IDENTIFICATION OF SIMPLE MONETARY POLICY RULES WITH THE USE OF HEURISTIC METHODS OF DATA ANALYSIS

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Summary

The paper deals with the problem of modelling simple monetary policy rules, example of which is the Taylor rule, which is widely present in the literature of macroeconomics. More precisely, the aim of this paper is realized through verification whether the monetary policy that is carried out by central banks (reduced to setting of nominal short-term interest rate) may be in a statistically significant way modelled in the form of simple decision rules based on macroeconomic variables. Apart from generating monetary policy rules, the paper also aims at verifying the impact of global economic crisis of 2008-2009 on their stability as well as identifying the differences between monetary policy rules for various central banks.

The paper makes use of heuristic methods of data analysis (data mining) as they enable identification of relations in data sets without preliminary hypotheses, which is the aim of this paper. The cases of three central banks are analyzed: the National Bank of Poland, the European Central Bank and the US Federal Reserve.

The best rules as regards both statistical significance and economic interpretation are rules generated for the Federal Reserve, whereas the results for the other central banks are unsatisfactory. It was also established that simple monetary policy rules are significantly destabilized in the period of the global economic crisis of 2008-2009.

Keywords: central bank, interest rate, Taylor rule, direct inflation target, decision tree, kappa statistic.

1. Introduction

The aim of this paper is the identification of monetary policy rules concerning the level of central banks’ interest rates with the use of data mining methods.

The analysis of literature on monetary policy proves the existence of the unsettled problem of effectiveness of various models of monetary authorities’ actions. The modelling of these actions, that is the decision-making processes that lead to the changes of monetary policy parameters, is subject of great interest in economics due to the fact that monetary policy (understood as control over the quantity and price of money in the economy), is, along with fiscal policy, the basic tool of economic stimulation.

In this paper the controlled by the central bank short term interest rate is considered the main instrument of monetary policy, which is in line with the standard adopted by central banks in most of the developed countries at the end of 20th century. The short term interest rate expresses the cost of capital in the economy, which has considerable impact on the key macroeconomic variables.
Interest rate cuts stimulate current consumption as lower capital cost means lower saving inclination and therefore lower alternative cost of today’s consumption. Lower cost of money is also a positive stimulus for investment in the economy because under eased credit conditions more potential investments become profitable (the required return rate is lower). This proves that the short term interest rate may be a tool used for stabilization of business cycle fluctuations.

In relation to the significant role of monetary environment in the economy there is a field of research in economics that deals with monetary policy rules, that is procedures, according to which central banks take decisions on interest rates. Monetary policy rules are divided into two groups: simple and complex ones.

Simple monetary rules are rules according to which central banks’ decisions result from short uncomplicated algorithms based on historical values of macroeconomic variables. In turn, complex monetary rules are algorithms that model a far more complicated decision-making process based on forecasts of macroeconomic variables.

As far as simple monetary rules are concerned, the breakthrough achievement in this field was the Taylor rule, which was estimated for the US economy, see [14]. It relates the level of nominal interest rate with the size of the economy’s output gap (deviation of GDP from its potential level) and inflation gap (deviation of inflation from its target level).

The other group of monetary policy rules are complex rules. As it was mentioned above, complex rules are based on forecasts of macroeconomic variables. The most popular example of this approach is the policy of direct inflation target, which has been adopted by many central banks all around the world.

The question whether the direct inflation target policy may be called a policy rule was considered by Bernanke and Mishkin in [1], who concluded that it is not a classic type of monetary rule due to a high degree of discretion within it, which concerns the concrete actions that should be taken in order to induce a desired level of inflation in the medium term. This discretion is an inherent element of complex monetary policy rules and is the key feature that distinguishes complex rules from simple ones, in case of which decisions are unambiguously determined by the macroeconomic environment.

This paper concentrates on simple monetary policy rules. Due to their simplicity they have much greater potential than complex rules in the process of shaping expectations of the future monetary policy among the participants of the economic system. They have especially great significance for financial markets, where the situation is closely related with the central banks’ monetary policy. The existence of efficient monetary policy rules contributes to greater transparency and stability of financial markets as well as supports the efficient market hypothesis, see [4].

More precisely, the aim of this paper is realized by verification whether the central banks’ monetary policy (understood as setting the short term nominal interest rate) may be modelled in a statistically significant way by economically interpretable simple rules based on macroeconomic variables. Apart from generation of monetary policy rules, the aim of the paper is also verification of the impact of the global financial and economic crisis of 2008-2009 on their stability and identification of differences between monetary rules for various central banks.

In relation to the fact that within the framework of traditionally used in macroeconomics statistical and econometric methods it is only possible to verify research hypotheses that are set a priori, this paper makes use of heuristic methods of data analysis as they enable identification of rules within data sets without preliminary hypotheses, which is the aim of this research. The
advantage of such an approach is much greater elasticity of analysis as well as the possibility of identification of a wider class of relations within the data sets than in the case of statistical and econometric methods.

The research was carried out with the use of the computer program WEKA 3.7.0. The cases of three economies were analyzed: Poland, the eurozone and the USA.

The layout of the paper is the following. Chapter 2 discusses the heuristic methods of data analysis as well the data that were used in the research. Chapter 3 shows and discusses monetary rules generated for various central banks, along with the sensitivity analysis of their statistical efficiency to the changes within the procedure of their creation. Chapter 4 sums up the identified monetary rules and suggests new research directions.

2. Monetary rules and heuristic methods of data analysis

Results of decision rules identification are strictly related with the employed model estimation measures. Data-mining methods are implemented in this paper and precisely three classification algorithms: OneR, JRip, J48 (see section 2.1).

The statistical quality of models was evaluated with the use of the kappa statistic (see section 2.2).

Within the research the monetary rules were generated for three central banks: the National Bank of Poland, the US Federal Reserve and the European Central Bank (see section 2.3).

2.1. Econometric methods vs. data-mining

Econometric models seem to be the most reliable tool of economic data analysis and thus, they dominated the economic research, see Kothari and Warner (2004). The Taylor rule is the primary example of this approach in the field of monetary rules estimation. However, econometric and statistical procedures require numerous assumptions that could be summed up as data regularity, which are often not met (e.g. data completeness, homoscedasticity or lack of autocorrelation of random errors). Such restrictions are not necessary in the case of heuristic methods of data analysis (data-mining). What’s more, data-mining enables to seek potential scientific hypotheses in the data set without the need to formulate them a priori. It is useful in the case of the analysis of a large number of variables and not easily discerned patterns. In contrast, econometric procedures are used to test hypothesis that are assumed a priori. These are the reasons for the substitution of econometrics with heuristic methods of data analysis in this paper.

A wide class of procedures is used within data-mining, including neural networks, see [11], genetic and evolutionary algorithms, see [7], decision trees and simulated annealing, see [6].

In this research from among various methods employed within data-mining we selected decision trees. This choice was made for two reasons. Firstly, rules generated with the use of decision tree algorithms are usually simple and easy to interpret. Secondly, the procedures in question are appropriate for modelling decision-making processes for they emulate the process of human perception.

Three algorithms implemented in the computer program WEKA 3.7.0 were used to generate decision trees: OneR, JRip, J48.
2.2. Statistical evaluation of rules

The kappa statistic serves as the primary measure of statistical quality of the generated rules, see [13]. It informs how far the constructed model is better than a random predictor. It can take values between -1 and 1, where positive values mean the model is better than the random predictor and negative values mean it is worse. Generally, values of kappa statistic higher than 0.3 are perceived as acceptable.

The procedure of kappa statistic calculation is depicted in the example of tables 2.2 and 2.3.

Table 2.2. Confusion matrix of a hypothetical rule

<table>
<thead>
<tr>
<th>Predicted class</th>
<th>-0.5</th>
<th>-0.25</th>
<th>0</th>
<th>0.25</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>-0.25</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>72</td>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>0.25</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>total</td>
<td>0</td>
<td>1</td>
<td>93</td>
<td>2</td>
<td>96</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

Table 2.3. Confusion matrix of the corresponding random predictor

<table>
<thead>
<tr>
<th>Predicted class</th>
<th>-0.5</th>
<th>-0.25</th>
<th>0</th>
<th>0.25</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.5</td>
<td>0</td>
<td>0.01</td>
<td>0.97</td>
<td>0.02</td>
<td>1</td>
</tr>
<tr>
<td>-0.25</td>
<td>0</td>
<td>0.09</td>
<td>8.72</td>
<td>0.19</td>
<td>9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.78</td>
<td>72.66</td>
<td>1.56</td>
<td>75</td>
</tr>
<tr>
<td>0.25</td>
<td>0</td>
<td>0.11</td>
<td>10.66</td>
<td>0.23</td>
<td>11</td>
</tr>
<tr>
<td>total</td>
<td>0</td>
<td>1</td>
<td>93</td>
<td>2</td>
<td>96</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

Tables 2.2 and 2.3 show the so-called confusion matrices for a hypothetical rule and random predictor accordingly. The class variable (y) represents the decision of monetary authorities concerning interest rates. The bolded value 72 in the table 2.2 means that 72 instances (out of 75) with the actual class y=0 (interest rates kept unchanged) were classified correctly. The value 11 (bolded as well) determines that 11 instances with the actual class y=0.25 were classified wrongly as belonging to the class y=0.

On the basis of the confusion matrix from table 2.2 the random predictor confusion matrix is created (table 2.3). The number of instances from each predicted class is distributed into the ‘real’ subgroups (vertically) according to the empirically estimated actual distribution of the class y in each predicted class. As an example, the bolded value 72.66 in the random predictor confusion matrix is calculated as follows:

\[ 72.66 = \frac{75}{96} \times 93 \]  

The hypothetical model classifies correctly 72 instances, whereas the random one 73. Hence, the kappa statistic is calculated in this case as follows:
Identification of simple monetary policy rules with the use of heuristic methods of data analysis

\[ \kappa = \frac{72 - 73}{96 - 73} = -0.043 \] (2.2)

The negative value of the kappa statistic means the hypothetical rule is statistically less significant than the random predictor, which makes it unacceptable.

2.3. Data

The cases of three central banks were researched in this paper: the National Bank of Poland (NBP), the US Federal Reserve (Fed) and the European Central Bank (ECB). The key factor in the selection of cases for the analysis was the diversity in terms of monetary policy in order to ensure maximal variety of the generated monetary rules.

Firstly, the above-mentioned central banks represent different monetary policy targets – the NBP and the ECB represent the direct inflation target policy in contrast to the Federal Reserve, which does not have a quantified inflation target. Secondly, Poland has a relatively short history of the free market economy, whereas the USA and the eurozone countries have much greater experience of running the monetary policy in market conditions.

The analysis encompasses years 2000-2009 – such a selection of sample is justified by one of the aims of the research, which is the identification of influence of the financial and economic crisis of 2008-2009 on the stability of monetary policy rules (the time range of the analysis includes the period of the crisis as well as the period directly before it).

In the models of monetary policy rules we constructed the explanatory variables (attributes) are macroeconomic variables that most often appear in the statements of the monetary authorities as the key factors for the monetary policy. Because of the fact that for all three central banks these are the same or very similar variables, the same set of variables is used for all three cases in order to simplify the analysis. The selected variables are: industrial output, retail sales, harmonized unemployment rate, GDP, investment, private consumption, CPI and PPI inflation, foreign exchange rate\(^{13}\). In the case of most variables their annual dynamics is used. The only exceptions are foreign exchange rate (monthly dynamics\(^{14}\)) and unemployment rate (level). The frequency of the variables GDP, private consumption and investment is quarterly, whereas in all other cases it is monthly. In the analysis lagged explanatory variables were used as well (cases with a maximum of two lags of all variables were tested).

The response variable is the change of the central bank’s reference rate expressed in percentage points (e.g. -0.5 pp., 0 pp., +0.25 pp. etc.).

All the macroeconomic data used in the analysis come from the OECD database, whereas the data on the central banks’ reference rates come directly from the central banks.

The single instance in the constructed models is a set of macroeconomic data known to the members of monetary authorities at the moment of their meeting on interest rates, along with the corresponding decision on rates.

Because each central bank has its own schedule of monetary policy meetings (8 meetings a year in the case of the Fed and monthly meetings of both the NBP and the ECB; apart from that each central bank has also its special meetings), despite the same time range the case of every central bank has its own number of instances.

\(^{13}\) In the Appendix 1 the precise definitions of the variables used in the analysis along with their abbreviations are given.
\(^{14}\) Monthly dynamics compares the variable’s level from a certain month with the level from the previous month.
In order to verify the impact of the financial and economic crisis of 2008-2009 on the stability of monetary policy rules, in the case of each central bank the rules were generated for two samples: the first one limited to the period before the crisis and the second one that is the sum of the first one and the period of the crisis. Then, results from these two samples were compared.

3. Simple monetary rules

This section presents the generated monetary rules. They were selected according to two desirable features: economic meaningfulness and statistical accuracy.

Section 3.1 deals with the rules constructed with the use of OneR algorithm, section 3.2 – Jrip and section 3.3 – J48. Section 3.4 focuses on the sensitivity analysis of the statistical efficiency of generated rules to the changes within the procedure of their creation.

3.1. OneR

Rules generated with the OneR algorithm proved to be unstable across the investigated countries. Thus, there are different determinants of monetary councils’ decisions in the USA, the eurozone and Poland.

The most economically meaningful rule was achieved in the case of NBP, see formula 3.1.

\[
\begin{align*}
\text{CPI:} \\
< 0.65 & \rightarrow -0.25 \\
< 11.15 & \rightarrow 0 \\
\geq 11.15 & \rightarrow 1.5
\end{align*}
\]  

(3.1)

According to the rule depicted in formula 3.1, the Polish MPC decreases interest rates by 25 basis points as a response to lower than 0.65% CPI inflation. If CPI dynamics is between 0.65% and 11.15%, the rates remain unchanged and in the case of inflation higher than 11.15% the MPC hikes the rates by 150 basis points.

The rule generated is consistent with the economic theory. In order to stop excessive price increase, the MPC raises interest rates and cuts them when inflation is too low. The kappa statistic of this rule amounts to 0.14, which means its statistical significance is not acceptable.

The model generated for the USA (see formula 3.2) is substantially better as far as its statistical quality is concerned (its kappa statistic exceeds 0.47). Nevertheless, the model does not fulfil the requirement of economic meaningfulness.

\[
\begin{align*}
\text{UNP_RATE:} \\
< 4.65 & \rightarrow 0 \\
< 5.65 & \rightarrow 0.25 \\
\geq 5.65 & \rightarrow 0
\end{align*}
\]  

(3.2)

It follows from the model in formula 3.2 that in the case of unemployment rate lower than 4.65% and higher than 5.65% the Fed should keep interest rates level unchanged. In other cases, the Fed hikes rates by 25 basis points. Such an outcome is inconsistent with the theory of economy as according to this rule there are no conditions, under which the central bank should cut rates (even in the case of extremely high unemployment). However, it must be underlined that the designation of unemployment rate as the explanatory variable is in line with the Fed’s policy target, which is, among others, promotion of full employment.

The rule generated for the ECB was neither economically meaningful nor statistically significant.
3.2. JRip

In the case of JRip classifier the most satisfactory in terms of statistical significance were the rules generated for the Fed, see formula 3.3.

\[
\begin{align*}
\text{RET\_SLS} & < 0.1 \quad \text{and} \quad \text{RET\_SLS-1} < 0.5 \quad \Rightarrow \quad \text{DEC} = -0.5 \\
\text{INVEST} & > 4.3 \quad \text{and} \quad \text{PPI} > 4.5 \quad \Rightarrow \quad \text{DEC} = 0.25 \\
\Rightarrow & \quad \text{DEC} = 0
\end{align*}
\]  

(3.3)

According to the JRip rule for the USA, if the retail sales annual dynamics was lower than 0.1% last month and lower than 0.5% in the month before, then the Fed should cut interest rates by 50 basis points. In turn, investment dynamics of 4.3% or more in the last quarter and PPI inflation of more than 4.5% last month determines interest rate hike by 25 basis points. In the other cases the Fed should keep rates unchanged.

The rule should be considered as satisfactory in terms of statistical quality as its kappa statistic is at 0.49. The model is also in line with the theory of economy as it suggests interest rate cuts during the economy’s sluggishness periods and rate hikes when the economy is in the full swing. This way the rule defines conditions both for rate hikes and cuts, which the OneR rule for the USA lacked.

The monetary rule generated with the JRip algorithm for the eurozone is to some extent economically meaningful, however it is not reliable from the statistical point of view.

\[
\begin{align*}
\text{IND\_PRD} & < -18.64 \quad \Rightarrow \quad \text{DEC} = -0.25 \\
\text{INVEST} & < 1.26 \quad \text{and} \quad \text{FX\_MOM} > -0.7 \quad \text{and} \quad \text{CONS} < 1.42 \quad \Rightarrow \quad \text{DEC} = -0.5 \\
\Rightarrow & \quad \text{DEC} = 0
\end{align*}
\]  

(3.4)

As the rule in formula 3.4 implies, the ECB cuts interest rates by 25 basis points if industrial production dynamics is below 18.64%. If investment growth rate is below 1.26%, the euro depreciates or appreciates against the US dollar by less than 0.7% and private consumption dynamics is below 1.42%, then the ECB lowers the reference rate by 50 basis points. In the other cases the rates remain unchanged. The rule is only partly consistent with the economic theory – firstly, rate cuts are not a good reaction to the domestic currency’s depreciation (such a move may only deepen the currency’s losses) and secondly, the rule lacks the definition of conditions in which the ECB should tighten the monetary policy (that is hike interest rates). What’s more, the statistical significance of this rule is very low (kappa statistic at 0.02), which makes it unacceptable.

In the case of Poland the JRip rules turned out statistically insignificant and lacked proper economic interpretation.

3.3. J48

No satisfactory rules were generated with the use of the J48 algorithm. The generated rules were mostly long and complex, which made their economic interpretation impossible. Therefore, the J48 algorithm seems to be an inappropriate tool for the problem considered in this paper.

3.4. Statistical efficiency of monetary rules and the procedure of their generation

In this section we analyze the impact of various elements of the monetary rules generation procedure on their statistical efficiency (assessed by the statistic kappa). Table 3.1 presents the
kappa indicators for monetary rules that were generated for different configurations of its
generation procedure elements.

The above-mentioned elements are:
- sample (time range),
- algorithm of rule generation,
- set of explanatory variables.

As far as the time range is concerned, two samples were used in the analysis: the first ranging
over years 2000-2009 (full sample) and the second limited to the period before the 2008-2009
crisis that is the years 2000-2007 (pre-crisis sample). As to the algorithms of rule generation,
OneR, JRip and J48 algorithms were used. In the case of explanatory variables’ sets three different
sets were distinguished on the basis of the number of lags taken into account (sets with
a maximum of two lags were considered).

Table 3.1. Sensitivity of rules’ statistical quality to elements of rule generation procedure

<table>
<thead>
<tr>
<th>Sample</th>
<th>Algorithm</th>
<th>Set of explanatory variables</th>
<th>USA</th>
<th>Eurozone</th>
<th>Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-crisis sample</td>
<td>OneR</td>
<td>0 lags</td>
<td>0.474</td>
<td>-0.048</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.474</td>
<td>0.064</td>
<td>0.206</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.490</td>
<td>0.064</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>JRip</td>
<td>0 lags</td>
<td>0.381</td>
<td>0.007</td>
<td>0.252</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.485</td>
<td>-0.037</td>
<td>0.103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.367</td>
<td>-0.058</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>J48</td>
<td>0 lags</td>
<td>0.434</td>
<td>-0.001</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.449</td>
<td>-0.019</td>
<td>0.086</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.492</td>
<td>-0.045</td>
<td>0.134</td>
</tr>
<tr>
<td>Full sample</td>
<td>OneR</td>
<td>0 lags</td>
<td>0.216</td>
<td>0.007</td>
<td>0.143</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.215</td>
<td>0.038</td>
<td>0.155</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.257</td>
<td>0.038</td>
<td>0.143</td>
</tr>
<tr>
<td></td>
<td>JRip</td>
<td>0 lags</td>
<td>0.325</td>
<td>0.024</td>
<td>0.109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.430</td>
<td>-0.019</td>
<td>0.204</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.423</td>
<td>0.022</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>J48</td>
<td>0 lags</td>
<td>0.310</td>
<td>0.041</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 lag</td>
<td>0.284</td>
<td>-0.026</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lags</td>
<td>0.367</td>
<td>-0.036</td>
<td>0.078</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

The analysis of table 3.1 allows to determine two significant relations. Firstly, the most
statistically effective rules were generated in the case of the USA – their kappa statistics are
considerably higher than in the case of the monetary rules for the eurozone and Poland. As
a matter of fact, only for the USA the generated monetary rules’ kappa indicators are at acceptable
levels, whereas for the other countries they are definitely unacceptable (in the case of the eurozone
they are even negative). Such a low statistical quality of monetary rules for European central banks
is, however, no surprise. The reason is the fact that European central banks run the policy of direct inflation target, which is a complex monetary policy rule. Taking this into account it is understandable that no simple rule could be generated in their case. In turn, the USA is a country with a strong tradition of simple monetary policy rules in the academic society (the Taylor rule was originally estimated for the Fed’s monetary policy). Hence, the rules generated for the Fed have relatively good statistical quality.

The second important relation that can be seen in the table 3.1 is the fact that rules created for the pre-crisis sample (years 2000-2007) have generally higher kappa statistics than the ones generated for the full sample (2000-2009). It is visible in the case of the USA and Poland, only for the eurozone there is no clear relation in this respect. Such a result suggests that the economic crisis significantly destabilizes the monetary policy rules. It is fully in accordance with the practice of monetary policy during the 2008-2009 financial crisis, when the major central banks were forced to change their policy very deeply (among others, new monetary policy instruments were introduced in order to inject large amounts of liquidity into financial markets).

4. Concluding remarks

In the analysis simple monetary policy rules were generated for three selected economies: Poland, the eurozone and the USA. The rules illustrate the decision-making process of monetary authorities concerning the changes of interest rates’ level on the basis of macroeconomic conditions. Most of the generated rules proved statistically insignificant or lacked economic interpretation. The best rules in terms of both these criteria were created in the case of the USA, whereas for the other economies the results were not satisfactory. Such outcome of the analysis results from the fact that the European monetary policy is dominated by the direct inflation target policy, which cannot be modelled as a simple monetary rule, whereas the US Federal Reserve does not run this kind of monetary policy.

It was also determined that simple monetary policy rules are significantly destabilized in the period of the 2008-2009 financial and economic crisis.

The results of this research is in line with the results of Taylor, [14], as we proved that the Fed’s monetary policy can be successfully modelled with the use of simple monetary rules. Another similarity of our results to the Taylor rule is that in the case of the US monetary policy the key explanatory variables include dynamics of investment or retail sales, strongly correlated with the size of the economy’s output gap, which is, in turn, a crucial part of the Taylor rule.

There are many possibilities of broadening the analysis that was carried out in this paper. Firstly, one should attempt to estimate simple monetary rules for the above-mentioned central banks with the use of econometric methods and compare the results with the outcome of this paper. Secondly, larger sets of explanatory variables should be taken into account, that is both higher number of variables as well as their lags. Thirdly, an important direction of further research may be the use of alternative definitions of the explained variable in the monetary rules. The change of the reference rate may be expressed, for instance, by a variable with smaller number of classes (e.g. one could distinguish only 3 types of interest rate decision: hike, cut and stabilization) or instead of the change of the reference rate one could model its level.
Bibliography


**Appendix 1. Variables used in the paper**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>Consumer price index; growth over the corresponding period of the previous year (%yoy); monthly data</td>
</tr>
<tr>
<td>FX_MOM</td>
<td>Exchange rate - price of USD expressed in the domestic currency; growth over the previous month (%nom); monthly data</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product; growth on the same period of the previous year (%yoy); quarterly data</td>
</tr>
<tr>
<td>INVEST</td>
<td>Gross fixed capital formation; growth over the corresponding period of the previous year (%yoy); quarterly data</td>
</tr>
<tr>
<td>UNP_RATE</td>
<td>Harmonized unemployment rate; level (%); monthly data</td>
</tr>
<tr>
<td>IND_PRD</td>
<td>Industrial production; growth over the corresponding period of the previous year (%yoy); monthly data</td>
</tr>
<tr>
<td>PPI</td>
<td>Producer price index; growth over the corresponding period of the previous year (%yoy); monthly data</td>
</tr>
<tr>
<td>CONS</td>
<td>Private final consumption expenditure; growth over the corresponding period of the previous year (%yoy); quarterly data</td>
</tr>
<tr>
<td>RET_SLS</td>
<td>Retail sales; growth over the corresponding period of the previous year (%yoy); monthly data</td>
</tr>
<tr>
<td>DEC</td>
<td>Decision on interest rates; change of the central bank’s main interest rate (basis points); data frequency dependent on the central bank’s meeting schedule</td>
</tr>
</tbody>
</table>

Source: Own elaboration.
IDENTYFIKACJA PROSTYCH REGUŁ POLITYKI MONETARNEJ
PRZY UŻYCIU HEURYSTYCZNYCH METOD ANALIZY DANYCH

Streszczenie

W artykule rozważono zagadnienie modelowania prostych reguł polityki monetarnej, których przykładem jest reguła Taylora, szeroko cytowana w literaturze makroekonomicznej. Dokładniej, celem artykułu jest sprawdzenie, czy polityka monetarna banków centralnych (w tym przypadku sprowadzona do ustalania nominalnych stóp procentowych w krótkim okresie czasu) może być modelowana w sposób statystycznie znaczący w postaci prostych reguł opartych na zmiennych makroekonomicznych. Niezależnie od identyfikacji reguł polityki monetarnej, artykuł także ma na celu sprawdzenie wpływu globalnego kryzysu lat 2008-2009 na stabilność reguł oraz identyfikację różnic między regułami polityki monetarnej różnych banków centralnych.

W pracy posłużono się heurystycznymi metodami analizy danych (drzewa decyzyjne), jako pozwalających na identyfikację związków w zbiorach danych bez wstępnych hipotez, co jest przedmiotem pracy. Przeanalizowano przypadki trzech banków centralnych: NBP, Europejskiego Banku Centralnego oraz Banku Rezerw Federalnych Stanów Zjednoczonych.

Najlepsze reguły z punktu widzenia zarówno istotności statystycznej, jak i interpretacji ekonomicznej, zostały wygenerowane dla USA, podczas gdy wyniki dla pozostałych banków były niezadowalające. Stwierdzono także, że proste reguły polityki monetarnej zostały w sposób znaczący zdestabilizowane w okresie kryzysu globalnego lat 2008-2009.

Słowa kluczowe: bank centralny, stopa procentowa, reguła Taylora, cel inflacyjny, drzewa decyzyjne, statystyka kappa.

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