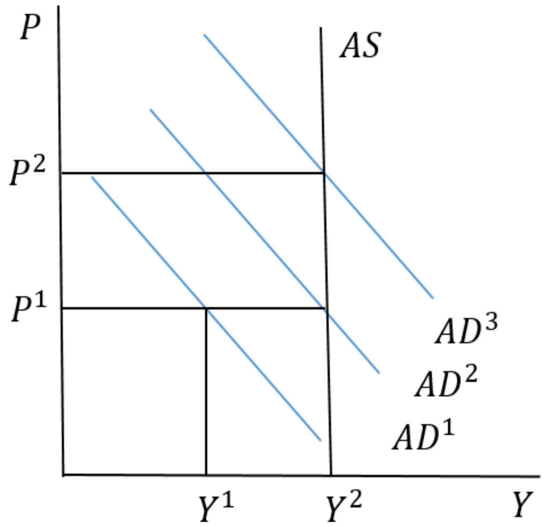
Aggregated demand (AD^1); At price level P^1 and AD^1 demand is below full production. Thus, according to Keynes theory, the government should intervene in order to stimulate the economy achieve full production.

Aggregated demand (AD^2); At price level P^1 and AD^2 we have an equilibrium and the demand now fulfills full production. So, there is no excess demand and thus there would be no inflation.

Aggregated demand (AD^3); At price level P^2 and AD^3 the demand covers the full production with "excess". This will cause inflation because the long-run equilibrium between aggregated demand and supply with Y^2 as a constraint will generate higher prices, causing inflation.

This lands in the conclusion that "excess demand" i.e. demand above the full level of production creates inflation and that higher inflation initially have a positive effect on growth, but in the long-run, inflation should have no effect on growth.

Figure (2.1.1). *Keynesianism inflation theory*



2.2 Monetarism

This theory was developed by Milton Friedman (1956) and has since been developed further. Gokal and Hanif (2004) states that the monetarists core focus is on “the long-run supply-side properties of the economy as opposed to short-run dynamics.” The long-run properties of the economy include Quantity Theory of Money and the Neutrality of Money.

Thus, the monetarism view is that the money supply is the dominated factor that determines the price level in the economy. Furthermore, Biswas et.al (2016) states that the government should only manage the growth rate of the money supply to synchronize it with the long-run growth rate of output. Inflation occurs when the money supply increases at a faster rate than the national income. However, the effect of the money supply differs in short-run and long-run. In the short run, the money supply affects real variables (real GDP and employment) and the price level. However, in the long-run, variations in the money supply affects the price level and nominal variables, not on real variables.

Monetarism also introduced expectation into the model. In the short run, if expected inflation is less than the actual inflation, real wages will be lower than nominal wages. This will increase firms' profits. However, in the long-run, workers will not stumble on the same stone several times. The workers will demand higher nominal wages and the results is that they must pay more for goods and services, but they do not mind because they have higher wages. When expected inflation is sequent with actual inflation, then inflation will not affect output and other real variables. Gokal and Hanif (2004) calls this notion for "neutrality of money".

3 Literature review

Mundell (1963) and Tobin (1965) were two of the first to explain how economic growth is affected by inflation. This effect is called the Mundell-Tobin Effect. In their model, they assume that money and capital are substitutes. When the inflation rate increases, the return on money falls and consequently capital gets more attractive relatively consumption due to higher returns on capital. This will lead to an increase in capital accumulation, hence higher economic growth.

Sidrauski (1967) did the next development. In his model, money is super-neutral which means that real variables, for example growth rate of output, are invariant to changes in the money supply. Sidrauski concludes that an increase in the inflation rate has no effect on the capital stock and neither on output nor economic growth.

Stockman (1981) says the opposite of what Mundell and Tobin concluded. An increase in inflation rate results in lower outputs and individual's welfare reduces. In his model, money is a compliment to capital, dissimilar Mundell (1963) and Tobin (1965) who assumed substituting effects. Furthermore, Stockman (1981) also assumes a "cash-in-advance limitation". He argues that because of inflation reduces purchasing power of money, individuals will also reduce their purchases of goods and capital. And the relationship between inflation and economic growth is negative.

An extensive work is done by Levine and Renelt (1992) in the area of growth estimating. They do cross-country regressions on forty countries in order to disguise the significance of the macroeconomic variables which determines growth. Inflation was among these variables. They depart from previous studies in the area and run test of robustness with gross domestic product (GDP) per capita as their dependent variable. Their conclusion is that they both confirm and deny various variable. Their findings are that foreign investments, share of trade (i.e. trade openness) and initial GDP (i.e. GDP lagged one time period) and inflation is significant when testing.

Fisher (1993) develops the previous study done by Levine and Renelt (1992) with inflation as the core variable to determine growth. He estimates a variety of test and obtain a perception that the results are somewhat contradictory. Inflation is negative correlated with growth yet lower rates of inflation is no guarantee for high growth. He concludes that the relation is dependent the negative relation that inflation has on investments and thus economic growth.

Bruno and Easterly (1996) supports this view as well to some extent. They look at the behavior of growth before, during and after high inflation crisis. They are defining high inflation as 40 percent annually. They find no evidence of a relationship between inflation and growth at annual inflation rates below 40 percent between 1961 and 1992. They do however find a relationship in the short- to medium-run relationship and it is also negative.

Gosh and Phillips (1998) uses a panel regression and allows for nonlinear specification to see if inflation and growth has any relationship. They use a large data set, covering all IMF members between the years of 1960-1996. The results show that low inflation rates (2-3 percent per year) are positively correlated with growth. Otherwise, inflation and growth are negatively correlated, but the relationship is complicated and nonlinear. The decline in growth when inflation increases from 10 to 20 percent is much larger than in the inflation increases from 40 to 50 percent.

Kahn and Senhadji (2000) examines the threshold effects in the relationship between inflation and growth. They study 140 countries and compare industrialized and developing countries between the 1960-1998. They use a regression where the real growth rate of GDP is the dependent variable and CPI index, investments, population growth, income per capita and growth rate of trade to name a few, as independent variable. They conclude that inflation slows growth when inflation is above the threshold at 1-3 percent for industrialized countries and 7-11 percent for developing countries. Fabayo and Ajilore (2006) follows this methodology and adopt it on Nigeria and concludes that inflation below 6 percent has a positive effect on growth while inflation rates above 6 percent retards growth performance.

The same conclusion goes for Asian countries, but the threshold is a bit higher. Vinayagathasan (2013) used dynamic panel threshold growth regression with data from 32 Asian countries between 1980-2009. He found evidence that inflation above 5.43 percent hurts growth, however the inflation has no effect on growth below this level.

Table (3.1.1) Summary of literature review

Author(s)	**Year**	**Results**
Mundell	1963	Positive relationship
Tobin	1965	Positive relationship
Sidrauski	1967	No relationship
Stockman	1981	Negative relationship
Levine and Renelt	1992	Inflation has a significant effect on growth
Gosh and Phillips	1998	Positive relationship below a threshold level of inflation. Negative relationship otherwise. Concludes nonlinear relationship.
Kahn and Senhadji	2000	Positive relationship below a threshold level of inflation. Negative relationship otherwise. Concludes nonlinear relationship.
Fabayo and Ajilore	2006	Positive relationship below a threshold level of inflation. Negative relationship otherwise. Concludes nonlinear relationship.
Vinayagathasan	2013	Positive relationship below a threshold level of inflation. Negative relationship otherwise. Concludes nonlinear relationship.

4 Methodology

In order to solve for our research question, we must determine the relationship between our two variables gross domestic product and consumer price index. In previous studies by Kahn and Senhadji (2000), Ahmed and Mortaza (2005) and Mallik and Chowdhury (2011) a generally accepted model has been developed. By solving for the co-integration relationship both in short, medium and long run, we are able to conclude the terms of which the variables affect each other. This will be done using a simple OLS regression. We will run an additional test, an Engle-Granger (EG) test which tests the relationship with it's actually critical values to get a more precise result according to MacKinnon (1990). The Engle-Granger test are looking at the long-run relation between the variables and thus we will complement this test with the Error Correction Mechanism (ECM) which inversely try the short, medium run. But in order to run these tests and avoid spurious results we need to test the variables of interest for the presence of a unit root. Then in order to test for what level of inflation that maximizes growth we estimate a simple OLS were we desire low residual sum of squares do determine a possible threshold level.

In order to avoid spurious results, we're following the approach of Ahmed and Mortaza (2005) and their guideline for non-stationary in levels but stationarity in differences, this before we test for the co-integration relationship. If the results are significant, we drastically reduce the risk for spurious output. To minimize other potential biases in our results we will do multiple test with the argument that a conclusion can't be drawn on a single test. Stationarity tests are constructed in different ways and thus are likely to give different results. This might lead to a wrong interpretation of the output and thus a decision should be based on that a certain output is predominate, this according to Mallik and Chowdhury (2001).

In this paper we will use the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) test in two different selections with in each, with trend and without trend. The regular DF test with trend are presented in equation (4.1.1) and the DF test with trend in equation (4.1.2).

Equation (4.1.1). $$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \varepsilon_t$$

Equation (4.1.2). $$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \varepsilon_t$$

As mentioned above we need to test both variables for a unit root. Thus, both GDP and CPI will take the value Y_t and Y_{t-1}, separately. β_1, β_2 and δ are the parameters being estimated were β_1 is a simple constant, β_2 is the trend variable in the ADF-test and ε_t is the error term. With the test we examine if $\delta = 0$. With the null hypothesis that $\delta = 0$ this would indicate that we have a unit root present and the time series is non-stationary. On the other hand, if $\delta \neq 0$ then we can conclude that no unit root is present and thus we have a stationary process. The same goes for the ADF test which are presented in equation (4.1.3) without trend and with trend in (4.1.4).

Equation (4.1.3). $$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-i} + \varepsilon_t$$

Equation (4.1.4). $$\Delta Y_t = \beta_1 + \beta_2 t + \delta X_{t-1} + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-i} + \varepsilon_t$$

What differ the DF and the ADF test is that the augmented Dickey-Fuller test is using lags to test for stationarity and are often used with more complex time series, Dickey and Fuller (1981). Following Ahmed and Mortaza (2005) we are running a lag-order selection test to determine the optimal counts of lags in order to manage the potential risk for auto-correlation problems which might weaken our results. Our decision on the count of lags will be based on Akaike Information Criteria (AIC). The AIC-test will do a trade-off between the quality of the model and the loss of degrees of freedom.

Our results are assumed to be in line with Ahmed and Mortaza (2005) and the guideline of non-stationarity in levels $I(1)$ and stationary in differences $I(0)$. Were $I(0)$ indicate that the residuals fluctuate around zero and don't deviate from the mean. While $I(1)$ defies this statement. The DF and ADF test will be applied on the GDP and CPI in logarithmic. Once the results have been achieved, we will predict residuals from the relationship between inflation and growth. This will be done by running an OLS model with equation (4.1.4) and (4.1.5) separately.

Equation (4.1.4). $$GDP_t = \beta_1 + \beta_2 CPI_t + e_t$$

Equation (4.1.5). $$CPI_t = \beta_1 + \beta_2 GDP_t + r_t$$

The OLS will estimate e_t and r_t were we once again will run DF and ADF test. This time with no constant and no drift like Ahmed and Mortaza (2005). Once again, this is to determine that our results won't be spurious. The output should indicate that the residuals are stationary $I(0)$. If the results would be integrated of order zero, then this this would suggest that we found a long-run equilibrium between inflation and growth. Thus, to say for sure there will be an evaluation of this possible co-integration between the variables with an Engle-Granger test.

The evaluation departs from the generally accepted model which uses an Engle-Granger test for the long-run co-integration and the Error Correction Model for the short, medium-run.

Equation (4.1.6). $$GDP_t - \beta CPI_t = \varepsilon_t$$

Equation (4.1.7).

$$\Delta GDP_t = \alpha_1 + \sum_{i=0}^{L} \alpha_2 \, \Delta CPI_{t-i} + \sum_{j=1}^{L} \alpha_3 \, \Delta GDP_{t-j} - T_1 r_{t-1} + \varepsilon_t$$

Equation (4.1.8).

$$\Delta CPI_t = \alpha_1 + \sum_{i=0}^{L} \alpha_2 \, \Delta GDP_{t-i} + \sum_{j=1}^{L} \alpha_3 \, \Delta CPI_{t-j} - T_1 r_{t-1} + \varepsilon_t$$

In equation (4.1.6) the EG test are displayed. The interpretation of the test is; that when adding a constant (β) to consumer price index this should equal an error term which circuits around zero. If the relation is significant, we have a long-run steady state equilibrium, Engle and Yoo (1991). The later equation (4.1.7) and (4.1.8) is the Error Correction Mechanism (ECM) test. The idea with ECM is that a part of the disequilibrium in one period is corrected in the next period and does not drift away. The change in GDP in one period may be dependent on the change in CPI in the previous period. Thus, significant results indicate that there is a return to the steady state in short/medium run as well as the long run. An insignificant result suggests that there might be a relation but there is a drift away from the long run equilibrium. Thus $T_1 r_{t-1}$ which is a trend term do not equalize the in equation (4.1.7) and (4.1.8).

Once the co-integration is established there is possibility to test for the threshold level of inflation, were the equation (4.1.9) is in focus and are to estimate using a simple ordinary least square regression.

Equation (4.1.9).

$$\Delta GDP = \alpha_0 + \gamma_1 \pi_t + \gamma_2 \left(d_t^* (\pi_t - \pi^*) \right) + \theta^t X_{it} + \varepsilon_t$$

$\Delta GDP = Growth\ rate\ GDP$

$d_t^* = Dummy \begin{cases} 1\ if\ \pi_t > \pi^* \\ 0\ if\ \pi_t < \pi^* \end{cases}$

$\pi_t = Inflation\ CPI$

$\pi^* = Test\ of\ threshold\ level$

$X_t = Vector\ of\ control\ variables$

The equation will create a structural break to establish a possible threshold level by using a dummy variable d_t^*. Thus, we will set the values of π^* starting at 1.5 and increasing the level of inflation until we observe a possible decrease. If there is a threshold level this can be seen that at a certain π^* level we minimize the residual sum of squares (RSS) and thus maximizes the R^2 value, indicating that it exists a threshold level between inflation and economic growth Ahmed and Mortaza (2005).

5 Data

Departing from the model that Khan and Senhadji (2001) and Ahmed and Mortaza (2005) uses we will use real gross domestic product (GDP) as our dependent variable. As independent variables Khan and Senhadji (2001) explored the threshold level of inflation and growth on industrialized and non- industrialized countries where they use a set of time dependent variables in order to strengthen their results. Thus $\theta^t X_{it}$ explained in the methodology equation (4.1.9) is a vector of country specific variables which includes Gross fixed capital formation (GFCF), Share of trade (TRD) and Population (POP). These variables have also been confirmed as robust and significant when measuring growth according to Levine and Renelt (1992) which has tested multiple variables for their significance and robustness.

The variables range between 1971-2017 and are presentenced with their abbreviations in table appendix (A.2). The variables will be expressed in log-form due to the non-linear relationship between the dependent and the independent variables. And the first difference is calculated according to equation (5.1.1) were X is replaced with the specific variable.

Equation (5.1.1).

$$\Delta X_t = \frac{\log X_t - \log X_{t-1}}{\log X_{t-1}}$$

5.1 Dependent variable

Real Gross domestic product

Real gross domestic product is used in multiple threshold analysis when studying the inflation and growth relationship. The variable is the dependent variable like Khan and Senhadji (2001). And it's the logical choice for measure of the real wealth and prosperity of a country. The variable is obtained from Statistics Sweden (2019) and are expressed in SEK.

5.2 Independent variables

Consumer price index (CPI)

Consumer price index is acquired via Statistics Sweden (2019) and is an index of price increases. Inflation is measured in multiple ways, for instance the Swedish Central Bank uses a variety of inflation measures. The core inflation measure that the Swedish Central Bank uses is the consumer price index with fixed interest rate (CPIF) which they applied early 2017, Riksbank (2019). Before the change they used consumer price index as their core measure, however, due to the short history of CPIF and the fact that our observations range between 1971 and 2017 we will use CPI even though it's not the current measure.

Gross fixed capital formation (GFCF)

Gross fixed capital formation acquired at Statistics Sweden (2019). The definition of GFCF is fixed investment in infrastructure (roads, sewages etc.), machinery (equipment and machines) and public and private construction (school, hospitals, commercial buildings etc.). The value can be interpreted as how much new value that is invested on fixed assets in the economy. Gross fixed capital formation will take a positive value and is measured as percentage of GDP.

Share of trade (TRD)

Share of trade is also known as openness to trade and is the import plus export summed, for both goods and services. The data is collected from Statistics Sweden (2019). The value of share of trade is expressed in percentage of GDP, where a high value indicated a country which trades a lot with other countries. A high share of trade would have a positive effect on growth due to the exchange of goods, services and knowledge across borders.

Population growth (POP)

Population growth is straightforward; it's the annual change in a country's population measured in percentage. The value will be positive or negative depending on if there is an increase or decrease in the population during the current year.

6 Results

The initial table (6.1.1) show the test of stationarity for our variables of interest. Where $I(1)$ indicate that a unit-root is present and thus not stationary. The vice versa could be said about $I(0)$ suggesting that the time series is indeed stationarity. The augmented version of the test is based on one lag according to the results from the AIC test determining the optimal counts of lags, the AIC table is shown in appendix, table (A.1).

Even if the DF test for CCPI and CGDP fails to hold for the guideline that our variables should be non-stationary in levels but stationary in differences the overall results suggest that we have $I(1)$ in levels and $I(0)$ indifferences.

Table (6.1.1) Test of stationarity on variables of interest

Variables	Dickey-Fuller		Augmented Dickey-Fuller		Conclusion
	W/O Trend	Trend	W/O Trend	Trend	
LGDP	I(1)	I(1)	I(1)	I(1)	I(1)
CCPI	I(0)	I(1)	I(1)	I(1)	I(1)
CGDP	I(0)	I(0)	I(0)	I(1)	I(0)
CCCPI	I(0)	I(0)	I(0)	I(0)	I(0)

Notes: 1: ΔCPI failed to hold stationarity. Thus, second difference is used to acquire this.
2: The presented results are selected with a ten-percentage significance level.
3: I(0) = Stationary (no unit root), I(1) = Non-stationary (unit root)
4: Amounts of lags based on Akaike's information criterion (AIC)
Source: Statistics Sweden (2019) and own calculations

We continue by estimate our equations presented in equation (4.1.4) and (4.1.5) to confirm a co-integration relationship in the long-run with a simple linear model. The results are presented in Table (6.1.2) respective (6.1.3).

Table (6.1.2) LGDP estimation OLS

Source	SS	df	MS			
				Number of obs	=	47
				F(1, 45)	=	105.47
Model	.339224805	1	.339224805	Prob > F	=	0.0000
Residual	.144732619	45	.00321628	R-squared	=	0.7009
				Adj R-squared	=	0.6943
Total	.483957424	46	.010520814	Root MSE	=	.05671

LGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCPI	-.0712167	.0069345	-10.27	0.000	-.0851835	-.0572499
_cons	5.598564	.0119634	467.97	0.000	5.574469	5.62266

Source: Statistics Sweden (2019) and own calculations

Table (6.1.3) CCPI estimation OLS

Source	SS	df	MS			
				Number of obs	=	47
				F(1, 45)	=	105.47
Model	46.8817629	1	46.8817629	Prob > F	=	0.0000
Residual	20.0024298	45	.444498439	R-squared	=	0.7009
				Adj R-squared	=	0.6943
Total	66.8841927	46	1.45400419	Root MSE	=	.66671

CCPI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LGDP	-9.842341	.9583663	-10.27	0.000	-11.77259	-7.912092
_cons	55.47569	5.281309	10.50	0.000	44.83859	66.1128

Source: Statistics Sweden (2019) and own calculations

The interpretation is that inflation dampens growth. The numbers suggest that an increase of one percent in CCPI will lead to a weakening of real GDP by 0,07 percent. GDP in return will diminish the CCPI level by 9,54 percent. In the tables we also see the model is significant of one percent and have R^2 values of 0,7009.

The results above strengthen the linear relationship but in order to confirm the results are not spurious we need to test for stationary residuals $I(0)$. These stationarity results have been acquired and are presented in table (6.1.4) and the underlying DF and ADF test are shown in appendix table (A.3) and the residuals are plotted in in graph (A.4) respective (A.5).

Table (6.1.4) Test on stationarity on residuals

Variables	Dickey-Fuller	Augmented Dickey-Fuller	Conclusion
	No trend	No trend	
e	I(0)	I(0)	I(0)
r	I(0)	I(0)	I(0)

Notes: 1: The presented results are selected with a ten-percentage significance level.
2: The result form the data is shown in appendix (A.2)
3: I(0) = Stationary (no unit root), I(1) = Non-stationary (unit root)
Source: Statistics Sweden (2019) and own calculations

In order to control for the robustness for the results we will run the Engle-Granger test i.e. equation (4.1.6) which are testing the residuals co-integration relationship as well but with the real critical values from MacKinnon (1990, 2010). The results of this test are shown in appendix (A.6) and (A.7) and are highly statistically significant.

The long-run equilibrium is found and now we test for the short, medium-run with the second stage of Engle-Granger known as the error correction mechanism in equation (4.1.7) and (4.1.8). We once again use Akaike information criterion to decide the lag length, the results shown in appendix

(A.8). We run the test for both; the results are found in appendix (A.9) and (A.10). The results found are that we receive negative residuals for both estimations which implies that it confirms the long-run though we found that the residuals for gross domestic product isn't significant on any level while CCCPI are at one percentage. The interpretation is that both will retract to the steady state and thus the long-run equilibrium holds.

Table (6.1.5) Threshold level between inflation and growth

Value of π^*	RSS	R^2
1.5	0.3883	0.6909
2.0	0.3638	0.7104
2.5	0.3619	0.7119
3.0	0.3554*	0.7171*
3.5	0.3712	0.7045
4.0	0.3671	0.7078
4.5	0.3676	0.7074
5.0	0.3676	0.7074

Source: Statistics Sweden (2019), and own calculations

We are now able to estimate our final model which is presented in equation (4.1.9). The results are found in appendix (A.11 – A.18) and above in table (6.1.5) we have presented a summary of the results. Where an inflation level of three percentage minimizes the residual sum of square and by this maximizes the R^2 value and the lowest probability value for our dummy at 0,059 being statistically significant at the ten-percentage level.

7 Discussion

These generalized econometric tests to solve for the co-integration and threshold level between inflation and economic growth has been proven and confirmed way by multiple studies before us, Ahmed and Mortaza (2005) look on the case of Bangladesh and Risso and Carrera (2009) instead look on Mexico. Our results of Sweden indicate that after a three percent inflation level, the inflation starts to harm the economic growth. This is in line with previous research of which too high levels of inflation starts to harm the economy. Khan and Senhadji (2001) who did the study on industrialized and non-industrialized countries found that industrialized countries has a threshold level of 1-3 percent. In Sweden's case we can confirm that they are not an outliner in this sense

Our results hope to shed some light to the ongoing debate of whether the inflation target should be changed. Thoughts on both increases and decreases are being debated. A conclusion from our paper suggest avoiding an increase of the inflation target to a level which are close to three percent, this due to the fluctuations of CPI. Though our results should be embraced with care because we have estimated a simple economic model who omits vital information. For example, we do not consider debt, unemployment, the housing market and/or other essential markets. These might have significant effects how monetary policy, but also fiscal policy is run and sometimes policymakers face a certain trade off. Our results suggest that the inflation target should be set in a range between zero and three percent, when complementing our results with the research of Gokal and Hanif (2004) and their results that deflation harm the economic growth.

Other implications might be our choice of CPI instead of any other inflation measure. Something that could have significant effects on our results. Though as CPI was the core measure in the period selected the choice was logical because decision makers based their decisions on CPI, Riksbank (2019). During the period selected, we also encounter changes in monetary and fiscal policies. For example, the independence of the Swedish Central Bank in 1990 lead to changes. The most known events are the change to floating exchange rate in 1992 and the inflation target which was introduced at the same time. An event which rapidly brought down inflation by 6-7 percentage units. To control for such changes is an interesting field for potential further studies but also to test for the variety of different measures of inflation, this to achieve more robust results.

8 Conclusion

The aim of this paper was to investigate the long-run relationship between inflation and economic growth in Sweden and to find a potential threshold level. In order to do so we first estimated a simple OLS model to see if there exist a co-integration between the variables in the long run. We complement this by running a 2-step Engle-Granger procedure to test for the short, medium and long run to achieve more robust results on how inflation and economic growth affect each other.

Our results suggest that we indeed have a negative relation between inflation and economic growth in Sweden. Once this relation was established, we ran a serious of threshold test where we found that after an annual inflation of three percent the inflation starts to harm the economic growth causing a nonlinear relation between the variables. These results are in line with previous research in the field, such as Ahmed and Mortaza (2005), and Mallik and Chowdhury (2001), Kahn and Senhadji (2000), Fabayo and

Ajilore (2006) and Vinayagathasan (2013). However, they are not in line with the theories in this paper. Both Keynesianism and Monetarism conclude that in the long run, there exists no relationship between inflation and economic growth.

The implications and contributions of our analysis could be of interest to certain policy makers such as fiscal and monetary policy makers. By knowing the threshold level where the inflation starts to harm the economy an inflation target can be set by monetary authorities to avoid such events. This interpretation goes for fiscal policy makers as well; to be aware and to avoid stimulating the economy too much so that the three percent threshold level is not violated.

In context, Sweden has to some extent managed to control the inflation since the introduction of inflation targeting in 1992, even if some years have had CPI levels above three percentage. We hope to have shed some light on the topic of inflation and it is currently debated relation to growth. Even if we can’t draw any conclusions on the optimal level of inflation our results suggest avoiding inflation targets to close to three percent due to the fluctuations of CPI.

9 References

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Appendix

Table (A.1). Akaike information criterion

```
Selection-order criteria
Sample:  1975 - 2017                        Number of obs      =        43
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-51.6368				.041544	2.49474	2.52494	2.57665
1	-11.8582	79.557	4	0.000	.00787*	.830613*	.921238*	1.07636*
2	-9.21339	5.2896	4	0.259	.008396	.893646	1.04469	1.30323
3	-6.53661	5.3536	4	0.253	.008962	.955191	1.16665	1.52861
4	-1.08358	10.906*	4	0.028	.008433	.887608	1.15948	1.62485

Table (A.2). Variable summary and their abbreviations

Variable	Logarithmic form	1st difference of logarithmic form	2nd difference of logarithmic form
GDP	LGDP	CGDP	-
CPI	LCPI	CCPI	CCCPI
TRD	LTRD	CTRD	-
GFCF	LGFCF	CGFCF	-
POP	LPOP	CPOP	-

Table (A.3). AD and ADF test of residuals

Dickey-Fuller test for unit root — Number of obs = 46

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.545	-2.626	-1.950	-1.608

. dfuller e, noconstant lags(1)

Augmented Dickey-Fuller test for unit root — Number of obs = 45

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.613	-2.628	-1.950	-1.608

.
. dfuller r, noconstant lags(0)

Dickey-Fuller test for unit root — Number of obs = 46

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.079	-2.626	-1.950	-1.608

. dfuller r, noconstant lags(1)

Augmented Dickey-Fuller test for unit root — Number of obs = 45

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.915	-2.628	-1.950	-1.608

Table (A.4). Residuals of LGDP

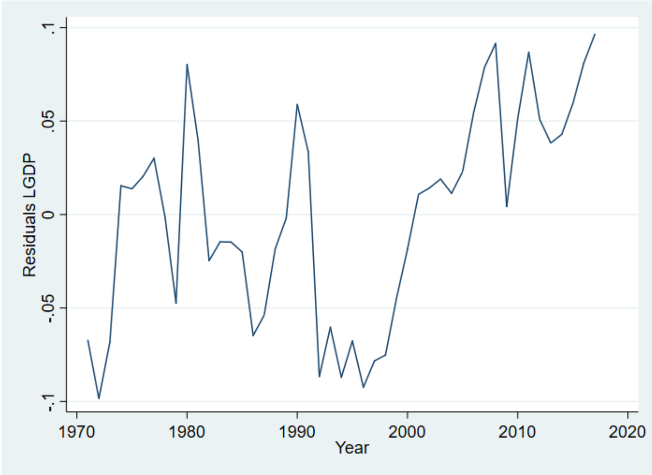

Table (A.5). Residuals of CCPI

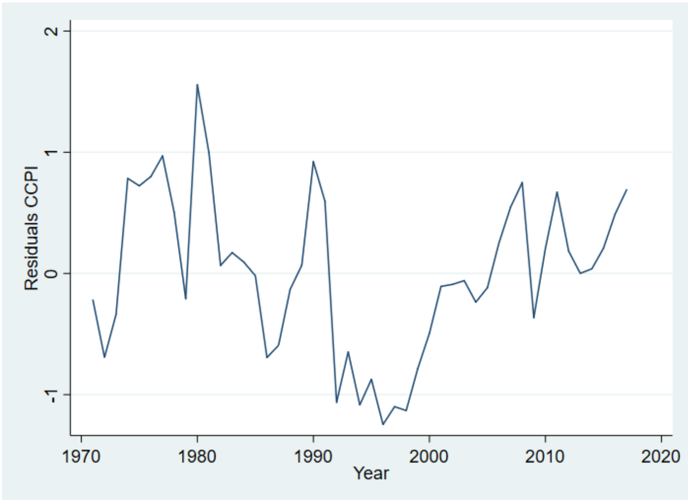

Table (A.6). Engle-Granger test for co-integration

Engle-Granger test for cointegration — N (1st step) = 46; N (test) = 45

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-5.009	-4.151	-3.475	-3.140

Critical values from MacKinnon (1990, 2010)

Table (A.7). Johansen test for co-integration

Johansen tests for cointegration

Trend: constant — Number of obs = 44

Sample: 1974 - 2017 — Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	6	20.970008	.	30.0660	15.41
1	9	35.940852	0.49363	0.1243*	3.76
2	10	36.003	0.00282		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	6	20.970008	.	29.9417	14.07
1	9	35.940852	0.49363	0.1243	3.76
2	10	36.003	0.00282		

Table (A.8). Akaike information criterion

Selection-order criteria
Sample: 1975 - 2017 Number of obs = 43

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	49.5471				.000376	-2.21149	-2.18128	-2.12958
1	167.164	235.23*	4	0.000	1.9e-06*	-7.496*	-7.40538*	-7.25025*
2	170.648	6.9683	4	0.138	2.0e-06	-7.47201	-7.32097	-7.06243
3	172.648	3.9998	4	0.406	2.2e-06	-7.37898	-7.16752	-6.80557
4	175.45	5.6045	4	0.231	2.3e-06	-7.32327	-7.0514	-6.58602

Table (A.9). Engle-Granger 2-step ECM on CGDP

Engle-Granger 2-step ECM estimation N (1st step) = 46
Number of lags = 3 N (2nd step) = 42

Engle-Granger 2-step ECM

D.CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_egresid						
L1.	-.6783568	.2879156	-2.36	0.024	-1.263472	-.093242
CGDP						
LD.	.0156263	.2509145	0.06	0.951	-.4942934	.525546
L2D.	-.2100666	.2088985	-1.01	0.322	-.6345994	.2144661
L3D.	-.1571639	.1943274	-0.81	0.424	-.5520847	.2377569
CCCPI						
LD.	-.0073522	.0091362	-0.80	0.427	-.0259192	.0112148
L2D.	-.0069699	.0220334	-0.32	0.754	-.0517472	.0378074
L3D.	-.0452052	.0247435	-1.83	0.076	-.09549	.0050795
_cons	-.0073585	.0269127	-0.27	0.786	-.0620517	.0473348

Table (A.10). Engle-Granger 2-step ECM on CCCPI

Engle-Granger 2-step ECM estimation — N (1st step) = 46
Number of lags = 3 — N (2nd step) = 42

Engle-Granger 2-step ECM

D.CCCPI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_egresid						
L1.	-3.213228	1.09058	-2.95	0.006	-5.429553	-.9969016
CCCPI						
LD.	2.353703	1.037705	2.27	0.030	.2448333	4.462573
L2D.	.0292683	.8302478	0.04	0.972	-1.657998	1.716535
L3D.	.6350176	.5200459	1.22	0.230	-.4218427	1.691878
CGDP						
LD.	-1.227518	2.529701	-0.49	0.631	-6.368488	3.913453
L2D.	-5.144308	2.690046	-1.91	0.064	-10.61114	.3225238
L3D.	2.06012	3.117718	0.66	0.513	-4.275846	8.396086
_cons	.9744901	.6527846	1.49	0.145	-.3521278	2.301108

Table (A.11). Regression with optimal inflation at 1.5

Source	SS	df	MS
Model	.868010315	5	.173602063
Residual	.388298807	37	.010494562
Total	1.25630912	42	.029912122

Number of obs	=	43
F(5, 37)	=	16.54
Prob > F	=	0.0000
R-squared	=	0.6909
Adj R-squared	=	0.6492
Root MSE	=	.10244

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0153226	.0151007	-1.01	0.317	-.0459196	.0152744
dcv15	-.0213841	.0370597	-0.58	0.567	-.0964742	.0537059
CGFCF	.0551447	.0072399	7.62	0.000	.0404752	.0698142
CTRD	.0111818	.0122101	0.92	0.366	-.0135583	.0359219
CPOP	-2.444075	.7319926	-3.34	0.002	-3.927233	-.9609171
_cons	.2188845	.03986	5.49	0.000	.1381204	.2996486

Table (A.12). Regression with optimal inflation at 2.0

Source	SS	df	MS			
Model	.892492576	5	.178498515	Number of obs	=	43
Residual	.363816546	37	.00983288	F(5, 37)	=	18.15
				Prob > F	=	0.0000
Total	1.25630912	42	.029912122	R-squared	=	0.7104
				Adj R-squared	=	0.6713
				Root MSE	=	.09916

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0139422	.0145997	-0.95	0.346	-.0435239	.0156395
dcv20	-.0552582	.0327598	-1.69	0.100	-.1216359	.0111194
CGFCF	.0542617	.0070302	7.72	0.000	.0400171	.0685062
CTRD	.009698	.0118352	0.82	0.418	-.0142825	.0336785
CPOP	-2.710867	.725717	-3.74	0.001	-4.181309	-1.240425
_cons	.246967	.0378781	6.52	0.000	.1702187	.3237153

Table (A.13). Regression with optimal inflation at 2.5

Source	SS	df	MS			
Model	.89440128	5	.178880256	Number of obs	=	43
Residual	.361907842	37	.009781293	F(5, 37)	=	18.29
				Prob > F	=	0.0000
Total	1.25630912	42	.029912122	R-squared	=	0.7119
				Adj R-squared	=	0.6730
				Root MSE	=	.0989

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0174813	.014633	-1.19	0.240	-.0471305	.0121679
dcv25	-.0585073	.0334719	-1.75	0.089	-.1263278	.0093132
CGFCF	.053788	.0070372	7.64	0.000	.0395293	.0680468
CTRD	.0095699	.0118073	0.81	0.423	-.014354	.0334939
CPOP	-2.8395	.741653	-3.83	0.000	-4.342231	-1.336768
_cons	.2515933	.0390464	6.44	0.000	.1724778	.3307088

Table (A.14). Regression with optimal inflation at 3.0

Source	SS	df	MS
Model	.900951611	5	.180190322
Residual	.355357511	37	.009604257
Total	1.25630912	42	.029912122

Number of obs	=	43
F(5, 37)	=	18.76
Prob > F	=	0.0000
R-squared	=	0.7171
Adj R-squared	=	0.6789
Root MSE	=	.098

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.015645	.0144266	-1.08	0.285	-.0448762	.0135862
dcv30	-.061709	.0316824	-1.95	0.059	-.1259036	.0024857
CGFCF	.0539309	.0069569	7.75	0.000	.039835	.0680269
CTRD	.010748	.0116745	0.92	0.363	-.0129067	.0344028
CPOP	-2.815028	.7254186	-3.88	0.000	-4.284866	-1.34519
_cons	.2497906	.0362312	6.89	0.000	.1763793	.3232019

Table (A.15). Regression with optimal inflation at 3.5

Source	SS	df	MS
Model	.885049265	5	.177009853
Residual	.371259857	37	.01003405
Total	1.25630912	42	.029912122

Number of obs	=	43
F(5, 37)	=	17.64
Prob > F	=	0.0000
R-squared	=	0.7045
Adj R-squared	=	0.6645
Root MSE	=	.10017

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0130901	.0147877	-0.89	0.382	-.0430529	.0168727
dcv35	-.0470116	.0328636	-1.43	0.161	-.1135997	.0195765
CGFCF	.0540981	.0071227	7.60	0.000	.0396662	.0685301
CTRD	.0098269	.0119579	0.82	0.416	-.0144021	.034056
CPOP	-2.807519	.7590368	-3.70	0.001	-4.345474	-1.269564
_cons	.2369135	.0365166	6.49	0.000	.1629238	.3109033

Table (A.16). Regression with optimal inflation at 4.0

```
. reg CGDP L3.CCCPI dcv40 CGFCF CTRD CPOP
```

Source	SS	df	MS			
Model	.889196983	5	.177839397	Number of obs	=	43
Residual	.367112139	37	.00992195	F(5, 37)	=	17.92
				Prob > F	=	0.0000
				R-squared	=	0.7078
				Adj R-squared	=	0.6683
Total	1.25630912	42	.029912122	Root MSE	=	.09961

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.012063	.0147592	-0.82	0.419	-.041968	.0178419
dcv40	-.0515615	.0326922	-1.58	0.123	-.1178023	.0146792
CGFCF	.0539931	.0070824	7.62	0.000	.0396429	.0683433
CTRD	.0087672	.0119455	0.73	0.468	-.0154368	.0329711
CPOP	-2.813872	.748968	-3.76	0.001	-4.331425	-1.296319
_cons	.2383691	.0355528	6.70	0.000	.1663323	.3104058

Table (A.17). Regression with optimal inflation at 4.5

Source	SS	df	MS			
Model	.888688501	5	.1777377	Number of obs	=	43
Residual	.367620621	37	.009935692	F(5, 37)	=	17.89
				Prob > F	=	0.0000
				R-squared	=	0.7074
				Adj R-squared	=	0.6678
Total	1.25630912	42	.029912122	Root MSE	=	.09968

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0126422	.014732	-0.86	0.396	-.0424921	.0172077
dcv45	-.0519648	.0333157	-1.56	0.127	-.1194688	.0155392
CGFCF	.0536747	.0071143	7.54	0.000	.0392598	.0680896
CTRD	.0087445	.0119572	0.73	0.469	-.015483	.0329721
CPOP	-2.845645	.7569	-3.76	0.001	-4.37927	-1.31202
_cons	.2382888	.0356963	6.68	0.000	.1659613	.3106163

Table (A.18). Regression with optimal inflation at 5.0

Source	SS	df	MS
Model	.888688501	5	.1777377
Residual	.367620621	37	.009935692
Total	1.25630912	42	.029912122

Number of obs	=	43
F(5, 37)	=	17.89
Prob > F	=	0.0000
R-squared	=	0.7074
Adj R-squared	=	0.6678
Root MSE	=	.09968

CGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CCCPI						
L3.	-.0126422	.014732	-0.86	0.396	-.0424921	.0172077
dcv50	-.0519648	.0333157	-1.56	0.127	-.1194688	.0155392
CGFCF	.0536747	.0071143	7.54	0.000	.0392598	.0680896
CTRD	.0087445	.0119572	0.73	0.469	-.015483	.0329721
CPOP	-2.845645	.7569	-3.76	0.001	-4.37927	-1.31202
_cons	.2382888	.0356963	6.68	0.000	.1659613	.3106163