Inflation and Economic Growth
Analyzing the Threshold Level of Inflation
-Case Study of Finland, 1980-2010
Acknowledgement

I would like to express my deepest gratitude to my supervisor Ulf Holmberg, whose guidance and support enabled me to develop a better understanding of the subject.
Abstract

The existence and nature of a link between inflation and economic growth has been the subject of considerable interest and debate. High and sustainable economic growth and low inflation are two of the main objectives of macroeconomic policy. Hence, if high inflation is harmful for an economy and low inflation is beneficial, then it is reasonable to ask, what is the optimal level of inflation for an economy? In general, is there any link between inflation and economic growth? In this thesis, we estimate the relationship between inflation and economic growth by studying their co-integrated relationship using the error correction model. After estimating this link, we turn to estimate the threshold level of inflation. The results indicate that there exist a positive long-run relationship between inflation and economic growth in Finland. In addition, by assuming that such a relationship is non-linear, we find that the Finnish economy grows at its highest rate when inflation is at 4 percent.
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1. Introduction

In many countries high and sustainable economic growth and low inflation are two of the main objectives of macroeconomic policy. A widely accepted concept in macroeconomics is that low inflation is essential for economic growth. Although the debate about the precise relationship between inflation and economic growth remains open, the question of the existence and nature of this link has been the subject of considerable interest and debate (Munir and Mansur, 2009). Different schools of thought offer different evidence on the link between inflation and economic growth. For instance, structuralists believe that inflation is necessary for economic growth, but according to monetarists’ view, inflation is harmful to economic growth (Mallik and Chowdhury, 2001).

In the 1960s, models of inflation and economic growth emphasized the portfolio substitution mechanism, i.e. that higher inflation made capital more captivating to hold relative to money. This caused higher capital intensity, and in the transition period to higher economic growth (Fisher, 1993). However, in the 1970s, in countries with high inflation rates, economic growth rates began to decrease. High inflation and hyperinflation in Latin American countries in the 1980s caused the emergence of a view that inflation has a negative impact on economic growth, contrary to the prevailing view that inflation has a positive impact on the economic growth (Erbaykal and Okuyan, 2008). According to (Fisher, 1993), time periods associated with high inflation tends to hamper economic growth. This since inflation has an adverse effect on the allocation of resources working through a change in relative prices. Time periods associated with low inflation levels, on the other hand, make prices and wages more flexible, promoting economic growth (Lucas, 1973). If high inflation is harmful and low inflation is beneficial for an economy, then it is reasonable to think about the optimal level of inflation for an economy.

17 Member States of the EU (including Finland) use the euro as their currency. There is an inflation target of 2 percent for the euro area, and this policy is established by the European
Central Bank (ECB). The main objective of ECB's monetary policy is to maintain price stability. If ECB can consistently meet its indicated inflation target of 2 percent, businesses and financial markets will hold their inflationary expectations stable. However, there are different points of view concerning the inflation target among economists. Most economists support the prevailing inflation target, but some argue that the inflation target is too low for the whole euro area. The main reason for such a view is the difference in growth rate among the countries of the euro area (“International Economy”, 2003). Thus, the objectives of this study are to examine the relationship between inflation and economic growth and to find the optimal level of inflation in Finland over the period of 1980-2010.

The reminder of the paper is organized as follows: The next Section presents the relevant theory and in Section 3, we review the relevant literature. In Section 4, we describe the empirical models and in Section 5, we present the results. The final Section concludes.
2. Theory

Economic theories have different points of view about the relationship between inflation and economic growth. In this section, we briefly discuss two fundamental economic theories, related to this subject: the Monetarist Theory and the Neoclassical Growth Theory.

The Monetarist Theory is a fundamental theory, which is mainly associated with the work of economist Milton Friedman. According to the theory, change in money supply is the most important determinant of economic growth. As such, the behavior of the business cycle is ultimately linked to money supply. According to the theory, inflation originates from increase in money supply. More specifically, inflation occurs if money supply increases faster than national income growth rate. Underlying the Monetarist Theory is the Quantity Theory of Money, and there are two versions of it: The Cash Balance Approach (Cambridge version) and Transaction Approach (Fisher’s version). The Cash Balance Approach to the Quantity Theory of Money can be described by the following:

\[
\pi = \delta \frac{R}{M}
\]

(1)

where, \( \pi \) is the purchasing power of money, \( \delta \) is the proportion of income that people like to hold in the form of money, \( R \) is the volume of real income, and \( M \) is the stock of supply of money in a country. This equation explains that the purchasing power of money (\( \pi \)) varies directly with \( \delta \) or \( R \), and inversely with \( M \). Since, \( \pi \) is the reciprocal of the general price level, which is \( \pi = 1/P \), the equation (1) can be described as follows:

\[
1/P = \delta \frac{R}{M}
\]

(2)

or

\[
P = M/\delta R
\]

(3)

such that,

\[
dP/dM = 1/ \delta R
\]

(4)

Thus, the growth in prices varies directly with money supply.
Turning to the Transaction Approach to the Quantity Theory of Money, it can be described by the following equation:

\[ MV = PT \]  

(5)

where, \( M \) is a total supply of money, \( V \) is the velocity of circulation of money, \( P \) is the general price level, and \( T \) is the total transactions in physical goods.

According to this view, the causalities moves from left to right in the equation (5), meaning that prices are directly affected by an increase in money supply. If \( T \) increases, \( P \) will remain relatively constant. However, if there is no corresponding increase in the quantity of goods and services produced, \( P \) will increase. In general, production, employment and price levels are affected by a change in money supply.

Neoclassical growth theory is another fundamental theory which explains how a stable economic growth rate will be achieved with the suitable amounts of three important factors: capital, labor and technology. Based on neoclassical growth theory, Solow (1956) and Swan (1956) originated a growth model which can be explained by the following:

\[ y_t = f(k_t, l_t) \]  

(6)

where, \( y_t \) is output, \( k_t \) is capital and \( l_t \) is labor at time \( t = 0, 1, 2..., \). In addition, a law of motion for the capital stock is introduced, \( k_{t+1} = (1 - \sigma) k_t + \mu y_t \) where \( \sigma \in (0, 1) \) is the depreciation rate and \( \mu \in (0, 1) \) is the savings rate. In order to get the entire time path of capital stock, we substitute (6) (the production function) into the law of motion for capital:

\[ k_{t+1} = (1 - \sigma) k_t + \mu F(k_t) = g(k_t) \]  

(7)

Given this path, a path of output \( (y_t) \) can be derived. A steady state of the system is a solution to \( k = g(k) \).

Consequently, Abramovits (1956) and Solow (1957) provide the growth accounting model:

\[ \frac{[Y^*(t)/Y(t)] - [L^*(t)/L(t)]}{[K^*(t)/K(t)] - [L^*(t)/L(t)]]} + R(t) = \alpha(t) \]  

(8)
where, $Y^*(t)/Y(t)$ is the growth rate of output, $L^*(t)/L(t)$ is the growth rate of labor, $K^*(t)/K(t)$ is the growth rate of capital, $\alpha_k(t)$ is elasticity of output with respect to capital at time $t$, and $R(t)$ is the Solow Residual, which explains the total factor of productivity (technological progress) (Xiao, 2009).

Further, J. de Gregorio (1996) explains how inflation affects long-run growth based on neoclassical approach:

$$y_t = \theta f(k_t, l_t)$$  \hspace{1cm} (9)

where, $y_t$ is output at period $t$, $\theta$ is a technological parameter, and $k_t$ and $l_t$ are the stock of capital and employment in period $t$, respectively. After log-differentiating (9), the following expression for the growth rate of the economy is obtained:

$$\gamma = \theta f'(k_t, l_t)i$$  \hspace{1cm} (10)

where, $\gamma$ is the rate of growth of output ($\gamma = d\log(y_t)/dt$), $\theta f'(k_t, l_t)$ is the marginal productivity of capital, $i$ is the investment rate, $(1/y)(dk/dt)$.

According to equation (10), growth may be generated by an increase in the rate of investment or an increase in the marginal productivity of capital $\theta f'(k_t, l_t)$. On the other hand, if we assume that $f$ is a linear in $k$, such that $f'$ is an increasing function of $l$; decline in $f'(k_t, l_t)$ leads to a decline in the rate of growth, since capital accumulation becomes less efficient. If individuals have to choose between consumption and leisure, and to buy consumption goods, individuals face a cash-in-advance constraint. Since individuals will have to hold money in order to purchase consumption goods, the effective price of consumption goods will include the rate of inflation. Thus, an increase in inflation rate will raise the price of consumption with respect to the price of leisure inducing substitution from consumption to leisure, and thereby reducing the labor supply. Hence, an increase in inflation will reduce the efficiency of investment and the rate of growth.
3. Literature Review

Previous work, both theoretical and empirical, is divided in their view on inflation-growth relationship. In general, the obtained results show that the link between inflation and economic growth is not stable.

Mundell (1963) and Tobin (1965) explained the impact of inflation on economic growth based on neoclassical growth theory. They argue that an increase in the nominal interest rate caused by inflation, makes an investment more preferable than consumption. This, in turn, will cause an increase in the accumulation of capital, which will lead to economic growth. This is the well-known Mundell-Tobin Effect.

Sidrauski (1967) developed a theoretical model by which he investigated the relationship between inflation and economic growth. In his model money is super-neutral, meaning that the rate of money growth has no real effect on the steady-state. But, his subsequent theoretical study show that in most general cases, steady-state stock of capital will be reduced due to inflation.

Stockman (1981) developed a long-term equilibrium growth model with the assumption of “cash-in-advance constraint”. His theory is a contrary to the conclusion of the Mundell-Tobin Effect. In the model of Stockman (1981), investment and real money balances are complements, but in the model of Mundell (1963) and Tobin (1965), those two variables are substitutes. According to this theory, the individuals in the future will receive the return on investment in the form of money. Thus, investment and real money balances will be reduced by inflation. Consequently, inflation will negatively affect economic growth.

On the other hand, most of the empirical studies conducted in 1990s, also found a negative relationship between inflation and economic growth. In particular, De Gregario (1992) studied 12 Latin American countries using data from 1950 to 1985. By Generalized Least Squares (GLS) he found a negative relationship between inflation and growth.
In addition, Fisher (1993) investigated the role of macroeconomic factors, such as inflation on growth using a panel data of 93 countries. He found that economic growth is negatively associated with inflation and that inflation reduces economic growth by reducing the growth in productivity and investment. Furthermore, by analyzing obvious outlier countries, he found that high inflation is not consistent with sustained economic growth.

Barro (1995) studied the effects of inflation on economic growth by using panel data for around 100 countries for the period of 1960-1990. From the empirical analysis, he found that the estimated impact of inflation on economic growth is significantly negative. However, he obtained statistically significant results only when high inflation data was included in the sample. He estimated that a 10 percentage increase in the average inflation per year reduces the per capita GDP growth rate by 0.2-0.3 percent. Further, Sarrel (1996) studied the possibility of a nonlinear impact of inflation on economic growth. He used panel data covering 87 countries for the period of 1970-1990. His findings show a significant structural break in the function that relates growth to inflation. According to his results, the estimated structural break occurs when the inflation rate is approximately 8 percent. Below this rate, he found that the inflation does not seem to have a significant impact on economic growth. Sarrel (1996) also found that an inflation exceeding 8 percent reduces the economic growth rate.

Paul, Kearney and Chowdhury (1997) studied the inflation-growth relationship for 70 countries for the period of 1960-1989. Their findings show no causal relationship between inflation and economic growth in 40 percent of the countries. Consequently, in 20 percent of the countries they reported bidirectional causality and in the rest of the countries they found a unidirectional relationship, which is either inflation to growth or vice versa.

Bruno and Easterly (1998) investigated the relationship between inflation and economic growth for 26 countries, which experienced an inflation crises over the period of 1961-1992. Their empirical analysis showed that the threshold level of inflation for an inflationary crisis is about 40 percent. They also found that the effect of low and moderate inflation on economic growth is quite uncertain. Consequently, Khan and Senhadji (2001)
examined the existence of threshold effects on the relationship between inflation and economic growth for developing and developed countries. They used a panel data set covering 140 countries for the period 1960-1998. Their finding suggests the existence of a threshold level of inflation beyond which inflation exerts a negative impact on economic growth. The estimated threshold level was 1-3 percent for developed countries and 11-12 percent for developing countries.

Furthermore, Mallik and Chowdhury (2001) used an error correction model in order to explore the short-run and long-run dynamics of inflation and economic growth for four South Asian countries. The authors found a long-run positive and statistically significant inflation-growth relationship for all four countries. They also emphasized that the sensitivity of inflation to changes in economic growth rates is larger than that of economic growth to changes in inflation rates. Similarly, Ahmed and Mortaza (2005) studied the link between inflation and economic growth for Bangladesh covering the period of 1980-2005. In addition, they examined the existence of the threshold level of inflation in the country. They used the same methodology as Mallik and Chowdhury (2001) to find the inflation-growth relationship. Consequently, to estimate the threshold level of inflation, they used the methodology developed by Khan and Senhadji (2001). From the empirical work, they found the existence of a statistically significant long-run negative relationship between inflation and economic growth. The estimated threshold level of inflation was 6 percent.

Erbaykal and Okuyan (2008) examined inflation and economic growth relationship in Turkey. To study the long-run relationship between the variables, they applied the Bonds test methodology developed by Pesaran et al. (2001). They did not find a statistically significant long-run relationship, but they did find a statistically significant short-run relationship between inflation and economic growth.
4. Empirical Models

In this section, the econometric methods used in the analysis are presented. We begin by presenting the co-integration and error correction model. We then follow Khan and Senhadji (2001), Ahmed and Mortaza (2005) and proceed with presenting the model used to determine the threshold level of inflation.

In order to analyze the long-run relationship between inflation and economic growth, the Engle-Granger (1987) two stage co-integration procedure is applied to test the presence of co-integration between two variables. Thus, we first check for stationarity for concerned variables.

When determining if a series is stationary, we test the series for unit root in levels as well as in first differences. We apply the Augmented Dickey Fuller (ADF) test (Dickey and Fuller (1981)) and Phillips-Perron (PP) test (Phillips and Perron (1988)) on the following equations:

\[ \Delta X_t = \beta_1 + \pi_1 X_{t-1} + \sum_{i=1}^{n} \rho_i \Delta X_{t-i} + e_{1t} \]  

(ADF)  

\[ \Delta X_t = \alpha + \pi_2 X_{t-1} + \phi(t - \frac{T}{2}) + \sum_{i=1}^{m} \varphi_i \Delta X_{t-i} + e_{2t} \]  

(PP)  

where \( e_{1t} \) and \( e_{2t} \) are covariance stationary random error terms of zero mean. In both equations (11) and (12), \( \Delta \) is the first difference operator and \( X_t \) is a variable under consideration (we consider two variables to be discussed later). The lag length \( n \) (for ADF test) is determined by Akaike’s Information Criteria (AIC) (Akaike (1973)), and \( m \) (for PP test) is obtained based on Newey-West’s (Newey and West (1987)) suggestions. We test the null hypothesis of non-stationary using a standard t-test on critical values calculated by MacKinnon (1991). If \( \pi_1 \) and \( \pi_2 \) are less than zero and statistically significant, we reject the null hypothesis that \( X_t \) is a non-stationary time series.
These tests are implemented for both variables by replacing $X_t$ with $LGDP_t$ and $LCPI_t$ in equations (11) (for the ADF test) and (12) (for the PP test).

In addition, when both time series are found to be integrated of the same order, the estimation of the following co-integration regression is applied:

$$LGDP_t = \alpha_0 + \alpha_1 LCPI_t + u_t$$

(13a)

$$LCPI_t = \alpha_0 + \alpha_1 LGDP_t + \mu_t$$

(13b)

where, $LGDP_t$ denotes the log of real gross domestic product and $LCPI$ denotes the log of the consumer price index, $u_t$ and $\mu_t$ are random error terms with zero means.

The ADF and PP unit root tests are applied on $u_t$ and $\mu_t$ by re-specifying equations (11) and (12) in terms of $u_t$ and $\mu_t$ instead of $X_t$. The errors, $u_t$ and $\mu_t$ measure the extent to which $LGDP_t$ and $LCPI_t$ are out of equilibrium. When $u_t$ and $\mu_t$ are found to be integrated of order zero, $I(0)$, it can be concluded that these two series (i.e. $LGDP_t$ and $LCPI_t$) are co-integrated and not expected to remain apart in the long run. That is, if the hypothesis of no co-integration is rejected, then a stable long-run relationship exists between economic growth and inflation.

The Johansen test for co-integration is applied (Johansen (1988); Johansen and Juselius (1990)). Actually, there are two types of Johansen test: the maximum eigenvalue test and the trace test. Each of these tests gives likelihood ratio (LR) statistics for the number of co-integrating vectors (or equations). If the null hypothesis (i.e. $r=0$, there is no co-integration) is rejected, then it can be concluded that the concerned variables are co-integrated. The set of bi-variables based on equations (13a) and (13b) is estimated under the Johansen test.

After establishing the order of integration, we proceed with estimating an Error Correction Model (ECM) on the first difference of GDP and CPI:
where $\Delta$ denotes the first difference operator, $u_{t-1}$ and $\mu_{t-1}$ are the error correction terms from (13a) and (13b) respectively. The number of lag lengths is determined by AIC. Consequently, $e_{3t}$ and $e_{4t}$ are random disturbance terms, subject to the usual assumptions.

The ECM was first applied by Sargan (1984) and later popularized by Engle and Granger (1987). The fundamental theorem is known as the Granger Representation Theorem and says that if two variables are co-integrated, then the link between the two can be expressed as in terms of an ECM. The objective in using this model is to find the short-run adjustments of the co-integrated variables. In order for the series to be related to the structural ECM, $i$ begins at one and $j$ begins at zero (Engle and Yoo (1991)). The parameters $t_1$ and $t_2$ show the deviation of the dependent variable from the long-run equilibrium. In order for the series to converge to the long-run equilibrium, $0 \leq t_1$, $t_2 \leq 1$ should hold. However, co-integration implies that not all $t_1$, $t_2$ should be zero (Mallik and Chowdhury (2001)).

We proceed with determining the threshold level of inflation following the procedure in Khan and Senhadji (2001), the equation takes the following conditional form:

$$\Delta LGDP_t = \beta_0 + \beta_1 (\Delta LCPI_t) + \beta_2 \ast D_t (\Delta LCPI_t - k) + \beta_3 (\Delta LGCF_t) + \beta_4 (\Delta LTRD_t) + \beta_5 (\Delta LPOP_t) + E_t (15)$$

where, $\Delta$ denotes first difference operator, $LGDP_t$ is the log of real gross domestic product, $LCPI_t$ is the log of consumer price index, $k$ is the threshold level of inflation, $LGCF_t$ is the log of gross capital formation, $LTRD_t$ is the log of total trade, $LPOP_t$ is the log of population, $E_t$ is the error term. In addition, $LGCF_t$, $LTRD_t$ and $LPOP_t$ are control variables and $D$ is a dummy variable constructed from:
\[ D_t = 1 \text{ if } \Delta LCPI_t > k; \quad D_t = 0 \text{ if } \Delta LCPI_t \leq k. \]

The parameter \( k \), which is a threshold level of inflation, has a property that the relationship between inflation and economic growth is given by \( \beta_1 \) when there is a low rate of inflation; and \( \beta_1 + \beta_2 \) when there is a high rate of inflation. By estimating the regressions for different values of \( k \), which is chosen in ascending order (i.e. 2, \ldots, 6), the optimal value of \( k \) is obtained by finding the value that maximizes the \( R^2 \) from the respective regression. In other words, the optimal threshold level (\( k^* \)) is that which minimizes the residuals sum of squares (RSS) (Ahmed and Mortaza (2005)). This implicitly assumes that the growth rate is concave in inflation, as illustrated in Figure 1 (where \( k^* \) is the threshold inflation).

![Figure 1. Threshold Inflation (Overall GDP growth)](image)
5. Data and Empirical Evidence

We use annual data on Consumer Price Index (2000=100), Real Gross Domestic Product (2000 year prices), Gross Capital Formation, Total Trade and Population over the period of 1980 to 2010. Data for Real GDP, CPI and Population are obtained from the International Monetary Fund (IMF) database; Data for Gross Capital Formation are obtained from The World Bank database; Data for Total Trade are obtained from United Nations Conference on Trade and Development (UNCTAD) database.

Inflation rates are calculated by multiplying the difference of logs of CPI by 100 (i.e. $\Delta LCPI*100$) and Economic growth rates are calculated by multiplying the difference of logs of GDP by 100 (i.e. $\Delta LGDP*100$). The summary statistics of inflation and economic growth is reported in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>30</td>
<td>3.2779</td>
<td>2.7624</td>
<td>11.333</td>
<td>0.1404</td>
</tr>
<tr>
<td>Growth</td>
<td>30</td>
<td>2.1718</td>
<td>3.0563</td>
<td>6.015</td>
<td>-6.4471</td>
</tr>
</tbody>
</table>

Further, in Figure 2, we present the time trend of inflation and economic growth. As can be seen, inflation and economic growth tend to share a common trend. Thus we turn to the test for stationarity.
The unit root tests are performed in the levels (i.e. log of CPI and log of GDP) and in the first differences (i.e. 1st difference of the log of CPI and 1st difference of the log of GDP). The results from the unit root tests are reported in Table 2 (in addition, time series plots of LCPI, LGDP, ΔLCPI and ΔLGDP are presented in the appendices).

**Table 2. Augmented Dickey-Fuller and Phillip-Perron Unit Root Tests**

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF (Intercept)</th>
<th>ADF (Intercept and trend)</th>
<th>PP (Intercept)</th>
<th>PP (Intercept and trend)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCPI</td>
<td>-2.206780 (1)</td>
<td>-2.327447 (1)</td>
<td>-8.049239*** (3)</td>
<td>-5.670369*** (3)</td>
</tr>
<tr>
<td>LGDP</td>
<td>-1.368884 (1)</td>
<td>-2.139432 (2)</td>
<td>-0.850477 (3)</td>
<td>-1.951888 (3)</td>
</tr>
<tr>
<td>ΔLCPI</td>
<td>-2.634663* (1)</td>
<td>-2.603076 (1)</td>
<td>-3.550722** (3)</td>
<td>-3.246819* (6)</td>
</tr>
<tr>
<td>ΔLGDP</td>
<td>-3.687679*** (1)</td>
<td>-3.606911** (1)</td>
<td>-2.629696* (1)</td>
<td>-2.479365 (3)</td>
</tr>
</tbody>
</table>

Notes:
1) LCPI denotes log of CPI and LGDP denotes log of GDP; Δ denotes first difference.
2) ADF and PP tests are based on null hypothesis of unit root.
3) Mackinnon (1991) critical values for rejection of null hypothesis are applied. ***, ** and * denote significance at 1%, 5% and 10% level respectively.
4) Figures within parentheses indicate the lag length.
5) All tests performed using Eviews 3.1 software.
From the reported results in Table 2, it can be seen that most of the tests in levels for the concerned variables failed to reject the null hypothesis. However, two PP tests for LCPI, PP(Intercept) and PP(Intercept and trend) tests rejected the null hypothesis. These results are non-reliable since the Durbin-Watson statistics are small (0.831936 and 1.017817), indicating that the LCPI series may suffer from autocorrelation. In general, from the obtained results it can be concluded that all the variables are non-stationary in levels. Furthermore, the test results in differences showed that only ADF (Intercept and trend) test for LCPI and PP(Intercept and trend) test for LGDP failed to reject the null hypothesis of unit root. Since all the other three tests rejected the null hypothesis of unit root for both variables, it can be concluded that the concerned variables are stationary and that they are integrated of order one, I(1).

The next step is to examine the co-integration relationship between economic growth and inflation.

**Table 3. Coefficient of the independent variables and the unit root tests for the residual from equations (13a) and (13b)**

<table>
<thead>
<tr>
<th>Coefficient of LCPI</th>
<th>Unit Root Tests for the Residual, $u_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Augmented Dickey-Fuller</td>
</tr>
<tr>
<td>0.753633</td>
<td>-2.238680** (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coefficient of LGDP</th>
<th>Unit Root Tests for the Residual, $u_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Augmented Dickey-Fuller</td>
</tr>
<tr>
<td>1.061412</td>
<td>-2.188728**(1)</td>
</tr>
</tbody>
</table>

Notes:
1) LCPI and LGDP denote log of CPI and log of GDP.
2) ADF and PP tests are based on null hypothesis of unit root.
3) Mackinnon (1991) critical values for rejection of null hypothesis are applied. ** and * denote significance at 5% and 10% level respectively.
4) Figures within parentheses indicate the lag length.
5) All tests performed using Eviews 3.1 software.
In Table 3, coefficients of the concerned variables and the results of the Augmented Dickey-Fuller and Phillip-Perron tests for residuals are presented. From the results, it can be seen that the residuals are integrated order of zero, $I(0)$. Hence, it can be concluded that the two variables are co-integrated and therefore a valid and positive long-run relationship exist between economic growth and inflation. Consequently, Johansen test for co-integration is applied. The results are presented in appendix (in Table 4). This test also confirms the rejection of the null hypothesis of no co-integration between the concerned variables. In both tests, the likelihood ratio (LR) statistic indicates a co-integrating equation at the 5% significance level. This again implies a long-run relationship between inflation and economic growth in Finland.

According to the Granger representation theorem, when variables are co-integrated, there must also be an error correction model (ECM) that describes the short-run dynamics of the co-integrated variables towards their equilibrium values. The ECMs are estimated using equations (14a) and (14b). The results are presented in Table 5.

From Table 5 we can read that there is a long-run equilibrium relationship between inflation and economic growth (the series cannot move independently of each other or cannot move too far away from each other). Acknowledging that the concerned variables are co-integrated, the results suggest that, in the short-run, there is some adjustment process, which prevents the errors from becoming larger and larger in the long-run. The estimated coefficients of the error correction terms are significant at 5% and 1% levels. Therefore, we may conclude that about 9% of the disequilibrium is corrected each year by changes in CPI and about 24% of the disequilibrium is corrected each year by changes in GDP.
### Table 5. The Error Correction Model

<table>
<thead>
<tr>
<th>Error Correction</th>
<th>( \Delta LCPI )</th>
<th>( \Delta LGDP )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>0.020474 (0.00872)</td>
<td>0.69288 (0.01647)</td>
</tr>
<tr>
<td><strong>CointEq1</strong></td>
<td>-0.096845***(0.03781)</td>
<td>-0.241623***(0.07144)</td>
</tr>
<tr>
<td>( \Delta LCPI(-1) )</td>
<td>0.406937* (0.19751)</td>
<td>-1.155316*** (0.37315)</td>
</tr>
<tr>
<td>( \Delta LCPI(-2) )</td>
<td>-0.166616 (0.22141)</td>
<td>-0.419917 (0.41830)</td>
</tr>
<tr>
<td>( \Delta LGDP(-1) )</td>
<td>-0.035432 (0.10093)</td>
<td>0.580264*** (0.19068)</td>
</tr>
<tr>
<td>( \Delta LGDP(-2) )</td>
<td>0.058121 (0.08533)</td>
<td>-0.435362** (0.16122)</td>
</tr>
</tbody>
</table>

**R-squared** | 0.835073 | 0.741727 |
**Adj. R-squared** | 0.797590 | 0.683028 |
**Sum sq. resid** | 0.001949 | 0.006958 |
**S.E. equation** | 0.009413 | 0.017784 |
**F-statistics** | 22.27849 | 12.63623 |
**Log likelihood** | 94.28375 | 76.47020 |
**Akaike AIC** | -6.305982 | -5.033585 |
**Schwarz SC** | -6.020510 | -4.748113 |
**Mean dependent** | 0.027897 | 0.021755 |
**S.D. dependent** | 0.020923 | 0.031588 |

**Notes:**
1) Standard errors within parentheses.
2) ***, ** and * indicate the significance at 1%, 5% and 10% levels respectively comparing critical \( t \) statistics from the standard \( t \)-table.

Further, equation (15) is applied in order to find the threshold level of inflation by ordinary least squares (OLS). The results are presented in Table 6. From the results, it can be seen that the value that maximizes \( R^2 \) is obtained when \( k = 4\% \). Further, we can see that the coefficients of \( D(\Delta LCPI-k) \) are significantly decreasing, when \( k > 4\% \) (suggesting that the inflation rate above this level will affect growth rate negatively); and when \( k \leq 4 \), there is no large difference between the coefficients of \( D(\Delta LCPI-k) \) (suggesting a stable growth rate).
### Table 6. Estimation of the Threshold Model (Dependent variable: $\Delta LGDP$)

<table>
<thead>
<tr>
<th>$k$</th>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-statistics</th>
<th>Probability</th>
<th>R-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>$\Delta L CPI$</td>
<td>-0.770832</td>
<td>1.006821</td>
<td>-0.765610</td>
<td>0.4514</td>
<td>0.535770</td>
</tr>
<tr>
<td></td>
<td>$D(\Delta L CPI-k)$</td>
<td>1.041303</td>
<td>1.153326</td>
<td>0.902870</td>
<td>0.3756</td>
<td>0.513997</td>
</tr>
<tr>
<td></td>
<td>$\Delta LGCF$</td>
<td>0.103623</td>
<td>0.042541</td>
<td>2.435863</td>
<td>0.0227</td>
<td>0.502565</td>
</tr>
<tr>
<td></td>
<td>$\Delta LTRD$</td>
<td>0.114385</td>
<td>0.034313</td>
<td>3.333595</td>
<td>0.0028</td>
<td>0.502565</td>
</tr>
<tr>
<td></td>
<td>$\Delta LPOP$</td>
<td>-3.911841</td>
<td>3.446321</td>
<td>-1.135077</td>
<td>0.2676</td>
<td>0.502565</td>
</tr>
<tr>
<td>3%</td>
<td>$\Delta L CPI$</td>
<td>-0.531037</td>
<td>0.547750</td>
<td>-0.969489</td>
<td>0.3420</td>
<td>0.550062</td>
</tr>
<tr>
<td></td>
<td>$D(\Delta L CPI-k)$</td>
<td>0.911630</td>
<td>0.719938</td>
<td>1.266262</td>
<td>0.2176</td>
<td>0.550062</td>
</tr>
<tr>
<td></td>
<td>$\Delta LGCF$</td>
<td>0.101943</td>
<td>0.041638</td>
<td>2.448325</td>
<td>0.0220</td>
<td>0.550062</td>
</tr>
<tr>
<td></td>
<td>$\Delta LTRD$</td>
<td>0.117879</td>
<td>0.033973</td>
<td>3.469788</td>
<td>0.2823</td>
<td>0.550062</td>
</tr>
<tr>
<td></td>
<td>$\Delta LPOP$</td>
<td>-3.696470</td>
<td>3.360595</td>
<td>-1.099945</td>
<td>0.2823</td>
<td>0.550062</td>
</tr>
<tr>
<td>4%*</td>
<td>$\Delta L CPI$</td>
<td>0.030982</td>
<td>0.014195</td>
<td>2.316286</td>
<td>0.0294</td>
<td>0.564025*</td>
</tr>
<tr>
<td></td>
<td>$D(\Delta L CPI-k)$</td>
<td>-0.403290</td>
<td>0.547750</td>
<td>-0.969489</td>
<td>0.3420</td>
<td>0.564025*</td>
</tr>
<tr>
<td></td>
<td>$\Delta LGCF$</td>
<td>0.909488</td>
<td>0.547750</td>
<td>1.556727</td>
<td>0.1326</td>
<td>0.564025*</td>
</tr>
<tr>
<td></td>
<td>$\Delta LTRD$</td>
<td>0.106022</td>
<td>0.033973</td>
<td>3.469788</td>
<td>0.2823</td>
<td>0.564025*</td>
</tr>
<tr>
<td></td>
<td>$\Delta LPOP$</td>
<td>-3.437374</td>
<td>3.360595</td>
<td>-1.099945</td>
<td>0.2823</td>
<td>0.564025*</td>
</tr>
<tr>
<td>5%</td>
<td>$\Delta L CPI$</td>
<td>0.026020</td>
<td>0.012444</td>
<td>2.489773</td>
<td>0.0201</td>
<td>0.538083</td>
</tr>
<tr>
<td></td>
<td>$D(\Delta L CPI-k)$</td>
<td>-0.131600</td>
<td>0.033333</td>
<td>-1.052964</td>
<td>0.3028</td>
<td>0.538083</td>
</tr>
<tr>
<td></td>
<td>$\Delta LGCF$</td>
<td>0.565062</td>
<td>0.582990</td>
<td>0.969249</td>
<td>0.3421</td>
<td>0.538083</td>
</tr>
<tr>
<td></td>
<td>$\Delta LTRD$</td>
<td>0.110953</td>
<td>0.041429</td>
<td>2.678137</td>
<td>0.0131</td>
<td>0.538083</td>
</tr>
<tr>
<td></td>
<td>$\Delta LPOP$</td>
<td>-3.297386</td>
<td>3.402709</td>
<td>-0.969047</td>
<td>0.3422</td>
<td>0.538083</td>
</tr>
<tr>
<td>6%</td>
<td>$\Delta L CPI$</td>
<td>0.022559</td>
<td>0.011906</td>
<td>1.894702</td>
<td>0.0702</td>
<td>0.521512</td>
</tr>
<tr>
<td></td>
<td>$D(\Delta L CPI-k)$</td>
<td>0.063042</td>
<td>0.287158</td>
<td>0.219537</td>
<td>0.8281</td>
<td>0.521512</td>
</tr>
<tr>
<td></td>
<td>$\Delta LGCF$</td>
<td>0.176054</td>
<td>0.639726</td>
<td>0.275202</td>
<td>0.7855</td>
<td>0.521512</td>
</tr>
<tr>
<td></td>
<td>$\Delta LTRD$</td>
<td>0.111933</td>
<td>0.042152</td>
<td>2.655448</td>
<td>0.0138</td>
<td>0.521512</td>
</tr>
<tr>
<td></td>
<td>$\Delta LPOP$</td>
<td>-3.360972</td>
<td>3.473812</td>
<td>-0.967517</td>
<td>0.3429</td>
<td>0.521512</td>
</tr>
</tbody>
</table>

We know that if there is no inflation an economy may slip into deflation, i.e. a decrease in prices. Since decrease in prices leads to less production and wage cuts, an inflation rate at the threshold level will provide safer barrier against those negative consequences. Also, it may provide more confidence and optimism to investors, leading to an increase in the long-run aggregate supply and thus possibly higher rates of economic growth. Thus, it can be concluded that if annual growth in prices does not exceed 4 percent, inflation will help to keep stable economic growth rate. In contrast, if annual growth in prices exceeds 4 percent, inflation tends to become harmful, significantly reducing the growth of the Finnish economy.
6. Summary and Conclusion

In this paper, the causal relationship between inflation and economic growth was investigated by studying their co-integrated relationship and by estimating an error correction model. The main motivation of the study was to find out whether a relationship exists between them and if so, to analyze the nature of that relationship. The obtained results suggest the existence of the long-run positive relationship between inflation and economic growth. However, this relationship need not be linear and thus we asked the following question: at what level does inflation start to reduce the growth rate of the Finnish economy? In order to find an answer for this question, we use ordinary least squares (OLS) in order to find the threshold level of inflation in Finland over the period 1980-2010. We found that when inflation exceeds 4 percent, inflation will start to significantly reduce the economic growth rate in Finland. Viewing the ECB, inflation target in the light of this insight, the results in this study may have useful implications in adjusting the optimal level of inflation in Euro Countries. Further, since the price rate is set at the ECB level, further research is needed in order to determine an optimal inflation target at the European level.
References


Appendices

Table 4. Johansen Test for Co-integration

<table>
<thead>
<tr>
<th>Maximum Eigenvalue Test</th>
<th>Hypothesized N. of CE(s)</th>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None**</td>
<td>0.443505</td>
<td>16.41070</td>
<td>14.26460</td>
</tr>
<tr>
<td></td>
<td>At most 1</td>
<td>0.041023</td>
<td>1.172879</td>
<td>3.841466</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trace Test</th>
<th>Hypothesized N. of CE(s)</th>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None**</td>
<td>0.443505</td>
<td>17.58358</td>
<td>15.49471</td>
</tr>
<tr>
<td></td>
<td>At most 1</td>
<td>0.041023</td>
<td>1.172879</td>
<td>3.841466</td>
</tr>
</tbody>
</table>

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

Figure 3. Time series plot of LCPI
Figure 4. Time series plot of $LGDP$

Figure 5. Time series plot of $\Delta LCPI$
Figure 6. Time series plot of $\Delta L G D P$