“Risks and the influence of negative interest rates on economic activity: a case study of Sweden, Denmark, and Switzerland”

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RISKS AND THE INFLUENCE OF NEGATIVE INTEREST RATES ON ECONOMIC ACTIVITY: A CASE STUDY OF SWEDEN, DENMARK, AND SWITZERLAND

Abstract

The purpose of this paper is to analyze the impact of negative interest rates on economic activity in a selected group of countries, in particular Sweden, Denmark, and Switzerland, for the period 2009–2018. The central banks of these countries were among the first to implement negative interest rates to revive the economic growth. Therefore, this study analyzed long- and short-term relationships between interest rates announced by central banks and gross domestic product and blue chip stock indices. Time series analysis was conducted using Engle-Granger cointegration analysis and Granger causality testing to identify long- and short-term relationship. The first step, using the Akaike criteria, was to determine the optimal delay of the entire time interval for the analyzed periods. Time series that seem to be stationary were excluded based on the results of the Dickey-Fuller test. Further testing continued with the Engle-Granger test if the conditions were met. It was designed to identify co-integration relationships that would show correlation between the selected variables. These tests showed that at a significance level of 0.05, there is no co-integration between any time series in the countries analyzed. On the basis of these analyses, it was determined that there were no long-term relationships between interest rates and GDP or stock indices for these countries during the monitored time period. Using Granger causality, the study only confirmed short-term relationship between interest rates and GDP for all examined countries, though not between interest rates and the stock indices.

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INTRODUCTION

For central banks, negative interest rates have become a more important monetary policy tool than anticipated before the financial crisis. Prior to the global financial crisis, many economists assumed that negative interest rates would be effective when combined with other unconventional monetary policy tools as they would provide sufficient incentives to revive economic growth. Low or even negative interest rates should be used to revive the economy. The side effects of negative rates are greater than for more traditional monetary policy tools in areas such as asset price inflation. Negative interest rates can have some stimulating effect, but can also come with potentially significant downside risks. When conventional monetary policy instruments become ineffective, central banks resort to untraditional (unconventional) measures. Conventional monetary policy tools primarily began to fail in conjunction with the 2008 financial crisis, when many central banks reached near zero in setting monetary policy interest rates, and it was not possible to continue lowering the rates, thereby further easing monetary conditions. The central banks needed to resort to tools that they had no experience with. First of all, this led to setting negative rates, quantitative easing, and even forward guidance.

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Negative interest rates of the central bank occur when commercial banks pay the central bank for holding their excessive financial resources. The reason for applying negative interest rates is that banks do not allow their surplus funds to remain in their accounts at the central bank, but rather release them into the economy, e.g., in the form of loans for other economic entities. In conjunction with the financial crisis, central bank interest rates dropped to zero in 2008; in 2009, the central bank of Sweden was the first bank to use negative interest rates in practice. Shortly thereafter, Danish and Swiss banks followed the Swedish lead, and the ECB also joined the banks that apply negative interest rates in 2014.

The purpose of this paper is to find a relationship between negative interest rates and economic activity in the selected countries for the years 2009 to 2018 (specifically for countries that first implemented negative interest rates, i.e., Denmark, Sweden, and Switzerland), using statistical methods of cointegration analysis and Granger causality to identify long-term and short-term relationships.

1. THEORETICAL BACKGROUND

The subject of necessary changes to monetary policy in recent years has been explored by Mishkin (2017), who observed new trends in strategies and approaches to monetary policy in the wake of the financial crisis. Namely, it was demonstrated that the development of the financial sector has a much greater impact on a country's economic activity than before. He considers zero interest rates to be a serious problem, because conventional expansive monetary policy becomes ineffective when a negative shock impacts the economy. Low or even negative interest rates are thus necessary to revive the economy. In this situation, central banks lean towards untraditional (unconventional) monetary policy measures to revive the economy (for more detail, see e.g., Wu & Xia, 2016; Williams, 2014; Zamrazilová, 2014; or Svensson, 2015). Mishkin (2017) also warns that monetary policy should not entirely diverge from experience acquired before the financial crisis. Currently, most monetary policy steps are the same as those used before the financial crisis. However, the clear lesson taken from the financial crisis was that the behavior of financial markets can have a greater impact on economic activity in individual countries than central bankers had previously thought. Therefore, he outlines areas of monetary policy that would be worth reevaluating when pursuing monetary policy itself. These following steps were derived from the principles of the new neoclassical synthesis (in addition to Mishkin (2017), Woodford (2003) has also dealt with this issue) flexible inflation targeting, the reaction of monetary policy to asset bubbles, the dichotomy between monetary policy and financial stability, international coordination of monetary policy, and forward guidance.

Negative interest rates can be seen as a form of taxation that benefits central banks. Using this perspective, one can take into consideration the German economist Silvio Gesell, who in 1916 had already posited the theory of money as destructive and the idea of taxing it (with a holding fee), thereby discouraging people holding money from saving it. Gesell and his theories remained long forgotten until John Maynard Keynes revived them after the Great Depression. Naturally, the global financial crisis of 2007–2009 led to their further practical use.

In 2019, five central banks had negative interest rates – Japan and the Eurozone joined Swiss, Swedish, and Danish central banks. Negative interest rates, as we know them today, were also mentioned by the Swedish economist Svensson (2000), who dealt with the monetary policy transmission mechanism in open economies with zero interest rates. He concluded that this type of monetary policy is a reliable way to get out of the liquidity trap, consisting of a stable price level, currency depreciation, and temporary fluctuation of the exchange rate. Zero interest rates thus clearly result in jump-starting an economy, limiting the emergence of inflation and real depreciation of domestic currency, and increasing inflation expectations. Table 1 shows the actual amounts of the central bank interest rates.

Table 1. Negative interest rates of selected central banks (December 1, 2019)

Source: Danmarks Nationalbank (2019), Sveriges Riksbank (2019), Swiss National Bank (2019).

Central bank	Basic interest rate	Deposit interest rate
Danmarks Nationalbank	0.00%	–0.75%
Sveriges Riksbank	–0.25%	–0.35%
Swiss National Bank	–0.75%	–0.75%

Central bank interest rates are considered to be very useful indicators of economic activity (e.g., studies by Lapp, 2007; Gambacorta, Homann, & Peersman, 2014; van Stel, Carree, & Thurik, 2005; and Arestis & Sawyer, 2003). Despite its many drawbacks, the most commonly used indicator of economic activity is gross domestic product (*GDP*). However, empirical results do not unequivocally support the expectations of conventional economic theory, and the findings of individual authors are not consistent. Khatkhate (1988) analyzed the relationship among 64 of the least developed countries using various macroeconomic variables for the period of 1971 to 1980 and determined that real interest rates alone have little to no impact on the selected macroeconomic variables, including GDP. Lanyi and Saracoglu (1983) as well as King and Levin (1993) discovered positive correlation between interest rate levels and real GDP. On the other hand, Wu and Xia (2016) and Arestis and Sawyer (2003) came to the opposite conclusion. Crowder and Hoffman (1996), who examined data from the USA, also came to a similar conclusion – that interest rates cannot be used to predict the future behavior of GDP.

The behavior of financial markets also has a positive influence on global economic development. Many academic studies (for example, Levine & Zervos, 1996; Lee, 1992; and Cole, Mhirian, & Wu, 2017) found a relationship between interest rate levels, stock indices, and economic activity. For this reason, stock indices were chosen to be another indicator in the statistical analysis of this paper. Cole, Mhirian, and Wu (2017) revealed that interest rates influence yields from stock indices and that these indices impact future economic growth in the countries that were examined. It is also necessary to mention that Bencivenga, Smith, and Starr (1995) showed that more liquid stock markets, where trading is cheaper, are able to create less obstacles to long-term investment, which in turn improves economic growth. For example, Maysami, Howe, and Rahmat (2005), using the Singapore stock index, have demonstrated that the Singapore stock market creates an accountable relationship with changes in short- and long-term interest rates, industrial production, price levels, exchange rate, and money supply.

Globally, so-called blue chip indices are one of the most important stock indices. These are the indices used to measure and report changes in value for representative groups of stocks. A blue chip index combines companies that need to very strong financially and have excellent results when it comes to profit with low levels of debt. They must have a strong name in their field, and they should provide dominant products or services. They tend to be large international corporations with a long history of doing business, which are considered to be very stable. Some of the most famous blue chip indices are the CAC 40 index, the Deutscher Aktien Index 30, the Dow Jones, the India Titans 30, the Standard & Poor 500, and India's BSE SENSEX. Denmark, Sweden, and Switzerland also have their own stock indices. The Danish index is the OMX Copenhagen 20, comprised of the 20 most traded shares on the Copenhagen Stock Exchange; seven of these twenty most successful Danish companies are focused on the area of health care and medicine. Sweden's OMX Stockholm 30 is composed of the 30 most actively traded companies in Sweden, and companies dealing with industrial activities have the strongest representation on the index. The Swiss SMI index is made up of the country's 20 largest and most liquid companies, with banks and companies focusing on financial services and banks being most strongly represented on the index.

2. METHODOLOGY AND DATA

The concept of cointegration is a good choice to investigate the links between two variables. Among the first important authors to deal with cointegration were Granger and Engle (1987), who pointed out that time series may behave differently over the short term, whereas the values

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have a tendency to return to a certain state of equilibrium over the long term, thereby demonstrating mutual ties between the two variables. The analyses conducted here involve observing the relationships between the primary interest rate of the respective central bank and the value of both stock indices and GDP in the selected countries.

The input data for 2009–2018 for interest rates were obtained from the official websites of the respective central banks (Danmarks Nationalbank, 2019; The Swiss National Bank, 2019; Sveriges Riksbank, 2019); GDP values were obtained from the OECD database (2019), and the performance of the blue chip stock indices was obtained from investment websites (Investing.com, 2019). All calculations were conducted using the Gretl 1.9.4 program. Table 2 contains abbreviations and descriptions of variables that were selected for use in the time series analysis.

To determine the causal relationship between the variables under examination, it was necessary to first test the time series for optimal lag length, next to verify the existence of a unit root (i.e., the stationarity or non-stationarity of the time series), and then to conduct cointegration analysis using the Engle-Granger cointegration test. The following authors have described the individual tests in more detail in their studies: Kočišová (2018), Gerlach and Svensson (2003), and Černohorský (2017).

Testing time series for the optimal lag length is one of the prerequisites for Granger testing. When analyzing time series, the goal is to find the lowest value for the selected information criterion. The lag length is determined by locating where the lowest value occurs for the information criterion. Lag lengths that have been established in this way are then used in subsequent testing. The choice of the appropriate criterion depends on the number of observations. According to Liew (2004) and Gottschalk et al. (2000), it is appropriate to use the Akaike information criterion to determine optimal lag length when the number of observations is small (less than 60). This can be expressed as follows (Akaike, 1981):

$$AIC = n \cdot \ln\left(\frac{RSS}{n}\right) + 2k, \tag{1}$$

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

Next, an analysis to determine the existence of a unit root was conducted; this determines the stationarity or non-stationarity of the time series being examined. Time series' stationarity or non-stationarity was determined using the Augmented Dickey-Fuller test (ADF test), in which all three types of test were conducted, i.e., with a constant, without a constant, and with a constant and a trend. When testing, it is assumed that the process listed below, i.e., (2), which tests whether Ø = 0 (the variable contains a unit root), takes the form (Dickey and Fuller, 1979):

$$\Delta X_t = (\O 1 - 1) X_{t-1} + \sum_{i=1}^{p} \alpha i X_{t-1} + e_t, \tag{2}$$

Table 2. Description of variables used for analysis

Source: Authors.

Variable abbreviation	Variable description
DK_IR	Interest rate of the Danmarks Nationalbank
SW_IR	Interest rate of the Sveriges Riksbank
CH_IR	Interest rate of the Swiss National Bank
DK_GDP	Gross domestic product, Denmark
SW_GDP	Gross domestic product, Sweden
CH_GDP	Gross domestic product, Switzerland
DK_IX	Stock index value, OMX Copenhagen 20
SW_IX	Stock index value, OMX Stockholm 30
CH_IX	Stock index value, SMI

where Xt again expresses the dependent variable, p – lag, and e_t – the residual component.

The determination whether the time series are stationary or non-stationary is made by evaluating the p-value at a 0.05 level of significance, which thus establishes whether the null hypothesis should be rejected or not with 95% confidence. The null hypothesis is set as follows:

H_0: *The tested time series are non-stationary (there is no unit root).*

H_1: *The tested time series are stationary (there is a unit root).*

If the time series achieve integration at the same level, it is then possible to proceed to the third step, cointegration analysis, which is conducted through the Engle-Granger cointegration test. Accordingly, error terms are also checked using the ADF test to determine if there is a unit root (Engle & Granger, 1987):

$$\Delta e_t = \O e_{t-1} + \sum_{i=1}^{p} \alpha_1 \Delta e_{t-i} + e_t, \quad (3)$$

where e_t are the estimated residuals and p is lag.

Two hypotheses were established for this purpose:

H_0: *The tested time series are not cointegrated.*

H_1: *The tested time series are cointegrated.*

Time series ratios were determined using the p-value, which was identified with the Engle-Granger cointegration test. When the null hypothesis is not rejected ($p > 0.05$), the time series are not cointegrated, that is, they have a unit root. The opposite situation ($p < 0.05$) indicates that the time series should be identified as cointegrated. The results of the Engle-Granger test were then used to decide whether to continue using the error correction model – if the time series were cointegrated, or to test for Granger causality – if we were working with non-cointegrated time series. Error correction models have dynamic specification, because they contain lagged values for the explained and explanatory variables. At the same time, they make it possible to interpret short-term changes in the model's dependent variable regarding its past equilibrium as well as changes in the explanatory independent variables.

When the time series are non-cointegrated, one can proceed to the Granger causality test, using the following hypotheses:

H_0: *The X_t variable does not Granger-cause the Y_t variable.*

H_1: *The X_t variable does Granger-cause the Y_t variable.*

3. EMPIRICAL RESULTS

As already presented in Section 3, it is necessary to test the time series for optimal lag length before using the Engle-Granger tests. The interest rate was established as the independent variable in this relationship; the dependent variables were GDP and the behavior of the stock indices.

3.1. Testing for optimal lag length

Mankiw (2014) states that within the economic theory, the optimal lag length for time series is between 12 and 18 months, which corresponds to six lags for quarterly data established. In Table 3, *AIC* values were recorded for 6 lag lengths for tests with a constant, with a trend, and with a constant and a trend depending on which type of test exhibited the minimum *AIC* value.

Table 3 shows that the lag length for GDP in Denmark is three quarters, using the test with a constant and a trend. For Swedish GDP, the lag is four quarters for the test with a constant. Swiss GDP has a resulting lag length of four quarters using the test with a constant and a trend.

The optimal lag length test (see Table 4) determined a lag of one quarter for the Danish and Swedish stock indices using the test with a constant. The Swiss stock index also had a resulting lag of one quarter, though using the test with a constant and with a trend. These results were considered when testing for time series stationarity (the ADF tests) and cointegration.

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Table 3. Results of optimal lag via *AIC* for interest rates and GDP

Source: Authors' own work based on the results of Gretl.

Lag length	*DK_GDP*		*SW_GDP*		*CH_GDP*	
	Test with a constant	Test with a constant and a trend	Test with a constant	Test with a constant and a trend	Test with a constant	Test with a constant and a trend
1	12.971	12.902	20.109	20.112	15.948	15.692
2	13.028	12.963	20.105	20.139	16.007	15.734
3	12.984	12.783	20.132	20.185	15.842	15.743
4	13.045	12.838	20.028	19.966	15.898	15.672
5	13.104	12.900	20.090	19.959	15.768	15.707
6	13.163	12.961	20.096	20.016	15.830	15.721

Table 4. Results of optimal lag via *AIC* for interest rates and blue chip stock indices

Source: Authors' own work based on the results of Gretl.

Lag length	DK_IX		SW_IX		CH_IX	
	Test with a constant	Test with a constant and a trend	Test with a constant	Test with a constant and a trend	Test with a constant	Test with a constant and a trend
1	10.751	10.812	11.799	11.861	14.935	14.917
2	10.811	10.871	11.844	11.906	14.983	14.963
3	10.872	10.932	11.901	11.963	15.042	15.017
4	10.908	10.970	11.860	11.914	15.034	14.999
5	10.970	11.032	11.870	11.898	15.092	15.057
6	11.021	11.082	11.913	11.914	15.129	15.085

3.2. Testing for data stationarity

To verify whether the time series were stationary or not, the ADF test was used. The models with a constant or a trend were introduced into the ADF test depending on the results of optimal lag testing, i.e., the minimum *AIC* value. Table 5 depicts the resulting *p*-values and shows that all *p*-values are greater than the 0.05 level of significance, which means that the time series are non-stationary; therefore, the null hypotheses were not rejected. To achieve time series stationarity, it was necessary to conduct differencing using the first difference.

The results of the ADF tests for the differenced time series are shown in Table 6. Time series were tested for stationarity or non-stationarity at the same lag length using the same type of test (with a constant or a trend) as for the original time series.

Even after conducting the first difference, certain time series remained non-stationary. These were

Table 5. The results of the ADF test

Source: Authors' own work based on the results of Gretl.

Time series	*p*-value	H_0	Evaluation of ADF test results
DK_GDP	0.7956	Not rejected	Time series non-stationary
DK_IR	0.1915	Not rejected	Time series non-stationary
SW_GDP	0.9635	Not rejected	Time series non-stationary
SW_IR	0.827	Not rejected	Time series non-stationary
CH_GDP	0.2192	Not rejected	Time series non-stationary
CH_IR	0.4186	Not rejected	Time series non-stationary
DK_IX	0.6321	Not rejected	Time series non-stationary
DK_IR	0.2223	Not rejected	Time series non-stationary
SW_IX	0.2844	Not rejected	Time series non-stationary
SW_IR	0.7532	Not rejected	Time series non-stationary
CH_IX	0.8985	Not rejected	Time series non-stationary
CH_IR	0.6745	Not rejected	Time series non-stationary

Table 6. The results of the ADF test – the first difference

Source: Authors' own work based on the results of Gretl.

Time series	*p*-value	H_0	Evaluation of ADF test results
d_DK_GDP	0.3475	Not rejected	Time series non-stationary
d_DK_IR	0.02625	Rejected	Time series stationary
d_SW_GDP	0.002306	Rejected	Time series stationary
d_SW_IR	0.03311	Rejected	Time series stationary
d_CH_GDP	0.1612	Not rejected	Time series non-stationary
d_CH_IR	0.3738	Not rejected	Time series non-stationary
d_DK_IX	0.00083	Rejected	Time series stationary
d_DK_IR	3.866e-005	Rejected	Time series stationary
d_SW_IX	0.0001	Rejected	Time series stationary
d_SW_IR	0.06292	Not rejected	Time series non-stationary
d_CH_IX	2.112e-005	Rejected	Time series stationary
d_CH_IR	2.989e-006	Rejected	Time series stationary

Table 7. The results of the ADF test – the second difference

Source: Authors' own work based on the results of Gretl.

Time series	*p*-value	H_0	Evaluation of ADF test results
d_d_DK_GDP	0.02763	Rejected	Time series stationary
d_d_CH_GDP	0.009809	Rejected	Time series stationary
d_d_CH_IR	0.01162	Rejected	Time series stationary
d_d_SW_IR	5.161e-006	Rejected	Time series stationary

the series of *DK_GDP*, *CH_GDP*, *CH_IR* (for *GDP*), and *SW_IR*. It was necessary to conduct a second difference for these time series. Testing was done using the same lag length and same type of test as for the original time series.

Conducting the ADF test for the second difference of the selected time series resulted in all the time series becoming stationary (Table 7). This fact can also be verified via the graphic path of the time series' second difference (Figure 1).

The time series modified in this way were stationary at the level of significance ($p < 0.05$), i.e., they have a unit root. All of the stationary time series were subsequently included in the Engle-Granger cointegration test.

Source: Authors' own work based on the results of Gretl.

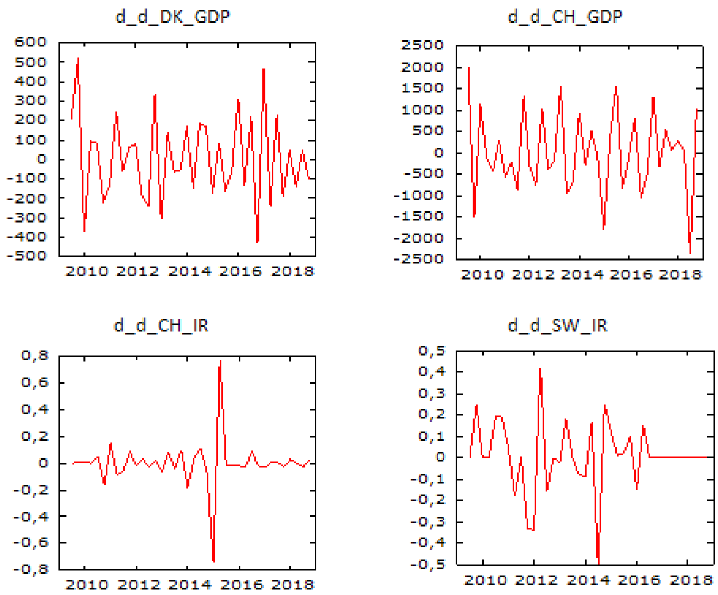

Figure 1. The course of development of the time series – the second difference

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3.3. Determining interdependence of the time series using the Engle-Granger cointegration test

The previous test determined that the original time series were non-stationary, and after modification by differencing, it was then found that some of the time series have the same order of stationarity. For these time series, it was possible to proceed to the Engle-Granger cointegration test, which assumes that the original time series are non-stationary (Table 5). Table 8 shows the relationship between the given pairs of time series, which were specified as fixed).

The determined *p*-value, which had values higher than the set level of significance ($p > 0.05$), show that the time series under examination are not cointegrated, i.e., there are no long-term relationships between them for any of the three countries being studied. In terms of determining the results of the ADF and Engle-Granger cointegration tests, causal relationships were determined by Granger causality – not with the error correction model that assumes the time series are cointegrated.

3.4. Granger causality for interest rates and other variables studied

When testing for Granger causality, as with cointegration, variables were tested for their effect in both directions. Based on the calculations, one can conclude that all the countries showed only a one-directional effect, which was always the interest rate's impact on GDP (Table 9). For relevant results, this study is interested in the *p*-values at 0.05 (**) and 0.01 (***) levels of significance, rather than *p*-values at a 0.1 (*) level of significance.

For Denmark, it was determined that the interest rate variable Granger-causes GDP at a lag length of two quarters; for Sweden, this caused a lag of three and five quarters; and there were lags of two and four quarters for Switzerland. It can thus be stated that interest rates in Denmark, Sweden, and Switzerland influenced GDP of their countries between 2009 and 2018 at the above lag lengths. This means that the accuracy of GDP forecasting can be improved by using the evolution of interest rates in the given country.

Similarly, the paper further tested Granger causality for the variables being studied. Based on these tests, no effect was found for Danish, Swedish, or Swiss interest rates and their corresponding blue chip stock indices. The *p*-value was greater than 0.05 for all the lag lengths tested, and it was, therefore, not possible to reject the null hypothesis in any of the cases. From this, one can conclude that there are no short-term causal relationships (Table 10).

On the basis of the analyses, it was found that there were no long-term correlations between interest rates and GDP or stock indices in the countries studied for the examined period. Other authors, Khatkhate (1988), Arestis and Sawyer (2003), and Wu and Xia (2016), also came to the same conclusion, i.e., they could not find a relationship between interest rate and GDP. The use of Granger causality allowed proving short-term correlation between interest rates and GDP for all the countries studied, though not between interest rates

Table 8. The results of the Engle-Granger cointegration test

Source: Authors' own work based on the results of Gretl.

Time series	*p*-value	H_0	Evaluation of EG test results
DK_IR/DK_GDP	0.09033	Not rejected	No cointegration
DK_GDP/DK_IR	0.8922	Not rejected	No cointegration
SW_IR/SW_GDP	0.353	Not rejected	No cointegration
SW_GDP/SW_IR	0.3692	Not rejected	No cointegration
CH_IR/CH_GDP	0.6721	Not rejected	No cointegration
CH_GDP/CH_IR	0.4209	Not rejected	No cointegration
DK_IR/DK_IX	0.1613	Not rejected	No cointegration
DK_IX/DK_IR	0.4393	Not rejected	No cointegration
SW_IR/SW_IX	0.6027	Not rejected	No cointegration
SW_IX/SW_IR	0.136	Not rejected	No cointegration
CH_IR/CH_IX	0.7343	Not rejected	No cointegration
CH_IX/CH_IR	0.6743	Not rejected	No cointegration

Table 9. The results of the Granger causality test for interest rates and GDP

Source: Authors' own work based on the results of Gretl.

	DK_IR/DK_GDP	*p*- value	*	H_0	DK_GDP/DK_IR DK_IR	*p*- value	*	H_0
Denmark	d_DK_GDP_1	0.7125		Not rejected	d_DK_IR_1	0.4934		Not rejected
	d_DK_GDP_2	0.0189	**	Rejected	d_DK_IR_2	0.6826		Not rejected
	d_DK_GDP_3	0.6491		Not rejected	d_DK_IR_3	0.5085		Not rejected
	d_DK_GDP_4	0.5142		Not rejected	d_DK_IR_4	0.0544	*	Not rejected
	d_DK_GDP_5	0.4285		Not rejected	d_DK_IR_5	0.2356		Not rejected
	d_DK_GDP_6	0.3995		Not rejected	d_DK_IR_6	0.736		Not rejected
	SW_IR/SW_GDP	***p*- value**	*	H_0	**SW_GDP/SW_IR**	***p*- value**	*	H_0
Sweden	d_SW_GDP_1	0.6021		Not rejected	d_SW_IR_1	0.1733		Not rejected
	d_SW_GDP_2	0.4088		Not rejected	d_SW_IR_2	0.3689		Not rejected
	d_SW_GDP_3	0.0252	**	Rejected	d_SW_IR_3	0.4891		Not rejected
	d_SW_GDP_4	0.9576		Not rejected	d_SW_IR_4	0.7863		Not rejected
	d_SW_GDP_5	0.0495	**	Rejected	d_SW_IR_5	0.1613		Not rejected
	d_SW_GDP_6	0.635		Not rejected	d_SW_IR_6	0.6101		Not rejected
	CH_IR/CH_GDP	***p*- value**	*	H_0	**CH_GDP/CH_IR**	***p*- value**	*	H_0
Switzerland	d_CH_GDP_1	0.2755		Not rejected	d_CH_IR_1	0.3975		Not rejected
	d_CH_GDP_2	0.0471	**	Rejected	d_CH_IR_2	0.7955		Not rejected
	d_CH_GDP_3	0.0995	*	Not rejected	d_CH_IR_3	0.9533		Not rejected
	d_CH_GDP_4	0.0141	**	Rejected	d_CH_IR_4	0.879		Not rejected
	d_CH_GDP_5	0.493		Not rejected	d_CH_IR_5	0.9006		Not rejected
	d_CH_GDP_6	0.2849		Not rejected	d_CH_IR_6	0.5293		Not rejected

Table 10. The results of the Granger causality test for interest rates and blue chip stock indices

Source: Authors' own work based on the results of Gretl.

	DK_IR/DK_IX	*p*-value	*	H_0	DK_IX/DK_IR	*p*-value	*	H_0
Denmark	d_DK_IX_1	0.5432		Not rejected	d_DK_IR_1	0.3434		Not rejected
	d_DK_IX_2	0.8557		Not rejected	d_DK_IR_2	0.8800		Not rejected
	d_DK_IX_3	0.6075		Not rejected	d_DK_IR_3	0.3278		Not rejected
	d_DK_IX_4	0.6230		Not rejected	d_DK_IR_4	0.1250		Not rejected
	d_DK_IX_5	0.8482		Not rejected	d_DK_IR_5	0.1940		Not rejected
	d_DK_IX_6	0.4706		Not rejected	d_DK_IR_6	0.7624		Not rejected
	SW_IR/SW_IX	***p*-value**	*	H_0	**SW_IX/SW_IR**	***p*-value**	*	H_0
Sweden	d_SW_IX_1	0.3086		Not rejected	d_SW_IR_1	0.1808		Not rejected
	d_SW_IX_2	0.3441		Not rejected	d_SW_IR_2	0.6980		Not rejected
	d_SW_IX_3	0.9735		Not rejected	d_SW_IR_3	0.3354		Not rejected
	d_SW_IX_4	0.4011		Not rejected	d_SW_IR_4	0.4749		Not rejected
	d_SW_IX_5	0.4014		Not rejected	d_SW_IR_5	0.2045		Not rejected
	d_SW_IX_6	0.3188		Not rejected	d_SW_IR_6	0.4203		Not rejected
	CH_IR/CH_IX	***p*-value**	*	H_0	**CH_IX/CH_IR**	***p*-value**	*	H_0
Switzerland	d_CH_IX_1	0.4016		Not rejected	d_CH_IR_1	0.7253		Not rejected
	d_CH_IX_2	0.6987		Not rejected	d_CH_IR_2	0.5495		Not rejected
	d_CH_IX_3	0.2396		Not rejected	d_CH_IR_3	0.9435		Not rejected
	d_CH_IX_4	0.9679		Not rejected	d_CH_IR_4	0.7043		Not rejected
	d_CH_IX_5	0.9101		Not rejected	d_CH_IR_5	0.6681		Not rejected
	d_CH_IX_6	0.0672	*	Not rejected	d_CH_IR_6	0.7041		Not rejected

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and stock indices. These results, relating to the inability to find any relationships between interest rates and stock indices in any of the surveyed countries, contradict the findings of other authors (e.g., Levine & Zervos, 1996; Lee, 1992 and Cole, Mhirian, & Wu, 2017). These conflicting results may have been caused by specific conditions in Sweden, Denmark, and Switzerland, because, unlike other studies, all these countries had negative interest rates during the period analyzed.

CONCLUSION

As noted above, there were no long-term relationships between interest rates and economic activity in Sweden, Denmark, and Switzerland during 2009–2018. Only short-term relationships between interest rates and GDP were confirmed. The issue of setting negative interest rates is very difficult to evaluate, as factors that arise outside the individual economy are part of the decision making process of central bank monetary policy. First of all, it concerns the dependence on the European Central Bank's monetary policy. As mentioned earlier, Sweden's central bank was the first to use negative interest rates as part of the fight against the effects of the financial crisis. With inflation targeting today, very low unemployment and economic growth naturally address the question of how to normalize monetary policy. Of course, this is not easy when you raise interest rates, while your main partner (the Eurozone) does the opposite. This can result in a situation where the weak Swedish krona (against the euro and the dollar) can rise sharply due to the difference in interest rates and thus threaten economic growth. Denmark has its own currency, but it is pegged to the euro, which essentially forces it to copy the European Central Bank's interest rates. Even the situation in Switzerland is linked to the global economy. The franc limit was dropped due to expectations of quantitative easing by the European Central Bank; without a significant reversal in developments in the Eurozone, the Swiss Central Bank has no room for maneuver. Therefore, it is currently forced fight against deflation using only negative interest rates. It first tried to avoid deflationary pressures by appreciating the Swiss franc by applying an exchange rate peg that plunged global financial markets into chaos. Investors did not expect this step at all, and the situation was not even helped by eliminating the peg in 2015, when the franc began to appreciate once more. Eventually abolishing the negative rates will subsequently cause enormous appreciation pressures.

When the basic interest rates of the given central banks are lowered, the transmission mechanism's interest rate channel, which affects the economy, should result in lowering interest rates on the interbank market, which can lead to lowered interest rates announced by banks. The outcome should be a revival of aggregate demand and its related economic activity. At the beginning of the period examined before the onset of the financial crisis, these central banks pursued a conventional monetary policy using changes in interest rates. Naturally, during the financial crisis, it turned out that all the central banks examined here decided to use unconventional monetary policy of negative interest rates as one of their tools, which did not naturally result in supporting the growth of economic activity. There are many negative impacts of negative interest rates, e.g. taking liquidity risk, especially when investors' capital is at risk in ways, which may not seem obvious to retail investors. Negative interest rates can distort financial markets and increase the risk of financial instability for a long time. These findings certainly do not preclude the possibility that negative interest rates could have long- or short-term impact on other economic variables in the selected countries or in others (such as, the price level or exports), which is a topic that may be the subject of future research.

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