Empirical evaluation of the inflation targeting system in Hungary

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Abstract.

The paper seeks to answer the question whether the inflation targeting introduced in June 2001 has contributed to the inflation and core inflation path in Hungary. The analysis is conducted on monthly data from 1995 to 2020 using OLS and VAR models. Models were also estimated for the full period and around the time of the IT adjustment. The main result is that we find evidence that inflation targeting had a positive effect on both core inflation and inflation at the time of IT adoption. When looking at the full period, inflation targeting is significant for the core inflation path and Hungarian monetary policy can also have an impact mainly on core inflation. No relationship was found between the volatility of underlying inflation indicators and IT. In our view, overall, inflation targeting has helped and is still helping to achieve inflation targets. We should not forget that as a small, open economy, our country is in many cases vulnerable to the economic cycles of the EU first and the world second.

Keywords: central bank, core inflation, monetary policy

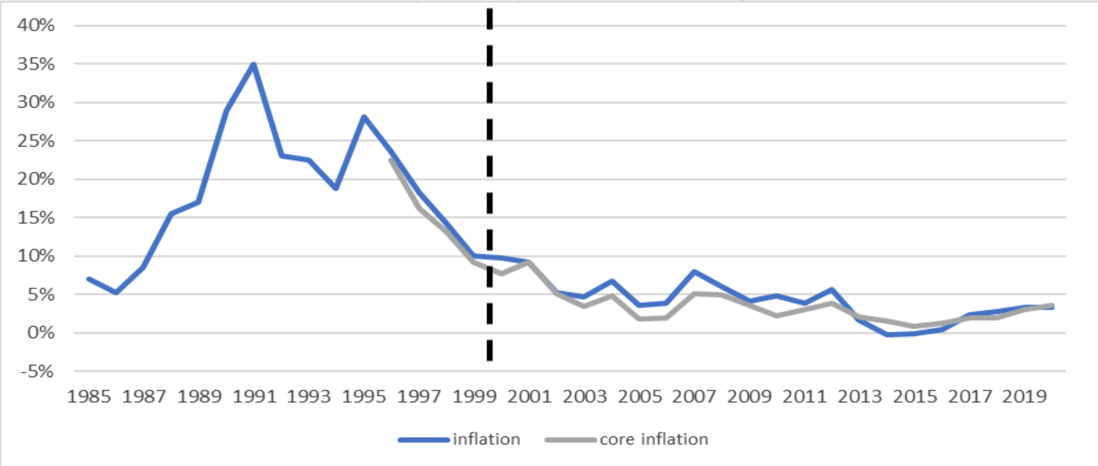
1. Introduction

Since the 2008 global economic crisis, we have lived in a state of grace for more than a decade. For more than a decade, monetary policy has been dominated by a rare long-run duality of nominally rising monetary aggregates and consequent real economic growth on the one hand, and low interest rates and low price level increases on the other. Even nearly five years ago, the Hungarian National Bank's (MNB) policy makers still considered a sustained low interest rate path to be the long-term reality: "We need to prepare for a sustained low interest rate environment." (Virág, 2016:2). In fact, even two years ago, low inflation was still the main concern for central bankers: 'In two-thirds of inflation-targeting countries, consumer price inflation is currently below target. These countries account for more than 60% of world GDP. All this is happening at a time when the world's major central banks have been keeping interest rates close to zero or even negative for a decade, while trying to stimulate their economies with more and more asset purchase programmes in the most grandiose attempt in economic history." (Matolcsy et al., 2019)

The constellation of low inflation and associated low interest rates and relatively low economic growth persisted until around the end of 2020. "The triad of around zero interest rates, chronically low inflation and moderate economic growth in advanced economies for a prolonged period of time became the main challenge for economists and economic policy makers." (Matolcsy et al., 2019) In 2021, this macroeconomic situation changed dramatically. The current annual inflation rate of more than 5% will be fuelled by serious factors on both the demand side (fiscal largesse) and the supply side.

The Hungarian National Bank is responsible for monetary policy in Hungary. The primary objective of the MNB is to achieve and maintain price stability. In order to achieve this primary objective, the MNB has been using inflation targeting (IT) since June 2001, which is a common monetary policy instrument internationally. Effective IT requires a clear commitment by the central bank to maintain price stability as its primary objective. A key element is a clear, quantifiable inflation target, which typically means low inflation of around 2-3%. Since March 2015, the MNB's inflation target has been 3% with a tolerance band of ±1 percentage point. The success of IT is significantly influenced by the transparency and accountability of the Central Bank. After the 2008 crisis, a debate on the reform of the inflation target in Hungary was launched, the main features of which were summarised by Ábel et al (2014).

Figure 1: Inflation and core inflation before and after IT adaptation (vertical dashed line)



Source: own editing based on KSH (2021)

In Figure 1, a vertical dashed line indicates the introduction of IT (2001M6) in the practice of the Hungarian National Bank. After its introduction, inflation and closely related core inflation (ρ=0.98) declined in the Hungarian economy, but the inflation target (see Table 1) was not achieved in all years, with CPI changes deviating by more than 2% points in several cases. After 2017 - more than 15 years after adoption - inflation was kept within the range set by the IT. In the last few years, the international macroeconomic environment has been favourable, which has also helped price stability in Hungary. The inflation targeting system in Hungary has not been based on the setting of a medium-term, transparent and attractive inflation target, but on the annual change of the inflation target band, with even an increase in the target band in December 2005 (see Table 1).

Table 1: Implementation steps for inflation targeting in Hungary

Date	Quantified medium-term inflation target
2001 december	7± 1%
2002 december	4,5 ± 1%
2003 december	3,5±1%
2004 december	3,5±1%
2005 december	4±1%
2006 december	3,5±1%
From 2007 to the present	3±1%

Source: MNB.hu

The medium-term target from 2007 was not set for one year, but was scheduled to be reviewed when the single European exchange rate mechanism (ERM II) was entered, but in 3 years at the latest. The decision of the Monetary Council of 22 August 2005 also provided for the continuation of the ± 1% band. (MNB, 2005).

The hypothesis of the study is that the introduction of inflation targeting in Hungary will have a moderating effect on core inflation and inflation developments. Following the introduction of inflation targeting, inflation indicators and their volatility are expected to be lower. In order to prove the hypothesis, the standard deviation of the inflation indicators is also included in the analysis. The advantage of core inflation over inflation is that it filters out one-off, transitory and non-market price changes. Of course, we are aware that inflationary processes are influenced by many factors - some of which are included in our empirical analysis - so we could not aim at a complete explanation of inflation developments in Hungary. The ceteris paribus principle, as in many areas of economic analysis, cannot be fully applied here.

In addition to the spike in inflation worldwide, the fact that the Fed will be the first in the world to switch to average inflation targeting (AIT) in 2020 also makes the examination of the inflation targeting regime topical. It did so with the aim of being able to more credibly pledge higher future inflation and thus have more room to manoeuvre to stimulate the economy by raising inflation expectations. This room for manoeuvre has become very limited in the developed countries' central banks since the financial crisis because of the zero lower bound (ZLB), i.e. the loss of effectiveness of interest rate policy in the negative range due to the liquidity trap.

In this sense, the average inflation is an asymmetric regime, because although the inflation target itself is symmetric, the compensation due to the averaging mechanism is essentially relevant for the ZLB, where monetary policy becomes one-sided. This is made clear and illustrative by the Fed's communication that if inflation is below target for a prolonged period, the Fed will target inflation above target. By comparison, a classical inflation-targeting central bank will always target its inflation target, regardless of whether it has under- or over-performed that target in the past.

2. Literature review

An open economy central bank attempts to smooth inflation (π) and output (y) in an objective function (Svensson, 2006).

$$L = \omega_1 (\pi - \pi^*)^2 + \omega_2 (y - y^*)^2 \tag{1}$$

For small, open economies, several studies (e.g. Jonas-Mishkin, 2003; Cuchie-Curti et al., 2008) suggest that the central bank target function should include the exchange rate (s) as a target variable, reflecting the need for the central bank to take into account not only the internal causes of inflation but also the external components. Thus, the central bank loss function (L) can be written in the following form:

$$L = \omega_1 (\pi - \pi^*)^2 + \omega_2 (s - s^*)^2 + \omega_3 (y - y^*)^2 \tag{2}$$

The study focuses on the inflation component of the three factors above. The economic literature is not consistent in its assessment of the impact of the introduction of inflation targeting on the inflation rate. A study by Antonakakis et al. (2021) found that inflation volatility was lower in countries adopting IT after than before the introduction of IT. The study examined more than 20 countries around the world with the earliest available inflation data up to 2016. They highlight that IT adoption must have a positive short-term effect, but that the long-term effect may not be the same in terms of volatility.

There is a dichotomy in the scientific literature on IT. On the one hand, we conclude from empirical models that IT helps to bring down inflation rates, but on the other hand we see that crises can occur in parallel with its use. Owoundi et al. (2021) investigate the relationship between IT and the quality of institutions (democracy, corruption, regulation, etc..), and their main result is that IT is less effective when it is associated with weak institutional backing, and that the financial stability of these countries is lower than that of countries with strong institutional backing. The use of inflation targeting alone does not solve financial stability.

Transparent and accountable central banks following IT are essential for successful implementation. The study by Kim and Yim (2020) shows that central banks following inflation targeting adjust the inflation target to inflation. The adjustment of the inflation target is more typical for less efficient central banks. Such behaviour can lead to imbalances, which impairs the efficiency of monetary policy and IT.

The effectiveness of IT is criticized in the work of Angeriz and Arestis (2006), who conclude that inflation targeting has an effect at the time of implementation, but that this effect quickly disappears and that typically a downward trend in inflation, not the implementation of IT, explains the decline in inflation. Wu's (2004) study of OECD countries, on the other hand, argues the opposite that the decline in inflation is not solely due to mean reverting, but that the introduction of IT has had an effect. Gonçalves and Salles (2008) investigated the impact of IT in developing countries, finding in their empirical study that inflation and its volatility also declined in countries that adopted IT compared to countries that did not.

A detailed description of the inflation targeting system in Hungary is unnecessary, as there are several publications on this topic in the literature. Among these, Csermely's (2006) work provides a professional summary of the lessons learned in the period after the introduction of inflation in Hungary in 2001. Csermely-Tóth's (2013) paper discusses the experiences of the seven years following the previous study. Sticking to the seven-year periods of analysis, Sebestyén (2020) in his review paper examined the monetary performance of inflation-targeting countries in the period August 2017-2020. His analysis shows that in the vast majority of countries, central banks failed to meet their mandates and the inflation targeting regime failed to deliver. The exceptions are Austria and Hungary, where the inflation targeting regime can be considered successful over this period.

Novák (2014) points out that although inflation targeting has contributed to a lower inflation environment, he considers the role of exchange rate stability to be more important. According to Huszti et al. (2006), "The monetary authority achieves the ultimate objective - in most cases, the reduction of inflation - through a so-called intermediate target. For six years from 1995 onwards, the exchange rate was this intermediate target, whose sliding depreciation and narrow banding acted as a nominal anchor for inflation." However, the study by Matolcsy et al. (2019) considers this effect to be diminishing: "In addition, we have seen significant changes in other important explanations, especially in small, open economies. The exchange rate-inflation link has also weakened, with the degree of exchange rate pass-through declining in both advanced and developing countries." The elements of the inflation causality mechanisms analysed by Matolcsys, moreover, have been transformed not only in the short run but also in the longer run (Oroszi, 2005; Marton, 2015).

The mechanism of inflation is to a large extent determined by the anticipated (correctly predicted) nature of inflation. This is generally highly correlated with inertial inflation, except when surprise inflation or deflation occurs. As Del Negro et al. (2014) point out, the magnitude and volatility of the inflation rate is largely influenced by inflation expectations, specifically long-run inflation expectations. In this respect, it is particularly important if the European Central Bank aims to stabilise the inflation rate at 2% in the long run.

The system of inflation targeting also has a special place in the analysis of the inflation impact mechanism. Mishkin and Schmidt-Hebbel (2001) and Thornton (2012) analyse the emergence of inflation targeting and thus its anticipation, which is an important feature of the study of inflation effects. In principle, the literature accepts the thesis that sufficiently predictable (anticipated) inflation is associated with significantly smaller redistributive effects. Although the predictability of certain inflation factors is debatable (Tatay and Kotosz, 2013), the literature generally accepts the proposition that sufficiently predictable (anticipated) inflation is associated with significantly smaller redistributive effects.

As Harmat (2001) points out, the magnitude of these costs is different for small and hyperinflation. "How significant are these 'menu costs'? As is generally accepted for "shoe-string costs", such costs, while relatively low under moderate inflation, become very significant under galloping or hyperinflation. Such costs are very difficult to quantify. The size and nature of both 'shoe-string costs' and 'menu costs' in moderate inflation situations explains why many Western countries attach so much importance to reducing inflation. One reason for the priority given to controlling and reducing inflation is the fear that the steady rise in inflation rates in the early 1970s could lead to hyperinflation. But the main reason is that costs rise when inflation is not perfectly anticipated." (Harmat, 2001 p. 2).

Between 2005 and 2011, the exchange rate had a really important impact on the inflation rate and the core inflation rate. In a small, open economy, the role of the exchange rate can be decisive, often crucial. The continuous reduction in the depreciation rate of the forint in a crowling peg system causes a continuous reduction in the inflation and core inflation rate.

In their study, Schmidt-Hebbel and Carrasco (2016) find that high inflation and a non-market-based exchange rate regime reduce the likelihood of inflation targeting, while high

GDP per capita, trade openness and financial development increase the likelihood of entry. Hu (2006) reaches a similar conclusion, with stable fiscal policy (budget deficit) and higher financial embeddedness (debt-to-GDP ratio) increasing the probability of IT adoption, and central bank independence and a floating exchange rate regime positively affecting adoption.

Table 2: The analysed studies on the impact of the inflation targeting system on the inflation rate

Paper	Period	Sample size	Impact on the inflation rate	Impact on inflation volatility
Antonakakis et al. (2021)	1976-2016	24 countries	have not examined	positive
Angeriz és Arestis (2006)	1980-2004	54 countries	positive (short term)	have not examined
Hu (2003)	1980-2000	66 countries	positive	neutral
Novák (2014)	1995-2012	15 countries	positive	positive
Wu (2004)	1985-2002	22 countries	positive	have not examined
Gonçalves és Salles (2008)	1980-2005	36 countries	positive	positive
De Mendonca (2007)	3 years after and before IT adoption	14 countries	positive	have not examined
Broto (2011)	after and before IT adoption	5 countries	positive	positive
De Mendonça és Souza (2012)	1990-2007	180 countries	positive (developing countries)	positive (developing countries)
Lin és Ye (2007)	1985-1999	22 countries	neutral	neutral
Kamal (2010)	1970-2007	3 countries	positive	have not examined

Source: own editing

3. Material, method and model specification

In the analysis, three methods were used to measure the impact of inflation targeting: the Kruskall-Wallis test to compare the pre- and post-IT periods, the ordinary least squares (OLS) method and the Vector Autoregressive (VAR) model to estimate the impact of IT.

The Vector Autoregressive (VAR) model is a distributed lag model, the dependent variable depends not only on the explanatory variables of the current period but also on their past values (Ramanathan, 2003). The choice of methodology was motivated primarily by the lagged nature of the effects on inflation. On the other hand, we would like to examine the impact of IT using at least two estimation procedures to obtain reliable results. We describe the VAR model based on Hamilton's definitive econometric textbook (Hamilton, 1994).

$$y_t = \alpha + \Phi_1 * y_{t-1} + \Phi_2 * y_{t-2} + \cdots + \Phi_p * y_{t-p} + \varepsilon_t \quad (3)$$

y_t: (n x 1) vector of model variables

α: (n x 1) vector containing constants

Φ: matrix of (n x n) autoregressive coefficients,where j=1,2,3,....,p

ε: (n x 1)-gaussian vector containing a discrete representation of a white noise process with Gaussian distribution, where $E(\varepsilon^t) = 0$ and $E(\varepsilon^t \varepsilon^{t'}) = \Omega$ if Ω = (n x n)-gaussian symmetric positive semidefinite matrix and $t = \tau$, and 0 otherwise.

For the variables, data filtered from monthly seasonality were available (see Table 3), so the number of elements in the time series is large, which allowed the VAR model to be applied. Analysis period 1996-2020. The analyses were performed using the statistical software STATA17.

A detailed description of the variables used in the study is presented in Table 3, and the main descriptive statistics are presented in Table 4. Our hypothesis is that inflation, core inflation and their volatility are lower after inflation targeting, and that these were affected by the introduction of inflation targeting.

Table 3: Variables used in the analysis

	Name	Symbol	Descroption	Measurement unit	Period	Source
Dependent variables	Core inflaton	cinf	monthly core inflation	%	1996M1-2020M12	MNB
	Volatility of core inflation	sd_cinf	12-month rolling standard deviation of core inflation	%	1997M1-2020M12	own calculation
	Inflation	inf	monthly inflation	%	1995M3-2020M12	MNB
	Volatility of inlation	sd_inf	12-month rolling standard deviation of inflation	%	1996M1-2020M12	own calculation
Independet variables	Inflation targeting	IT	=1 from the month the IT is applied	dummy variable	1996M1-2020M12	-
	Eurozone inflation	HICP	Monthly inflation in eurozone	%	1996M12-2020M12	Eurostat
	Central Bank presidents	CB_P	4 dummy variables, depending on who is the president of the central bank	dummy variables	1996M1-2020M12	-
	Central bank independence	CB_IND	= 1 if the government appointing the central bank governor is in government	dummy variable	1996M1-2020M12	-
	Economic growth	GDP	quarterly GDP growth	%	1996Q1-2020Q4	FRED

Source: own editing

In the case of inflation and core inflation, the value of the price index relative to the same period of the previous year was used in the analysis. As indicated above, the advantage of core inflation over inflation is that it filters out one-off, transitory and non-market price changes. This simplifies the modelling process. However, the focus of inflation targeting is on inflation, so we have run our models on both inflation indicators. To measure volatility, we have used a 12-month rolling standard deviation, at the 'cost' of losing the first 11 months of data, so the period of the models explaining core inflation volatility is that much shorter.

The inflation targeting (IT) binary variable takes on a value of 1 after the introduction of IT (2001M6). We expect that inflation targeting is also responsible for the decline in inflation and its anchoring at relatively low levels. We have a similar view on volatility, with inflation targeting playing a direct role in reducing volatility.

For euro area inflation (HICP), we expect a positive relationship for inflation indicators. Hungary conducts the bulk of its external trade with European countries, as a small and open country, inflation of our external trading partners is likely to be factored into our prices.

For the variable central bank governors (CP_P), there were a total of four governors of the Hungarina National Bank in the period under study (1996-2020): György Surányi, Zsigmond Járai, András Simor and György Matolcsy. The period as Governor is denoted by a 1. The dummy variables allow us to measure the relationship between whether inflation and its volatility have been reduced during the given central bank presidency.

The binary variable central bank independence (CB_IND) is assigned a value of one if the incumbent central bank governor is appointed by the president of the republic, who shares the same political views, on the recommendation of the prime minister. The question of central bank independence is itself a subject of heated debate today, and whether it is desirable, especially in recessions and crises. As with the changing nature of central bank governors, we can also assess the impact of independence on inflation and its dispersion.

The economic growth (GDP) variable is the only one available at quarterly level. In this form, a common econometric model cannot be used with monthly resolution data, and to overcome this problem, using quarterly GDP data, monthly GDP data have been estimated using third-degree polynomial interpolation. The purpose of interpolation is to provide an approximate estimate for unknown values of a function (Rappai, 2014). We expect a positive or neutral effect for the relationship between economic growth and core inflation. An expansion in GDP brings with it an expansion in demand and, in addition, the production capacity constraint is approached, to which producers may respond by raising prices. Novák (2014) found no statistically verifiable relationship between these two variables.

Table 4: Descriptive statistics for variables used in the analysis

	N. of item	Mean	Median	S.E.	Minimum	Maximum
cinf	300	5.384	3.576	5.165	0.471	26.163
sd_cinf	288	0.681	0.613	0.482	0.078	2.603
inf	310	6.980	4.750	6.870	-1.400	31.000
sd_inf	300	0.971	0.780	0.592	0.233	2.893
IT	310	0.758	1	0.429	0	1
HICP	289	1.604	1.740	0.915	-0.650	4.060
Surányi György (CBP)	310	0.232	0	0.423	0	1
Járai Zsigmond (CBP)	310	0.232	0	0.423	0	1
Simor András (CBP)	310	0.232	0	0.423	0	1
Matolcsy György (CBP)	310	0.303	0	0.460	0	1
CB_IND	310	0.639	1	0.481	0	1
GDP	111	8.137	7.953	6.802	-7.389	27.393

GDP*	310	8.682	8.047	6.783	-7.389	39.161

Source: own editing

4. Results

The difference between before and after the introduction of IT (Table 5) seems clear, with core inflation falling by more than 10 percentage points after the introduction of inflation targeting and inflation by around 13 percentage points. The volatility of lower core inflation has also fallen significantly. This is also evident in Figure 1.

Table 5: Trends in inflation indicators and their volatility before and after inflation targeting

Core inflation						
	Item no.	Mean	Median	S.E.	Minimum	Maximum
Before IT	65	13.496	12.116	5.340	7.404	26.163
After IT	235	3.140	3.216	1.719	0.471	9.692
Total	300	5.384	3.576	5.165	0.471	26.163
Core inflation 12 monthly standard deviation						
Before IT	54	1.133	0.931	0.584	0.365	2.603
After IT	235	0.578	0.512	0.388	0.078	1.764
Total	288	0.675	0.611	0.469	0.078	2.603

Inflation						
	Item no.	Mean	Median	S.E.	Minimum	Maximum
Before IT	75	16.764	15.960	7.122	8.900	31.000
After IT	235	3.857	3.800	2.409	-1.400	10.500
Total	310	6.980	4.750	6.870	-1.400	31.000
Inflation 12 monthly standard deviation						
Before IT	65	1.422	1.224	0.788	0.431	2.893
After IT	235	0.846	0.746	0.454	0.233	2.450
Total	300	0.971	0.780	0.592	0.233	2.893

Source: own editing

Based on the Shapiro-Wilk and Shapiro-Francia normality tests, the null hypothesis that the data come from a normal distribution is rejected. In the absence of normality, parametric tests such as the independent samples t-test or ANOVA are not applicable. To compare the pre- and post-IT periods, the Kruskall-Wallis test is used as a non-parametric "counterpart" to ANOVA. Based on the Kruskall-Wallis test, core inflation (chi2=148.676; p=0.000) and its standard deviation (chi2=49.495; p=0.000), as well as inflation (chi2=168.841; p=0.000) and its standard deviation (chi2=28.742; p=0.000), are significantly different before and after the introduction of inflation targeting. The difference shown in the descriptive statistics (Table 5) is statistically lower after the introduction of IT.

Further analysis is needed, the lower inflation environment is not necessarily causally related to inflation targeting, especially in light of the fact that Hungary is a small open economy with increased exposure to macroeconomic trends in Europe and the world. The problem of endogeneity has to be taken into account when comparing the factors influencing the inflation path. In our study, we have selected variables that are thought to be unidirectional in the direction of the relationship. OLS and VAR models were chosen as the analytical framework and the results are presented below.

The unit root test was carried out for all variants. The modified Dickey-Fuller test and the Phillips-Perron test were tested both with and without trend. Where necessary, the first difference of the variables was used in the analyses, with all variables being I(0) for the VAR model.

The results of the OLS estimation are presented in Table 6. The models satisfy all assumptions and tests. The dependent variable is core inflation (cinf) for model one, the volatility of core inflation (sd_cinf) for model two, followed by models three to four (inf and sd_inf) for inflation. The independent variables are the same for both models. In presenting the results, the models are treated together.

In the estimation of the models, the lag of each dependent variable (AR(1)) is included, so that the monthly value of inflation and its standard deviation also depend on the previous month's inflation rate. This measures the inertial inflation that the central bank has to contend with. In all four cases the estimated parameter is positive and significant, i.e. inertial inflation is present for both inflation and core inflation. One of the main motivations for introducing inflation targeting was to reduce inertial inflation. It should be noted that in 2001, the year of IT adoption, both inflation and core inflation were above 9%, in such an inflationary environment inertial inflation causes significant damage, but this effect helps to achieve price stability and to meet the inflation target in the long run. In the case of volatility, the inertia effect is at least as important. For economic agents, it is not only the achievement of annual price stability that is important, but also the path to it. This path needs to be smoothed by monetary policy.

The focus of our analysis is on inflation targeting (IT). Based on the Kruskall-Wallis test, we have seen that there is a statistically plausible divergence in the inflation environment before and after IT. The OLS estimation suggests that core inflation was indeed reduced by inflation targeting, but we could not verify this effect in the model for the standard deviation. This suggests that the adaptation of IT has helped to achieve price stability in Hungary, but the uncertainty is explained by other factors. For inflation, there is no measurable effect of inflation targeting.

Table 6: OLS estimation of inflation indicators and their standard deviation

	(1)	(2)	(3)	(4)
	cinf	sd_cinf	inf	sd_inf
L.cinf	0.208***		0.227***	
	(0.063)		(0.054)	
L.sd_cinf		0.742***		0.588***
		(0.061)		(0.068)
IT	-0.285**	0.01	-0.296	-0.001
	(0.126)	(0.025)	(0.220)	(0.034)
HICP	0.031	-0.020*	0.124	-0.013
	(0.076)	(0.011)	(0.117)	(0.021)
GDP	-0.002	0.001	0.048*	-0.003
	(0.016)	(0.003)	(0.027)	(0.005)
Járai	-0.153	-0.066**	-0.155	-0.06
	(0.171)	(0.031)	(0.274)	(0.048)
Simor	-0.587*	-0.142**	-0.711	-0.179
	(0.319)	(0.059)	(0.477)	(0.113)
Matolcsy	-0.725*	-0.173**	-0.878	-0.243*
	(0.394)	(0.075)	(0.576)	(0.140)

CB_IND	0.093	0.023	0.098	0.032
	(0.094)	(0.015)	(0.127)	(0.030)
Constant	-0.711***	-0.084**	-0.756***	-0.112
	(0.195)	(0.038	(0.283)	(0.076)
Number of observations	288	286	288	287
Linear timetrend	✓	✓	✓	✓
Non-linear timetrend	✓	✓	✓	✓
DW-statistics	2.035	1.819	2.055	2.058
R-square	0.175	0.615	0.113	0.387

**** p<0.01; ** p<0.05; * p<0.1*

Robust standard errors are given in parentheses for estimators (1) to (3) and semi-robust standard errors for estimator (4).

Estimation (4) included autocorrelation and was therefore estimated using a Cochrane-Orcutt AR(1) model.

Source: own editing

The only case where euro area inflation shows a significant negative relationship is at the 10% level of the standard deviation of core inflation. In our view, this is surprising, given that Hungary's largest export partners are in the euro area, such as Germany, Slovakia, Italy and Austria. For GDP, we find a positive (but weak) relationship with inflation, reflecting the mainstream view that GDP growth generates inflation in the economy. It is important to note here that modern monetary theory (MMT) tries to refute this. In our country, foreign currency indebtedness has been declining over the past decade as a result of a deliberate policy. Perhaps this is also the reason for the weak link between economic growth and inflation, and the lack of a statistically verifiable link with core inflation.

The dummy variable of central bank governors shows a very different picture for core inflation and inflation. The estimates in Table 6 show that inflation did not fall significantly under any central bank presidency, with only György Matolcsy's inflation standard deviation falling. In contrast, we find a strong relationship between core inflation and its volatility reduction under both Simor and Matolcsy. In the case of volatility, it is interesting to note that IT has not been able to reduce volatility directly, while it has done so for core inflation under the current and previous central bank presidencies. Based on the models, central bank independence (CB_INDP) is not violated, but it is worth noting that the coefficient is positive signed in all four models.

For the VAR model (Appendix 1) we used the same variables as for the OLS estimates (Table 6). In the lagged dependent variable order (cinf/sd_cinf/inf/sd_inf), euro area inflation (HICP) and economic growth (GDP) are endogenous, the dummy variables are exogenous in the models. To save space, lags of the dependent variables are in one row. The optimal number of lags is chosen based on the FPE, AIC, HQIC and SBIC criteria. A delay of 12 was adopted for all four models. The models were all considered stable based on the eigenvalue. For simplicity of interpretation, we performed an F-test on the lagged variables so that we can jointly test whether they are significantly different from zero, the results of which are presented in Table 7.

The only case where euro area inflation shows a significant negative relationship is at the 10% level of the standard deviation of core inflation. In our view, this is surprising, given that Hungary's largest export partners are in the euro area, such as Germany, Slovakia, Italy and Austria. For GDP, we find a positive (but weak) relationship with inflation, reflecting the mainstream view that GDP growth generates inflation in the economy. It is important to note here that modern monetary theory (MMT) tries to refute this. In our country, foreign currency indebtedness has been declining over the past decade as a result of a deliberate policy.

Perhaps this is also the reason for the weak link between economic growth and inflation, and the lack of a statistically verifiable link with core inflation.

The dummy variable of central bank governors shows a very different picture for core inflation and inflation. The estimates in Table 6 show that inflation did not fall significantly under any central bank presidency, with only György Matolcsy's inflation standard deviation falling. In contrast, we find a strong relationship between core inflation and its volatility reduction under both Simor and Matolcsy. In the case of volatility, it is interesting to note that IT has not been able to reduce volatility directly, while it has done so for core inflation under the current and previous central bank presidencies. Based on the models, central bank independence (CB_INDP) is not violated, but it is worth noting that the coefficient is positive signed in all four models.

For the VAR model (Appendix 1) we used the same variables as for the OLS estimates (Table 6). In the lagged dependent variable order (cinf/sd_cinf/inf/sd_inf), euro area inflation (HICP) and economic growth (GDP) are endogenous, the dummy variables are exogenous in the models. To save space, lags of the dependent variables are in one row. The optimal number of lags is chosen based on the FPE, AIC, HQIC and SBIC criteria. A delay of 12 was adopted for all four models. The models were all considered stable based on the eigenvalue.For ease of interpretation, an F-test was performed on the lagged variables so that they can be tested jointly to see if they are significantly different from zero, the results of which are shown in Table 7.

Table 7: F-test for VAR model variables

	(1) cinf		(2) sd_cinf		(3) inf		(4) sd_inf	
	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
lagged cinf	9.830	0.000***						
lagged sd_cinf			29.280	0.000***				
lagged inf					5.490	0.000***		
lagged sd_inf							37.18	0.000***
HICP	1.310	0.214	2.060	0.021**	3.430	0.000***	1.38	0.177
GDP	0.400	0.963	1.010	0.440	0.850	0.597	0.610	0.823

**** p<0.01; ** p<0.05; * p<0.1*

Source: own editing

The results of the F-test suggest an inertia effect for all inflation indicators and their volatilities, in which case the results are in line with the OLS estimation. For HICP, we found a significant relationship in models (2) and (3), and the OLS model also confirmed the relationship between HICP and the dispersion of core inflation, i.e. the long-run multiplier effect (LRP - sum of the coefficients of lagged variables) suggests that an increase in euro area inflation increases the volatility of core inflation and inflation in Hungary.

For inflation targeting (IT), we do not find a significant relationship in any of the models, i.e. there is no evidence of a direct effect between IT and inflation indicators based on the VAR models. In contrast, for central bank governors, we obtained the same results for all models using OLS. Central bank independence (CB_IND) is not violated in the VAR models either.

From Figure 1 and from the descriptive statistics (Table 5), we can see that inflation (and core inflation) has been able to remain at a steadily declining and lower level after 2001 compared to the previous decade. On the one hand we can assume that this is the result of the inflation target, on the other hand we know that globally low inflation has been the pattern, especially in the last 5-10 years. For this reason, we have looked at how the inflation path "behaved" immediately before and after the introduction of IT. The estimates in Table 8 cover the period from March 1995 to September 2007, the middle of this period being the introduction of inflation targeting.

Table 8: OLS estimate of inflation indicators and their standard deviation (1995M3-2007M9)

	(1)	(2)	(3)	(4)
	cinf	sd_cinf	inf	sd_inf
L.cinf/inf	0.686***		0.251***	
	(0.061)		(0.082)	
L.sd_cinf/inf		0.655***		0.741***
		(0.088)		(0.071)
IT	-0.125	0.003	-0.542***	0.042
	(0.098)	(0.033)	(0.150)	(0.029)
HICP	-0.314***	-0.007	-0.437*	0.036
	(0.117)	(0.029)	(0.242)	(0.054)
GDP	(0.060)	0.003	0.030	(0.030)
	0.022	(0.006)	(0.041)	-0.009
Járai	-0.106	-0.076*	0.214	-0.127**
	(0.121)	(0.045)	(0.272)	(0.049)
Simor	-0.337*	-0.184**	-0.326	-0.327***
	(0.201)	(0.086)	(0.514)	(0.103)
CB_IND	0.017	0.038	-0.088	0.069**
	(0.060)	(0.027)	(0.166)	(0.030)
Konstans	-0.302*	-0.159*	-0.317	-0.176*
	(0.172)	(0.082)	(0.492)	(0.101)
Number of observations	129	127	129	129
Linear timetrend	✓	✓	✓	✓
Non-linear timetrend	✓	✓	✓	✓
DW-statistics	2.035	1.819	2.055	2.058
R-square	0.651	0.533	0.208	0.645

**** p<0.01; ** p<0.05; * p<0.1*
For estimates (1)-(2) robust standard errors are given in parentheses, for estimates (3)-(4) semi-robust standard errors are given in parentheses.
Estimates (3)-(4) included autocorrelation and were therefore estimated using the Prais-Winsten AR(1) model.
Source: own editing

Previously, the Cochrane-Orcutt method and here the Prais-Winsten model were used to address the autocorrelation problem. The reason for the change of method is that in the first case the Prais-Winsten iteration did not converge. The results show that inflation (estimation 3) is reduced by IT, while in the other cases there is no significant relationship with core inflation, its variance and the variance of inflation. It is interesting to look at the inertia coefficients, for the full period estimates (Table 6), we obtain almost similar values for inflation, an indication that the inertia effect does not change or changes very slowly along the inflation path. Contrast this with core inflation, where the coefficient value is almost three times larger for the current estimate, while for the full period the inertia effect is the same as for the inflation path. A similar constancy is observed for volatility. VAR estimates for the same period are presented in Appendix 2 and Table 9.

The VAR models suggest that the introduction of IT has reduced both inflation and core inflation for the models run in a restricted time interval. As in OLS, inertial inflation is also significant here, significant for all estimates. For the HICP, the VAR model indicates a significant negative relationship for both core inflation and inflation, with a statistically verifiable relationship only for inflation in the full-period estimates. A similar effect is observed for the OLS estimate for the restricted period (Table 8).

Table 9: F-test for VAR model variables (1995M3-2007M9)

	(1) cinf		(2) sd_cinf		(3) inf		(4) sd_inf	
	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
lagged cinf	7.830	0.000***						
lagged sd_cinf			14.300	0.000***				
lagged inf					4.07	0.000***		
lagged sd_inf							11.93	0.000***
HICP	3.490	0.000***	1.380	0.197	2.28	0.016***	3.31	0.000***
GDP	1.640	0.098*	0.880	0.568	1.550	0.126	1.130	0.348

**** p<0.01; ** p<0.05; * p<0.1*

Source: own editing

5. Conclusion

Following the introduction of inflation targeting (IT), the Hungarian economy has experienced significantly lower inflation and core inflation. Compared to the period prior to the introduction of IT, the inflation path was also balanced, with lower volatility of inflation indicators.

The causal relationship between inflation, core inflation and the volatility of these indicators and inflation targeting was measured using OLS and VAR models. In all cases, the inertia effect is statistically robust, which is welcome in a low inflation environment but highly detrimental in a high inflation environment. In the case of core inflation, we find evidence of a positive impact of IT, with core inflation declining under the presidencies of former central bank governor András Simor and current central bank governor György Matolcsy. The volatility of core inflation also declined under the current and the previous central bank leadership. Based on the OLS models, IT has had no direct impact on inflation developments, and none other than the inertial inflation effect. The results suggest that while core inflation is affected by domestic monetary policy, inflation is shaped by other effects. The VAR models do not confirm the relationship between core inflation and IT, but indicate a positive relationship between HICP and inflation, i.e. the increase in HICP is incorporated into Hungarian inflation.

Countries that adopt inflation targeting typically choose to use IT in a period of high inflation, confident that it will solve inflation problems by breaking down inertial inflation. For this reason, we examined the impact of IT near its introduction (1995M3-2007M9). In this case, the result was reversed, with inflation significantly reduced, while core inflation was not affected by IT. However, VAR models suggest that both core inflation indicators were significantly reduced during this period.

In our view, overall, inflation targeting has helped and is still helping to achieve inflation targets. We should not forget that as a small, open economy, our country is in many cases vulnerable to the economic cycles of the EU first and the world second. Our analysis suggests that Hungarian monetary policy can have an impact primarily on core inflation, which measures the underlying inflation trend of our economy. The inertia effect is significant for all estimates, be it of the underlying inflation rate or its volatility. Inflation targeting has no effect on smoothing inflation paths, volatility is influenced by other factors.

In the modelling process, we have taken into account linear and non-linear time trends, filtering out economic growth and euro area inflation. In addition to central bank independence, we also controlled for the impact of individual central bank presidencies, and find evidence that inflation targeting has helped and is helping Hungarian monetary policy.

In interpreting our results, some limiting factors need to be taken into account. The euro exchange rate is not included in our models, the reason being that data on the EUR/HUF exchange rate are available from January 1999 at the earliest. Our study would have lost its focus if the euro exchange rate had been included, since only two and a half years of monthly data from the period before IT would have been available, and by omitting the euro we could work with more than six years of data for inflation and more than five years for core inflation. Of course, we do not think that this has a negligible impact on inflation.

For the core inflation models, we would have liked to replace the HICP with a European core inflation indicator, but this is not available. An important and interesting test would be the use of tax-filtered inflation, which would provide inflation data net of fiscal effects, but this inflation indicator is only available from 2003 onwards.

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8. Appendix

Appendix 1: VAR estimate of inflation indicators and their standard deviation

	(1)		(2)		(3)		(4)	
	cinf		sd_cinf		inf		sd_inf	
L.dependent variable	0.183***	(0.054)	1.652***	(0.060)	0.227***	(0,056)	0,782***	(0,059)
L2.dependent variable	0.041	(0.055)	-0.656***	(0.115)	0.003	(0,057)	-0,045	(0,076)
L3.dependent variable	0.096*	(0.055)	-0.096	(0.121)	0.038	(0,057)	-0,068	(0,076)
L4.dependent variable	0.039	(0.055)	0.018	(0.120)	0.009	(0,058)	-0,032	(0,075)
L5.dependent variable	0.036	(0.054	-0.022	(0.120)	0.068	(0,057)	-0,105	(0,075)
L6.dependent variable	0.053	(0.054)	0.054	(0.121)	-0.019	(0,056)	-0,029	(0,076)
L7.dependent variable	0.071	(0.054)	-0.052	(0.121)	-0.117**	(0,055)	0,017	(0,075)
L8.dependent variable	-0.144***	(0.054)	0.124	(0.121)	0.007	(0,055)	0,046	(0,074)
L9.dependent variable	0.071	(0.054)	-0.227*	(0.120)	0.022	(0,056)	-0,135*	(0,074)
L10.dependent variable	0.071	(0.054)	0.198	(0.121)	0.038	(0,055)	-0,024	(0,074)
L11.dependent variable	0.048	(0.054)	-0.042	(0.113)	0.126**	(0,055)	-0,005	(0,073)
L12.dependent variable	-0.446***	(0.053)	-0.028	(0.057)	-0.317***	(0,053)	0,059	(0,057)
L.HICP	-0.078	(0.067)	-0.017	(0.013)	0.439***	(0,103)	-0,039*	(0,021)
L2.HICP	-0.04	(0.067)	-0.009	(0.013)	0.162	(0,106)	-0,020	(0,021)
L3.HICP	0.074	(0.068)	-0.015	(0.013)	-0.178*	(0,107)	-0,005	(0,021)
L4.HICP	0.018	(0.068)	-0.008	(0.013)	0.054	(0,108)	-0,036*	(0,021)
L5.HICP	-0.123*	(0.067)	0.026**	(0.013)	-0.279***	(0,106)	0,033	(0,021)
L6.HICP	0.126*	(0.069)	-0.008	(0.013)	-0.001	(0,109)	0,014	(0,021)
L7.HICP	-0.081	(0.069)	-0.011	(0.013)	-0.100	(0,108)	-0,035*	(0,021)
L8.HICP	-0.008	(0.069)	0.018	(0.013)	0.039	(0,108)	0,022	(0,021)
L9.HICP	-0.083	(0.069)	0.040***	(0.013)	0.032	(0,108)	0,022	(0,021)
L10.HICP	-0.044	(0.068)	-0.005	(0.013)	0.035	(0,108)	0,003	(0,021)
L11.HICP	0.027	(0.068)	-0.016	(0.013)	-0.202*	(0,107)	-0,012	(0,021)
L12.HICP	0.102	(0.067)	0.017	(0.013)	0.195*	(0,108)	0,023	(0,021)
L.GDP	0.065	(0.139)	-0.007	(0.027)	-0.307	(0,217)	-0,034	(0,044)
L2.GDP	-0.214	(0.420)	0.032	(0.081)	0.985	(0,655)	0,065	(0,131)
L3.GDP	0.298	(0.626)	-0.087	(0.121)	-1.401	(0,976)	-0,026	(0,195)
L4.GDP	0.004	(0.590)	0.151	(0.114)	0.992	(0,921)	-0,055	(0,184)
L5.GDP	-0.617	(0.690)	-0.128	(0.134)	0.153	(1,083)	0,071	(0,215)
L6.GDP	0.932	(0.967)	-0.057	(0.186)	-1.336	(1,520)	-0,032	(0,301)
L7.GDP	-0.476	(0.972)	0.266	(0.187)	1.654	(1,522)	-0,022	(0,302)
L8.GDP	-0.417	(0.723)	-0.279**	(0.141)	-0.979	(1,129)	0,043	(0,225)
L9.GDP	0.95	(0.669)	0.044	(0.129)	-0.031	(1,048)	-0,069	(0,208)
L10.GDP	-0.802	(0.714)	0.172	(0.137)	0.528	(1,115)	0,094	(0,222)
L11.GDP	0.387	(0.484)	-0.178*	(0.093)	-0.425	(0,752)	-0,084	(0,150)
L12.GDP	-0.102	(0.163)	0.061*	(0.032)	0.099	(0,252)	0,032	(0,051)
IT	-0.164	(0.176)	0.033	(0.033)	-0.139	(0,263)	0,026	(0,052)
Járai	-0.147	(0.189)	-0.069*	(0.036)	-0.312	(0,284)	-0,054	(0,057)
Simor	-0.495*	(0.270)	-0.115**	(0.051)	-0.887**	(0,412)	-0,126	(0,082)
Matolcsy	-0.663**	(0.317)	-0.158***	(0.060)	-1.054**	(0,492)	-0,169*	(0,097)
CB_IND	0.099	(0.066)	0.023*	(0.013)	0.072	(0,102)	0,025	(0,021)
Constant	-0.671***	(0.171)	0.032	(0.044)	-1.007	(0,266)	-0,054	(0,051)
Linear timetrend	✓		✓		✓		✓	
Non-linear timetrend	✓		✓		✓		✓	
Number of observations	276		276		276		276	
R-square	0.419		0.984		0.409		0.670	

**** p<0.01; ** p<0.05; * p<0.1*
Standard errors are in parentheses.
The lagged variable is cinf for estimation (1), sd_cinf for estimation (2), inf for (3), and sd_inf for estimation (4).
Source: own editing

Appendix 1: VAR estimate of inflation indicators and their standard deviation (1995M3-2007M9)

	(1)		(2)		(3)		(4)	
	cinf		sd_cinf		inf		sd_inf	
L.dependent variable	0.058	(0.086)	0.800***	(0.098)	0.094	(0.090)	0.604***	(0.091)
L2.dependent variable	0.124	(0.085)	-0.135	(0.131)	-0.065	(0.084)	-0.108	(0.114)
L3.dependent variable	0.086	(0.084)	-0.010	(0.131)	0.105	(0.083)	0.116	(0.113)
L4.dependent variable	0.245***	(0.088)	0.023	(0.129)	0.279***	(0.085)	0.006	(0.108)
L5.dependent variable	-0.085	(0.088)	-0.182	(0.126)	0.111	(0.089)	-0.136	(0.107)
L6.dependent variable	0.004	(0.088)	0.138	(0.130)	-0.079	(0.087)	0.011	(0.111)
L7.dependent variable	0.067	(0.087)	-0.173	(0.128)	-0.189**	(0.085)	0.003	(0.109)
L8.dependent variable	-0.204**	(0.088)	0.259**	(0.127)	-0.121	(0.091)	0.226**	(0.110)
L9.dependent variable	0.119	(0.086)	-0.273**	(0.130)	-0.036	(0.087)	-0.359***	(0.112)
L10.dependent variable	0.105	(0.085)	-0.010	(0.132)	0.053	(0.084)	-0.015	(0.115)
L11.dependent variable	0.035	(0.088)	-0.052	(0.130)	0.269***	(0.084)	-0.060	(0.106)
L12.dependent variable	-0.463***	(0.086)	0.192**	(0.093)	-0.284***	(0.086)	0.231***	(0.084)
L.HICP	-0.635***	(0.122)	-0.090**	(0.034)	-0.097	(0.232)	-0.207***	(0.052)
L2.HICP	-0.370***	(0.118)	-0.040	(0.032)	-0.435*	(0.221)	-0.190***	(0.051)
L3.HICP	-0.178	(0.114)	-0.090***	(0.033)	-0.549**	(0.221)	-0.146***	(0.053)
L4.HICP	-0.223*	(0.116)	-0.058*	(0.035)	-0.301	(0.231)	-0.085	(0.056)
L5.HICP	-0.433***	(0.126)	-0.050	(0.036)	-0.626**	(0.242)	-0.051	(0.059)
L6.HICP	-0.352**	(0.134)	-0.034	(0.036)	-0.689**	(0.261)	-0.029	(0.060)
L7.HICP	-0.309**	(0.132)	-0.029	(0.037)	-0.752***	(0.268)	-0.008	(0.059)
L8.HICP	-0.081	(0.129)	-0.028	(0.035)	-0.507*	(0.271)	0.091	(0.057)
L9.HICP	-0.202	(0.123)	0.031	(0.034)	-0.197	(0.260)	0.148***	(0.055)
L10.HICP	-0.241**	(0.113)	-0.025	(0.031)	-0.502**	(0.237)	0.113**	(0.049)
L11.HICP	-0.035	(0.116)	0.019	(0.031)	-0.761***	(0.244)	0.117**	(0.049)
L12.HICP	0.130	(0.116)	0.031	(0.032)	0.099	(0.252)	0.183***	(0.050)
L.GDP	0.128	(0.183)	0.004	(0.051)	0.193	(0.375)	0.027	(0.080)
L2.GDP	-0.405	(0.512)	-0.045	(0.145)	-0.074	(1.041)	-0.194	(0.225)
L3.GDP	0.637	(0.724)	0.060	(0.206)	-0.738	(1.456)	0.357	(0.320)
L4.GDP	-0.003	(0.705)	0.010	(0.197)	2.212	(1.384)	-0.166	(0.302)
L5.GDP	-1.347	(0.841)	-0.133	(0.232)	-2.214	(1.660)	-0.358	(0.354)
L6.GDP	2.074*	(1.077)	0.136	(0.296)	-0.200	(2.156)	0.688	(0.465)
L7.GDP	-0.931	(1.101)	0.030	(0.297)	3.128	(2.170)	-0.383	(0.469)
L8.GDP	-1.049	(0.859)	-0.209	(0.232)	-3.469**	(1.656)	-0.199	(0.356)
L9.GDP	1.919**	(0.733)	0.183	(0.199)	0.848	(1.447)	0.435	(0.311)
L10.GDP	-1.070	(0.789)	-0.021	(0.212)	1.813	(1.557)	-0.190	(0.334)
L11.GDP	0.097	(0.548)	-0.056	(0.149)	-1.891*	(1.075)	-0.055	(0.230)
L12.GDP	0.147	(0.187)	0.020	(0.052)	0.741**	(0.368)	0.053	(0.079)
IT	-0.483***	(0.165)	-0.008	(0.043)	-0.782***	(0.292)	0.012	(0.062)
Járai	-0.224	(0.188)	-0.084	(0.052)	-0.176	(0.411)	0.050	(0.079)
Simor	-0.278	(0.289)	-0.188**	(0.082)	-0.423	(0.672)	-0.043	(0.121)
government_CBP	0.056	(0.096)	0.047*	(0.026)	-0.068	(0.189)	0.001	(0.039)
Constant	-1.628***	(0.442)	-0.147	(0.129)	-2.244**	(0.873)	0.306	(0.195)
Linear timetrend	✓		✓		✓		✓	
Non-linear timetrend	✓		✓		✓		✓	
Number of observations	117		116		117		117	
R-square	0.744		0.812		0.615		0.803	

**** p<0.01; ** p<0.05; * p<0.1*
Standard errors are in parentheses.
The lagged variable is cinf for estimation (1), sd_cinf for estimation (2), inf for (3), and sd_inf for estimation (4).
Source: own editing