The Impact of Monetary Policy on CPI and GDP in the Czech Republic and Switzerland for the Period 2000 - 2016

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Abstract. The aim of this paper is to compare the effectiveness of the monetary policy implemented at the time of low interest rates and foreign exchange interventions in the Czech Republic and Switzerland (using the monetary aggregate M3 and its impact on CPI and GDP). The followed relationship between these values is analyzed using the Engle-Granger cointegration test. These tests are conducted on select statistical data from the years 2000 to 2016. The input data are quarterly in nature and have been seasonally adjusted. For determining the cointegration relationship, it is possible to proceed with the Engle-Granger test, which is meant to determine the long-term relationship between the effectiveness of the monetary policy – between the monetary aggregates M3 and GDP and the relationship between M3 and CPI in the Czech Republic and Switzerland. On the basis of these tests, it was found that there is no cointegration relationship between any time series at a level of significance of 0.05; this means that no long-term relationship was found between the M3 and GDP and also for M3 and CPI. Not finding long-term relationships between M3 and CPI, respectively GDP, means that the monetary policy in the Czech Republic and Switzerland was in the period 2000-2016 ineffective.

Keywords: Monetary Policy, Cointegration Analysis, CPI, GDP, M3

1 Introduction

In the past, many central banks have exhausted the standard tool of monetary policy, i.e., interest rates, in their attempt to achieve inflation targets. Therefore, they have been forced to proceed using unconventional monetary policy, realized using quantitative easing, negative interest rates, or foreign exchange interventions. Unconventional monetary policy is based on a quantitative theory of money based on the knowledge that money supply growth affects price levels. This causality is empirically proven over a long period of time. Money supply growth only affects the price level in the long run. In the short term it is possible to find the influence of money supply on the development of the output of the economy. The inflation targeting, as introduced in [23], is based on monetarism and the thesis that monetary policy should focus on maintaining price stability. Inflation targeting in monetary policy implementation does not use monetary aggregates, which is in contrast to the monetary targeting strategy. During the 1970s many central banks chose monetary aggregates as intermediate goals [4]. For this reason, monetary aggregates have become an important instrument in the conduct of monetary policy. The main reason why both the Czech National Bank (CNB) and the Swiss National Bank (SNB) instigated foreign exchange intervention was that inflation that was too low and there was a near zero interest rate. In addition to this, the SNB had another reason, which was the fight against a strengthening domestic currency. Both before as well as during the intervention, the external and internal economic conditions in these individual countries were diametrically opposite.[24] In the Czech Republic, there was consistently low inflation and a decreasing GDP, whereas in Switzerland, GDP was growing and the franc was appreciating. The common impact of the interventions was the growth of foreign-exchange reserves. In Switzerland, the foreign-exchange reserves grew from CHF 50 mil. to CHF 500 mil. between 2009 and 2015. After the subsequent revaluation, the reserves reached as high as CHF 600 mil. – it was precisely this more than tenfold increase that was one of the main impulses for ending intervention. The SNB relinquished its fixed exchange rate suddenly, which led to a jump in the exchange value by nearly 20% and a decrease in export volume and GDP. In the Czech Republic, foreign-exchange reserves roughly tripled after a period of foreign exchange interventions lasting from 2013 to 2017. The koruna strengthened slightly after the announcement ending the fixed rate of 27 koruna to the euro.

The goal of this paper is to conduct a mutual comparison of the effectiveness of monetary policy executed via, among other things, the foreign exchange intervention in the Czech Republic and Switzerland – or, more precisely, by observing the influence of the M3 monetary aggregate's influence on CPI and GDP from 2000 to 2016. The central banks instigated foreign exchange intervention, which had the effect of increasing M3 with the goal of increasing inflation.

2 Review of literature

It is possible to undertake investigation foreign exchange intervention, i.e., the purchase and sale of domestic currency by a central bank, by comparing the bilateral relationships of macroeconomic aggregates. As stated by [16], these occur most frequently in the following relationships:

- the money supply → the exchange rate,
- the M2 & M3 monetary aggregates → GDP, and
- the M2 & M3 monetary aggregates → the inflation level.

The first part of the pair is always the amount of money in circulation in the given economy. This is the variable that is directly influenced by foreign exchange intervention: if the central bank conducts an expansive monetary policy, the monetary aggregate increases as a result, and if they resort to a restrictive monetary policy, the opposite results.

The impact of foreign exchange intervention in Japan from 1991 to 2001 monitored [15]. His conclusion was that the second phase of foreign exchange intervention was 20–50 times more effective than the first; this was primarily because bilateral intervention was conducted both with the yen and with the US dollar. A study by [8] dealing with intervention in Australia from 1984 to 2001 also confirms the relationship between foreign exchange intervention and the spot exchange rate. This study comes to the conclusion that a relationship exists between the intervention that was implemented and the exchange rate's level and volatility. Another conclusion in [7] also came to a conclusion similar to [8], i.e., that intervention influenced the spot exchange rate only weakly. Study [7] investigated the CNB's interventions between 2001 and 2002. Another study [18] dealt with the problem of foreign exchange intervention and the exchange rate. They came to the conclusion that the relationship of the exchange rate to the interventions that were conducted is derived from the ability to signal the central bank's future monetary policy to the public and that; conversely, transparency is thus desirable in this instance.

The macroeconomic impact of the growth of broad monetary aggregates is investigated in [17]. He applied his work to the United States of America (1960–2007), the Eurozone (1991-2007), Japan (1960–2007), Great Britain (1987–2007), and the Czech Republic (1993–2007), for example. In all the countries he analyzed, this meant growth of the broad monetary aggregate increased inflation and increased real GDP – at a ratio of 1:1.

According to [22], there is a correlation between the growth of the M3 money supply, inflation, and the growth of the economic product. They arrived at this conclusion in their study dealing with M2 and M3 monetary aggregates in Switzerland, specifically between 1996 and 1999. The correlation between the amount of money in the M2 supply and the price level and the subsequent confirmation of this relationship in the USA is analyzed in [14]. The foreign exchange intervention by 33 central banks between 1995 and 2011 is investigated in [11]. The authors came to the conclusion that foreign exchange intervention is a very effective monetary policy tool, though in relationship to influencing the exchange rate and not the monetary aggregate.

On the basis of the conclusions of the individual studies listed above, the following relationships have been selected as basic relationships for investigating the effectiveness of monetary policy in the CR and Switzerland:

- the influence of the M3 monetary aggregate on inflation,
- the influence of the M3 monetary aggregate on GDP.

3 Methods and Data

The input data for analysis are quarterly in nature and have been cleaned from seasonal influence. The data for analyzing the relationship of the M3 aggregate and the development of inflation was derived from the Organization for Economic Co-operation and Development (OECD) ([20] and [21]), and the data for analyzing the relationship of the M3 aggregate and GDP were derived from the portal of the Federal Reserve Bank of St. Louis (FRED) ([12]).

The economic research in this paper was conducted during the years 2000–2016. The actual foreign exchange interventions by the CNB and the SNB were implemented over a relatively short period of time. Because of the time lag that has been applied to the time series, it was not possible to conduct analysis for the period of the foreign exchange intervention only. The program Gretl 1.9.4. was used for econometric analysis.

Time series depict a specific progression of observations of selected economic indicators. The development shown by time series tends to be diverse over the short term, whereas the values have a tendency to return to a specific equilibrium over the long term. It is precisely because of this that it is possible to prove a mutual relationship for the two quantities being monitored. If two time series have a tendency to keep a constant distance between them over the long term, they are considered cointegrated. The concept of cointegration was first introduced by Granger in his article [10] concerning the use of time series analysis in econometric models. Cointegrated time series make it possible to analyze the nature of their dependence when observing relationships between economic time series. If the time series are not cointegrated, a common correlation does not exist, and further investigation is pointless, because they are developing independently of one another over the long term [10]. We consider time series to be stationary if the values for their mathematical average and variability are the same for the duration of the whole series. For estimating a regression model, it is necessary for the data to be stationary [10].

Testing time series for optimal lag length is one of the prerequisites for conducting Granger tests. First, testing is done using Akaike's information criterion (AIC), where the best series lag is always considered the lowest AIC value. Individual variables will be tested separately, and the best lag for the series will be applied in the subsequent tests. Akaike's information criterion was introduced in the 1970s by the Japanese statistician Akaike in [1].

$$AIC = n * ln\left(\frac{RSS}{n}\right) + 2k \qquad (1)$$

where RSS is the residual sum of squares;
k is the number of parameters;
n is the number of measurements; and
RSS/n is residual variance.

Next, the test to check for the existence of a unit root follows; here, it is determined whether the time series being investigated are stationary or nonstationary. A stationary series is distinguished by the fact that it has a tendency to return to a specific value or follow a specific recordable trend, whereas this does not exist for a nonstationary one. Formally, it is possible to proceed using the equations listed below [3]:

For the stochastic process { , t= 0, ±1, ±2,… }, we define the following terms:

the mean function:

$$\mu_t = E(X_t) \quad (2)$$

the variance function:

$$\sigma_t = D(X_t) = E(X_t - \mu_t)^2 \quad (3)$$

where Xt is the dependent variable, $E(Xt)$ denotes the mean, and $D(Xt)$ expresses variance.

For econometric analysis, an augmented Dickey-Fuller test (ADF test) is used next. Dickey and Fuller in [6] defined three types of these tests – with a constant, without a constant, and with a constant and a trend. When testing, we assume that the process listed below (Eq. 4), where we test that Ø=0 (the variable contains a unit root), takes the form [3]:

$$\Delta X_t = (\emptyset 1 - 1)X_{t-1} + \sum_{i=1}^{p} \alpha i \, X_{t-1} + e_t \quad (4)$$

Here, Xt again expresses the dependent variable, p is lag, and e_t is the residual component.

The decision concerning the time series' stationarity or nonstationarity will be made by evaluating the p value (the level of significance p is always defined as 0.05 for this paper), which thus establishes with a 95% level of probability whether the null hypothesis has been rejected or not. The null hypothesis has been established as follows:

- H_0: the series being tested are nonstationary (a unit root does not exist).
- H_1: the series being tested are stationary (a unit root does exist).

A third step, cointegration analysis, will follow if the time series achieve the same degree of integration. Here, this is done using the Engle-Granger cointegration test. In line with this, the error terms are further tested using the ADF test – in order to determine the existence of the unit root (for more on this problem, see, e.g., [9],[13] or [2]). The following hypotheses have been established:

- H_0: the series being tested are not cointegrated.
- H_1: the series being tested are cointegrated.

A decision concerning the time series' relationship is derived from the p-value as defined by the Engle-Granger cointegration test. If the null hypothesis is not rejected, ($p > 0.05$), the time series will be marked as noncointegrated – they contain a unit root. In the opposite scenario ($p < 0.05$), the time series will be marked as cointegrated.

Using cointegration testing on the monitored variables, it is possible to verify whether there is a long-term relationship among their trends or whether the regression between these variables is spurious. Therefore, the statistical concept of cointegration corresponds to the theoretical concept of long-term stability.

4 Results and Findings

4.1 Test for optimal time lag using Akaike's criterion

Before the Engle-Granger cointegration test, it is necessary to test the data for optimal time lag. CPI is entered as the dependent variable in this relationship. In Table 1, the AIC's values are lagged using 6 different orders of magnitude; the lowest value is highlighted. According to economic theory, the optimal lag for a time series is specified as being between 12 and 18 months, which agrees with the results that were determined. On the basis of the lowest value found for the information criterion, an optimal lag length of six is specified for the dependent variable of the CPI, which was determined for the AIC. For this time series, this concerned lag when including a constant for CPICZE and for CPISWI a test with trend. An optimal lag length of six is specified for the dependent variable of the HDPCZE (for test with constant and trend) and an optimal lag length of five six is specified for the dependent variable of the HDPCSWI (for test with constant and trend). This lags will be taken into consideration in the subsequent tests.

Table 1. Results of optimum delay in the Czech Republic and Switzerland.

Order of delay	**AIC for CPICZE**			**AIC for CPISWI**		
-	Test with constant	Test with trend	Test with constant and trend	Test with constant	Test with trend	Test with constant and trend
1	2.341131	2.372624	2.370802	1.955633	1.977728	1.876791
2	2.370524	2.404666	2.398340	1.605519	1.608004	1.582178
3	2.402727	2.435104	2.430413	1.546827	1.556384	1.510908
4	2.429199	2.454900	2.459450	1.305234	1.299736	1.299426
5	2.189065	2.255970	2.139762	1.208090	1.211334	1.188178
6	**2.03724***	2.07236*	2.052789*	1.012756*	**1.00029***	1.002161*
Order of delay	**AIC for HDPCZE**			**AIC for HDPSWI**		
-	Test with constant	Test with trend	Test with constant and trend	Test with constant	Test with trend	Test with constant and trend
1	2.663360	2.511841	2.450049	1.981278	1.983109	1.899336
2	2.250905	2.251815	2.191904	1.541850	1.554711	1.415631
3	2.233558	2.230233	2.159807	1.481415	1.498036	1.353858
4	2.258853	2.261478	2.182963	1.513450	1.529115	1.383651
5	2.285927	2.292069	2.201441	1.450532*	1.46893*	**1.322073***
6	2.20142*	2.19988*	**2.127688***	1.559670	1.569410	1.445222

4.2 Verifying the Stationarity of the Time Series

The possibility that the data is nonstationary could lead to spurious regression, which is dangerous primarily because it is possible to obtain statistically significant estimates for the regression function parameters when the least squares method is applied – even though the time series that were analyzed do not relate to each other. It is therefore necessary to test the time series involved using the ADF test. The ADF test results for the unit root are listed in Table 2, including a listing of the *p-parameter* values for all of the quantities that were analyzed.

Table 2. ADF test results for M3.

Variable abbreviation	Value of p-parameter	Evaluation of ADF test results	H_0:
M3CZE	0.9975	Time series non-stationary	Not refused
CPICZE	0.8688	Time series non-stationary	Not refused
M3SWI	0.6623	Time series non-stationary	Not refused
CPISWI	0.9995	Time series non-stationary	Not refused
HDPCZE	0.7095	Time series non-stationary	Not refused
HDPSWI	0.6623	Time series non-stationary	Not refused

For the observed time series, it is clear that all of the time series were marked as nonstationary at a 0.05 level of significance. Since the time series turned out to be nonstationary, i.e., they do not have a unit root, it is necessary for further analysis to resolve this problem using a suitable transformation, so-called stationarizing. One option is to difference the time series. Table 3 lists the values of the ADF test once more for the differenced variables. Modified in this way, the time series for inflation in the CR and inflation in Switzerland are stationary at a 0.05 level of significance, i.e., a unit root does exist for them.

Table 3. ADF test results for M3 - the difference time series.

Variable abbreviation	Value of p-parameter	Evaluation of ADF test results	H_0:
d_M3CZE	0,005362	Time series stationary	Refused
d_CPICZE	0,03606	Time series stationary	Refused
d_M3SWI	0,04666	Time series stationary	Refused
d_CPISWI	0,02742	Time series stationary	Refused

4.3 Cointegration analysis

The test for cointegration is done using the Engle-Granger test. For this test, it is necessary to have the original time series be nonstationary and for them to have the same degree of integration – these conditions were fulfilled for the selected variables

(Table 3). The null and alternative hypotheses for the Engle-Granger cointegration test that was applied are as follows:

- H_0: the time series being tested are not cointegrated.
- H_1: the time series being tested are cointegrated.

Table 4 depicts the relationship of the given pairs of time series, which were accordingly marked as stationary.

Table 4. Results of the Engel - Granger cointegration test and ADF test for M3

Variable abbreviation	Value of p-parameter	Optimum delay	Evaluation of Engel-Grangerova test	H_0:
M3CZE-CPICZE	0.3225	6	No cointegration	Not refused
M3SWI-CPISWI	0.1216	6	No cointegration	Not refused
M3CZE-HDPCZE	0.3225	6	No cointegration	Not refused
M3SWI-HDPSWI	0.1216	5	No cointegration	Not refused
M3CZE-CPICZE	0.3225	6	No cointegration	Not refused

The results of the tests above show that there was no proven correlational relationship between the M3 aggregate and inflation for either the Czech Republic or Switzerland. The first reason to consider explaining why the conclusions that were determined differed from [17] and [14] is the different time periods for which both these analyses were conducted. Next, there were the differences in how the central banks' monetary policies were set up during the periods that were observed. Last, but not least, there was also the presence of the economic crisis, which influenced all of the world's economies. A combination of these factors was the reason the analysis did not confirm the correlation between the investigated values (M3 and CPI or GDP) in the given countries for the years 2000–2016.

4.4 Discussion

On the basis of the tests that were conducted, the results did not confirm a relationship between M3 and CPI and between M3 and GDP in the Czech Republic and Switzerland from 2000 to 2016. The monetary policy effectiveness, which is realized through the targeting of monetary aggregates, was mainly dealt by monetarists. The monetarist's concept of the transmission mechanism explains the price level movements by changing the amount of money. The results confirmed that monetary policy in the Czech Republic and Switzerland is inefficient if monetary policy is realized by foreign exchange intervention when increase money supply. The foreign exchange intervention did not affect the CPI and GDP in selected countries. Both central banks are currently realizing their monetary policies primarily through interest rates and not by targeting monetary aggregates.

5 Conclusion

This paper focuses on analyzing the effectiveness of monetary policy in the Czech Republic and Switzerland as realized using foreign exchange intervention. First, macroeconomic variables suitable for analyzing this effectiveness were established via research in the literature. The M3/CPI and M3/GDP relationships were tested for the given countries. On the basis of research in the literature (e.g., [22]; [14]; and [17]), an assumption of the existence of a positive correlation between both pairs of indicators was also established. On the basis of the tests that were conducted, the results determined that a cointegration relationship does not exist between any of the time series at a 0.05 level of significance. The paper's conclusions correspond to the conclusions of [9]. Not finding a long-term relationship between M3 and CPI or GDP can be caused by a combination of a number of factors. It is important to note that the observed time series capture a shorter period of time compared to other studies. Furthermore, the period 2000 - 2016 was influenced by the global financial crisis, when central banks were forced to cope with specific situations in individual countries. Selected central banks have come to unconventional monetary policy at different times, and for example in the Czech Republic only less than four years have been implemented. Therefore, it would be appropriate to choose a longer time series to assess the effectiveness of the monetary policies of selected central banks. These factors could clearly be the reason why the previously proven positive relationship between the macroeconomic variables that were investigated was not statistically corroborated. However, the results can be considered as inspiring for further time series analyzes as the tests used are still not a common tool for analyzing time series. In further research, it would be possible for us to focus on models that allow for the endogeneity of variables. Such studies do exist, but they primarily process data from the USA (e.g. [5] or [19]). It would certainly be interesting to apply the same models to other countries that have tried to face deflation using the zero-interest rates in the form of unconventional monetary policy. Using these methods, however, requires a greater amount of observation and longer time series. If the model is extended by other variables (e.g. interest rates or money of zero maturity), their importance in relation to for this research, it is necessary to test the model again in the cointegration analysis of the Engle-Granger test. The new variables cause a change in quantification of the influence on CPI and GDP.

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