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Central Bank Modelling and Variables Doing Random Walks

SUMMARY: In developed countries, independent central banks control monetary policy. The goals and instruments of monetary policy are taught in every economics course; however, at times theory fails to work perfectly in practice. In our paper, we review the system of inflation targeting applied by the Hungarian central bank in the past ten years, as well as the modelling framework supporting the making of monetary policy decisions. Many input variables of inflation forecast models are traded commodities. This is why we asked ourselves whether central bank analysts could have given more precise projections on these variables than market players. We used appropriate statistical (stationarity) tests for the time series of a number of variables, running approximately 50,000 tests. Based on the tests, we concluded that input variables dominantly follow a random walk process on the time horizon of inflation targeting, thereby their future values cannot be predicted. Our final conclusion is that based on erroneous forecasts, the central bank could even have made incorrect monetary policy decisions, thereby driving the Hungarian economy in an undesired direction.

KEYWORDS: monetary policy, central bank, small open economy, forecast, random walk
JEL CODES: C22, E47, E52

In most countries, the original purpose of establishing central banks was to stabilise the financial system. By the beginning of the 20th century, central banks in many countries functioned as major economic policy entities. In the period following World War II, monetary policy responses to certain economic situations were well defined by the IS-LM interpretation framework created by *Hicks*. (Hicks, 1937) Up until the oil crisis of the 1970s, economic policy makers widely believed in the applicability of active monetary policy, which could have had a positive impact on the growth of the real economy. On the theoretical side, as of the 1960s it was monetarism that launched an attack against the continuation of active monetary policy aimed at stimulating the economy. The position of the school of monetarism is that monetary easing cannot result in long-term economic stimulus; in their view its effect only generates inflation. According to the school of monetarism, the task of monetary policy cannot be anything else but to shape money supply in a predictable and adaptive manner in line with the needs of the real economy. The task of the central bank controlling monetary policy is to regulate money supply. (Somogyi, 1996) However, the objective regarding money supply proved to be inadequate from a transparency aspect, which is why over the course of the past twenty years, many central banks have switched to the system of inflation targeting.

According to the position of reigning economic schools, monetary policy cannot affect the real economy. The consequence of monetary easing is an increase of the price level. Un-

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predictable price increases hinder the healthy long-term development of the economy. At the same time, monetary expansion may seem attractive to governments as the boosting of inflation may temporarily improve the budgetary balance by generating surplus and through the profits of money supply. Putting long-term development at the forefront, the view has been established that monetary policy should be detached from the influence of political interests thinking in short cycles. The central bank controlling monetary policy must be independent of the current government. According to assumptions, the guardians of price level stability could be central bankers committed against inflation. (Posen, 1995; Csontos, 1999)

An independent central bank can be credibly committed to anti-inflation monetary policy; it does not have to take other objectives into consideration. Credibility and the transparency of goals decrease the inflation expectations of the players of the economy. As a result, disinflation costs are also lower. By today, central bank independence has become an unquestionable dogma in modern economies. (Jankovics, 2006)

Within the European Union, economic policy makers have also embraced the principle of the necessity of central bank independence. The European Central Bank functions as an independent institution, and it is one of the criteria that Member State central banks also enjoy an independent status. In Hungary, the independence of the National Bank of Hungary in controlling monetary policy is guaranteed by law. (Kaponya et al., 2012)

At the same time, central banks must put that which has been set out in theory into practice. In order to achieve the goals, a toolset must be created and effect mechanisms must be modelled. Models can only provide foundations for correct decisions if the system of relations between model variables within is sound and if the range of input variables is appropriate. Unless these criteria are met, erroneous decisions may be made. In our study, we wished to find out whether the input variables of models that have substantiated the monetary policy decisions of the Hungarian central bank have truly provided the foundation for satisfactory projections over the last ten years. In our analysis, we will review the target system of the National Bank of Hungary as well as the planning model established by the central bank. We will examine input variables one by one, examine how market players prepare forecasts for the future development of these variables and why they fail to make correct predictions. Using statistical analysis, we will show in the case of certain variables that the development of their values probably cannot be predicted in advance.

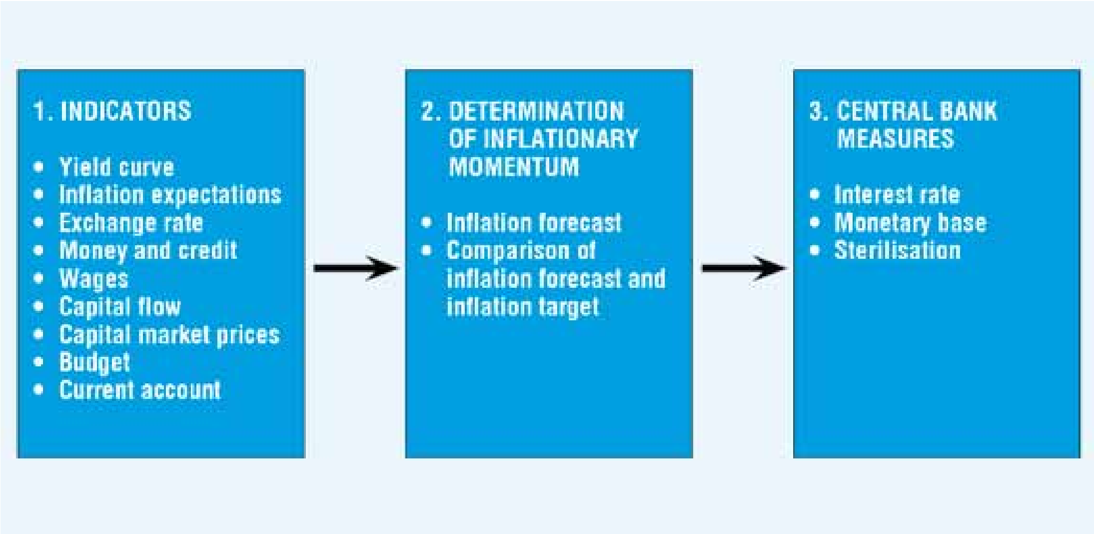
THE SYSTEM OF INFLATION TARGETING

Prevailing economic theories state that monetary policy can only have a lasting impact on inflation. It is obvious that as its objective, the central bank sets a level of inflation to attain. The inflation target serves as a nominal anchor for the players of the economy. At the same time, the central bank's target function, however, does not feature a leveraged value that is harder to link to the development of inflation. The relationship of the final target and the tools meant to serve its achievement are easier to interpret for all, and thus the measures taken by the central bank are easier to follow.

Within the system of inflation targeting, the central bank directly indicates the inflation target. *(See Chart 1)* It only takes steps when inflation is likely to deviate from the target value. The central bank engages in compliant behaviour. This is why the steps taken by the central bank are predictable for the players of the economy. Beyond maintaining

Chart 1

MANAGEMENT OF MONETARY POLICY IN CASE OF INFLATION TARGETING



Source: Csermely (1997, p. 243)

price stability, the central bank sets no other objectives. The central bank wishes to neutralise the ripple effects of inflation shocks. (Csermely, 1997)

The basic elements of inflation targeting are: the announcement of medium-term numerical inflation targets, commitment by the central bank to the inflation target, a monetary strategy based on a broad information base, increased transparency of the monetary policy, and the accountability of the central bank for attaining its inflation target. (Mishkin, 2002) In the following, our study will focus on the third element, and we will examine what information the central bank relied on to make its decisions and how it has used this information.

The central bank has several tools at its disposal to implement monetary policy. In the last ten years, of this tool-set the National Bank of Hungary has primarily utilised the changing of the base rate to achieve the inflation target. The base rate is currently the interest rate of the two-week MNB bill. The interest rates of other central bank schemes are also linked to the base rate, which is used as a reference value by the players of the economy. The amendment of the base rate will most likely shape the demand of the forint. By changing the base rate, the central bank can indirectly impact the economy. The changing of the base rate makes its impact felt through a complex system of mechanisms (transmission mechanism). (Kaponya et al., 2012)

This effect mechanism impacts a number of macro-economic variables. The development of these variables impacts the achievement of the inflation target. The central bank tries to indicate the development of these variables in advance. This means they want to accomplish the final goal in a forward-looking manner. One of the tools of this foresight is the forecast where central bank analysts try to grasp a wide range of variables in an attempt to make projections on their development. The importance of foresight is justified by the fact that central bank measures have a delayed impact on the economy.

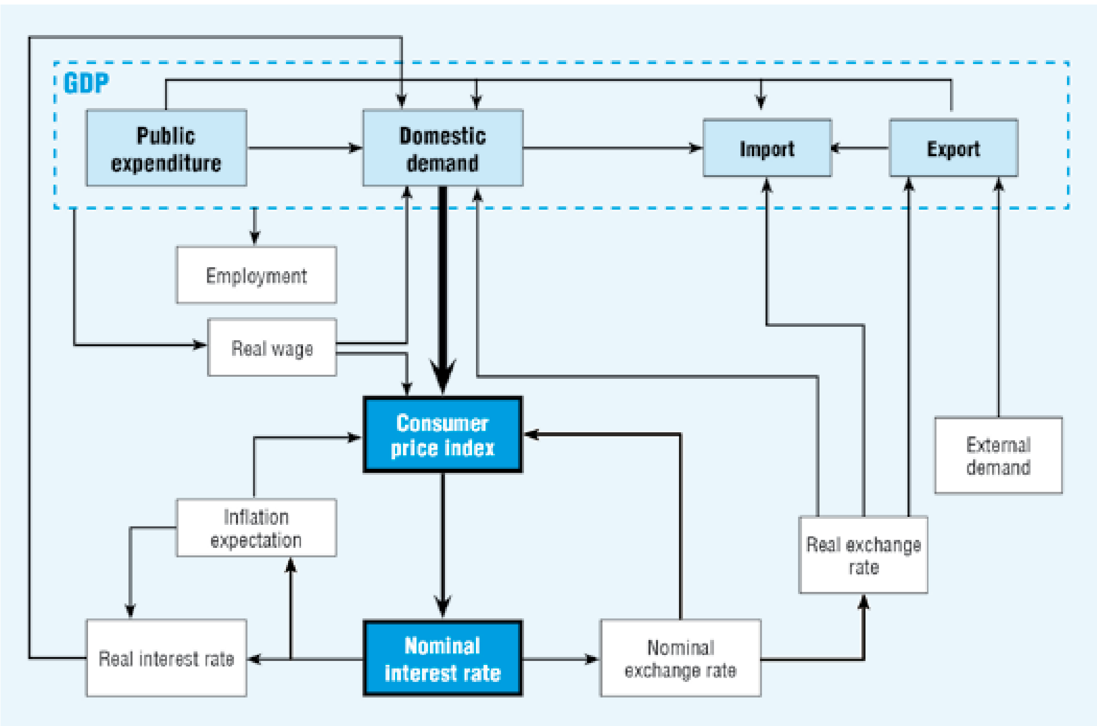
The central bank prepares forecasts regarding the processes of the economy. It projects the expected development of variables using a macro-economic model. The expected impact of the intervention of monetary policy on inflation is also built into the model. Should the projected inflation rise above the inflation target, the central bank off-sets it through an interest rate increase, while in the case of the projected drop of inflation, the central bank may cut the base rate. Monetary policy decisions, including the decisions regarding the base rate, are made by the Monetary Council.

In the past, the staff of the National Bank of Hungary prepared quarterly forecasts, and as of 2011, they generate projections with the help of the Monetary Policy Model. The new-Keynesian model describing a small open economy is at the same time a forecasting and decision supporting model. Within the model, inflation depends on demand and production costs; domestic demand depends on real interest rate; the interest rate path is determined by the decision maker based on rules that reflect its objectives, and the exchange rate develops based on the difference between present and future real interest rate and the risk premium. Its most important variable is price level change. The model treats the expected future development of the base rate endogenously. It provides a forecast for the business cycle, on which period the monetary policy has an impact. In the model, the expectations of players play a pivotal role in the development of inflation forecasts and the interest rate path. *(See Chart 2)*

Inputs for the model are provided by experts. They determine exogenous variables such as the expected level of public expenditures. They also determine the development

Chart 2

THE STRUCTURE OF THE MONETARY POLICY MODEL



Source: Horváth – Köber – Szilágyi (2011, p. 21) of the model's behavioural variables for the coming quarters. Certain unique items, for example the effect of major investment projects, are also input into the model by experts. (Horváth – Köber – Szilágyi, 2011)

The initial basis of the model is, therefore, several future values generated by various analysis procedures and expert estimates. The methods applied to the estimation of input variables are similar to the projection generating techniques of the players of financial markets; in fact, there are values among these input variables that are themselves money market products or commodities exposed to speculation. Interest rates, CDS, foreign currency, raw materials, as well as many other products, are widely-traded instruments. Alongside winners on the market, however, there are also many losers. They are the ones who did not guess right about future outcomes. What methods do these players use, and what criticism can be applied to these methods?

METHODS USED BY MARKET ANALYSTS, PROBLEMS OF ANALYSES

The players of financial markets have developed a variety of methods to evaluate investment instruments. These methods usually arise in connection with stock analysis, but certain methods are also applied in relation to other products, such as commodities and derivative products. Analysts are usually divided into two larger groups: fundamental analysts and technical analysts.

The theory of fundamental analysis was developed to evaluate stocks but, as the progress of the analysis shows, it was expanded to cover other instruments as well. Fundamental analysts evaluate real processes. Based on information regarding macro and micro-sectors, it seeks the factors that determine stock prices in the long-term. According to the theory, each investment instrument has a fixed point or "internal value" that can be determined. Being aware of these fundamentals, the price development of instruments can in essence be determined. (Malkiel, 1992)

When uncovering the internal value of stocks, analysts first evaluate macro-economic environment. They examine expected economic growth, the development of inflation, budgetary equilibrium as well as the future movement of any variable deemed relevant. Next up are industry data, the cyclical situation of the given industry, the analysis of competitor activity and the assessment of other industry tendencies. At the micro-level, they evaluate the indicators, internal processes and future outlooks of the given joint stock company. (Bodie – Kane – Marcus, 1996) The progress of analysis is similar in the case of determining the expected price of other instruments as well, such as derivative products, foreign currency exchange rates and commodity market products.

The examination of the whole of the economy is very similar to the content of central bank forecasts. When examining the macro-environment, they analyse factors that affect the performance of the real sector, and attempt to predict the development of more important macro-factors as well as preparing price projections. Numerous varieties of technical analysis tools are known. However, the initial assumptions of technical analysts are identical, which is reflected by their methods. Technical analysis builds on identifiable market trends and cycles. It is not concerned with the causes moving stock prices, only the consequences, in other words stock movements. Even though the tool-sets of mathematics and statistics are also utilised during technical analysis, stock movements are traced back to psychological reasons.

Technical analysts attempt to determine the future price of examined financial products (securities, futures, foreign currencies, commodities) through the statistical analysis of past stock movements, and on the basis of recurrent patterns and projections typical of these movements (trend calculation, extrapolation) as well as indicators reflecting market mood and market structure. The theory assumes the existence of psychological market characteristics which can be diagnosed. In essence, it identifies trends and predicts these and their changes in the various segments of the financial market.

The first principle of technical analysis is that stock prices and trading volume already reflect basic information. The second principle states that prices tend to move in trends, their changes are not random, and that regularity can be observed in these movements. The third principle is that history repeats itself, in other words, market players follow general rules of behaviour and are prone to behave in a similar manner in similar situations.

In spite of the sophisticated methods, the statistical and mathematical tool-set applied, the integration of expert experiences into models and information supported by computers, long-term winning investment strategies have yet to be created. But why not? Science has provided a possible answer to this as well.

The assumption of rationality and resulting identical actions have led to interesting conclusions when developing the theory of efficient markets.

The efficient capital market theory distinguishes three versions of market efficiency (weak, semi-strong and strong), depending on which group of market players acquires the market-related information and how fast (Bodie – Kane − Marcus, 1996). According to the weak version, past stock price data cannot be used to predict later prices. The semi-strong hypothesis states that publicly available information does not help in stock price prediction either. According to the strong version, not even insider information can help predict future prices, as any information, public or insider, is already reflected in the current stock price. (Fama, 1965)

Prices are random walks even at a weak level of market efficiency.

What is the random walk? It is a movement the future direction of which cannot be predicted from past movements. The short-term changes of stock prices cannot be seen in advance.

French mathematician *Bachelier* already wrote at the beginning of the 20th century when examining stock prices that they move randomly, and that past price developments are unsuitable to make any deductions regarding the future. (Bachelier, 1900)

In 1953, *Kendall* published an article in the Journal of the Royal Statistical Society, the subject of which was recurrent price cycles, or more precisely would have been, had he found any. Prices seemed to have a random behaviour; they seemed to follow a random walk. The best way to demonstrate this random walk is with a game of heads or tails. In his paper, Kendall determined that the series of wins and losses was just as random as a game of heads or tails. (Kendall, 1953) This phenomenon was already described by Bachelier some 53 years earlier. What this means in practice is that stock prices fully reflect the information arriving to the market, the past price movement of stocks as well as other data. As a result, no conclusions can be drawn from past price movements regarding present and future price development, as all past information is already built into the price. Information regarding the under or overvaluation of a given product arrive to the market randomly, the prices changing as a result will also do so randomly, in other words they are impossible to predict. As a consequence, stock exchange prices are unpredictable, and any efforts to make them predictable are futile.

In the case of medium efficiency capital markets, the price of securities reacts quickly to information made public, i.e. it fully reflects all publicly available information. In addition to market information, it also takes into account other data (profit development, liquidity, macro-news, political changes, etc.) This is why published information cannot help analysts in selecting undervalued stocks. To begin with, market price structure already includes all publicly available information contained in corporate statements, revenue statements and dividend statements. The professional analysis of these data, therefore, is useless.

In strong efficiency markets, all information reaches everyone instantly. In perfectly efficient capital markets, the price of securities reflects all available information and only changes when new information arrives on the market. As a result, everyone makes investment decisions in possession of the very same information, which means that no extraordinary profits are generated. Stock prices fully reflect all (publicly available and other) information. (Fama et al., 1969; Malkiel, 1992)

Similar things can be said about the price development of products in other instrument markets that operate similarly to stock markets. In light of this, it is understandable why no proven "winning strategy" can be established on the financial markets. Neither methods of fundamental analysis, nor those of technical analysis can be used to draw future conclusions that the market is not already aware of and does not reflect in prices. Information that is yet unknown arrives randomly, and no one knows when it is made public or whether it will be favourable or unfavourable.

CENTRAL BANK ANALYSES IN LIGHT OF RANDOM WALKS

Market analysts most probably think that only they can predict the future. They try to convince existing as well as potential clients of this fact. But what about the central bank staff? By default, all the players of an entire national economy make up their 'clientele'. Some of the input variables of the model used by MNB are products traded on the markets. It is very likely that no better forecast can be released about them than what the players operating on the market prepare.

MNB presents its notions regarding the development of factors impacting expected inflation in its quarterly publication entitled *Report on Inflation*. In this, they determine the projections given for the input variables of the aforementioned forecast model. The predictions can only prove to be significantly correct if the values of input variables do not change randomly. If a large number of input variables are exhibiting random movement, the effectiveness of modelling is called into doubt.

Regarding the range of applicable models, empirical studies have reached contradictory conclusions. Many (Liu – Smith, 2013; Faust – Wright, 2013; Ang et al., 2007; Stock – Watson, 2007) have concluded that naive (without model) and expert estimates have better statistical qualities than model-based forecasts. *Diron – Mojon* (2008) also point out that if there is inflation targeting, then inflation targets are the best inflation forecasts. *Bachmeier – Swanson* (2005) and *Canova* (2007) argue in favour of multi-variable (primarily Phillips-curve based) models, while Stock – Watson (2003) indicate that in certain countries and periods these models do behave better; however, on a general basis they do not. At the same time, *Tsyplakov* (2010) favours single-variable models, taking volatility as an inflation increasing factor into account.

In our examination, we tested a number of time series. These contained values that could typically be input variables of inflation forecast models. Inflation reports also formulate projections for these. The range analysed included commodities, foreign currency exchange rates and CDS spreads.

As part of technical analysis, we examined the stationarity of time series by testing their root of unity process nature. If the root of unity process nature of time series can be rejected, then they are stationary around some sort of deterministic path, in other words their path can be predicted. If the root of unity cannot be rejected, we are working with time series that are unpredictable in themselves. In line with standard econometric tests, we applied three versions of the Augmented Dickey−Fuller test (with constant, with constant and linear trend, and with constant and quadratic trend). (Said − Dickey, 1984) The rejection of the null hypothesis means that with deterministic trend – or potentially constant – the given time series is stationary. Similar tests were conducted by *Ang et al.* (2013), *Pincheira − Medel* (2012) and *Branch − Evans* (2012), who arrived at mixed results regarding the stationarity of examined variables, depending on the temporal position and length of the period under review. They found more-less stationary periods in the functions of examined countries, but it was not stationary periods that dominated.

The data series – if available – last from 2001 until the end of 2012. The frequency of the time series was varied (quarterly, monthly or daily). In line with the methodology of the inflation report, we set the review period at one-two years, where this made sense, and specifically examined four, six and eight quarter windows[1]. In essence, this means that we analysed the behaviour of the various time series at four, six and eight quarter time horizons alike. With the given window size, substantive analysis was possible only for data with at least a monthly frequency.

In the case of daily frequency data, we started the window from the beginning of the time series, and kept stepping forward observation by observation. This meant that depending on the length of the time series (some time series were only available in comparable form from later starting points) and window size (four, six or eight quarters), we were able to perform the three tests for 555−2,850 windows (i.e. we ran 6,000–24,000 tests for a given time series). We recorded the p value of each test and counted the number of times we were able to reject the null hypothesis of the root of unity for the various test-types with 1, 5 and 10 per cent significance levels. Due to the quantity of outputs, we are only showing aggregate tables that show how many times we found significant test results (i.e. non-root of unity processes) at 1, 5 and 10 per cent significance levels in the case of a given time series with varying window size and test specifications.

We used the Gretl and R software packages for the analysis.

The results are shown in Tables 1–7. In general, we can state that for the most part (89−100 per cent), in the periods under review the variables followed the root of unity process, in other words random walks. To put it another way, with the exception of a few (0−11 per cent) starting points, the time series cannot be predicted, and in the majority of periods the theory of market efficiency seems to hold true. These results for domestic data support the results of Ang et al., (2007), Pincheira − Medel (2012) and Branch − Evans (2012), but are also consistent with the conclusions of *Stock − Watson* (2003).

Based on *Table 1*, we can track what characteristics we used to describe the development of the USD/HUF exchange rate. Running the tests for the entire time series examined (02.01.2001–05.12.2012), using only constant we arrive at a p value of 0.158, while the values in the case of constant and linear trend and constant and quadratic trend are 0.548 and 0.089 respectively; in other words, in the case of the first two versions we cannot reject the root of unity process with the usual significance levels. Allowing quadratic trend,

Table 1

TESTS FOR THE USD/HUF EXCHANGE RATE (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.158)			With constant and linear trend (0.548)			With constant and quadratic trend (0.089)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (2850)	161	65	10	265	167	13	309	219	81
6 (2719)	38	5	0	221	81	12	143	70	22
8 (2589)	27	4	0	371	86	1	176	57	0

Source: own calculations

Chart 3

DEVELOPMENT OF THE USD/HUF (USDHUF CURNCY) EXCHANGE RATE

Source: Bloomberg

we cannot reject the root of unity above the 8.9 per cent significance level (the chart also suggests an inverse parabola-shaped trend). Examining the 2,850 possible four-quarter periods, we found 65 periods (2.3 per cent), where at a 5 per cent significance level and assuming only constant, we were unable to reject the root of unity process, while this same value in the case of constant and linear trend and constant and quadratic trend is 167 periods (5.9 per cent) and 219 periods (7.7 per cent) respectively. All this indicates that even allowing the usual deterministic trends, models assuming stationary variables can only be used with less than 10 per cent of possible analysis starting points. By increasing the duration of the window, the number and ratio of periods that can be described with non-root of unity processes typically dropped. As a result, we can see that for eight quarter (two-

Table 2

TESTS FOR THE EUR/HUF EXCHANGE RATE (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.190)			With constant and linear trend (0.027)			With constant and quadratic trend (0.063)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (2850)	251	132	34	294	192	79	419	236	68
6 (2719)	298	144	31	149	68	21	214	115	37
8 (2589)	267	146	47	105	60	12	220	120	4

Source: own calculations

Chart 4

DEVELOPMENT OF THE EUR/HUF (EURHUF CURRENCY) EXCHANGE RATE

Source: Bloomberg

year) periods at a 5 per cent significance level, we can talk about stationary time series in only 0.2 per cent of reviewable periods, while allowing deterministic trends, in 3.3 and 2.2 per cent of periods.

Table 2 shows the results of the analysis of the EUR/HUF exchange rate. A long-term increasing trend can be observed in the case of the exchange rate, which means that testing with the linear trend seems to be relevant. The calculations performed for the entire time series with a *p* value of 0.027 support this finding. In shorter periods, however, in the case of the majority of starting points, the exchange rate is not stationary (we were able to reject the root of unity in 6.7 per cent of cases for four quarters, 2.5 per cent for six quarters, and 2.3 per cent for eight quarters).

Table 3

TESTS FOR THE HUNGARIAN CDS SPREAD (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.445)			With constant and linear trend (0.190)			With constant and quadratic trend (0.448)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (2537)	130	71	33	141	59	5	259	111	23
6 (2405)	78	34	7	293	110	8	264	120	29
8 (2276)	48	30	7	238	104	1	360	207	20

Source: own calculations

Chart 5

DEVELOPMENT OF THE HUNGARIAN CDS SPREAD (REPHUN CDS USD SR 5Y CORP)

Source: Bloomberg

Based on *Chart 5*, the Hungarian CDS spread suggests the rejection of stationarity, something that is also supported by the *p* values (shown in *Table 3*) of tests performed for the entire time series. At the same time, the stable time series of pre-crisis years has the result that the ratio of time windows that can be considered stationary is slightly higher; depending on specification, we can consider 9.1 per cent stationary (at a 5 per cent significance level).

The data series of the price of corn cannot be considered stationary for the entire period; among the windows examined, the ratio of those where we can reject the root of unity process (the highest ratio with a 5 per cent significance level is 6.4 per cent) is also low; in other words, for the most part we are not

Table 4

TESTS FOR THE PRICE OF CORN (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.821)			With constant and linear trend (0.255)			With constant and quadratic trend (0.222)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (2850)	243	134	42	164	61	11	289	156	18
6 (2719)	330	174	64	102	43	16	142	99	49
8 (2589)	176	134	79	104	62	18	62	20	2

Source: own calculations

Chart 6

DEVELOPMENT OF THE PRICE OF CORN (C1 COMDTY)

Source: Bloomberg

dealing with a stationary time series. Policy decisions, such as the supporting of the promotion of bio-fuels, also played a role in the development of the price of corn.

The price of crude oil is not stationary in the whole of the time series. Examining shorter periods, we see that stationarity around the quadratic trend can be observed most frequently (in 9.5 per cent of periods in case of a six quarter window). The picture of the data series also suggests the existence of a long-term exponential trend, and it would be worth also running tests on the logarithm of the base data series as part of a non-standardised analysis (in order to ensure comparability, we have not utilised this solution).

The development of the price of steel is practically a textbook example of a random

Table 5

TESTS FOR THE PRICE OF CRUDE OIL (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.527)			With constant and linear trend (0.271)			With constant and quadratic trend (0.368)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (2850)	280	145	12	313	165	58	435	199	54
6 (2719)	201	88	6	250	104	27	428	259	60
8 (2589)	152	48	8	413	109	25	272	135	38

Source: own calculations

Chart 7

DEVELOPMENT OF THE PRICE OF CRUDE OIL (CL1 COMDTY)

Source: Bloomberg

walk. We cannot reject the root of unity for the whole of the time series – along a variety of assumptions – but the tests regarding shorter periods also indicate that the number and ratio of periods considered stationary is negligible (a maximum of 15 such periods at a 5 per cent significance level). The price of steel in itself, therefore, proved to be the least predictable time series in our examination.

The development of the price of timber is a good example of the problems with forecasts both in the short and the long-term. While the *p* values of the ADF test for this particular data series are the highest, a relatively high ratio (at a 5 per cent significance level up to 17.3 per cent) of certain sections of the typically fluctuating time series have proven to be stationary.

Table 6

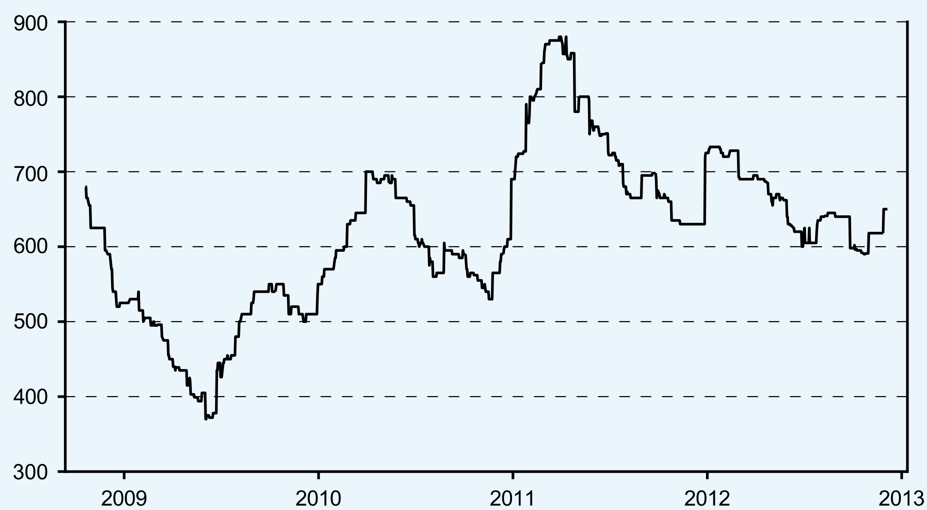
TESTS FOR THE PRICE OF STEEL (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.611)			With constant and linear trend (0.200)			With constant and quadratic trend (0.176)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (816)	24	6	0	17	11	4	14	4	1
6 (685)	41	15	0	20	2	0	5	2	0
8 (555)	0	0	0	16	7	0	0	0	0

Source: own calculations

Chart 8

DEVELOPMENT OF THE PRICE OF STEEL (HRC1 COMDTY)



Source: Bloomberg

The analysis of the above time series shows that, in essence, the input variables of the models used to forecast inflation can be considered root of unity processes. The detailed analysis served to provide a comprehensive picture, avoiding the mistake of whether a given hypothesis can be rejected or not in a selected period – as a result of random occurrence. The results of a total of close to 50,000 statistical tests are congruent, with stationary periods found in a relatively low ratio.

Of course we are aware of the fact that we only used a part of the analysis opportunity, applying the most widely and frequently used root of unity/stationarity tests. The calculations may also be repeated with other tests, but due to the robustness of the work, we should not expect fundamentally different results. An-

Table 7

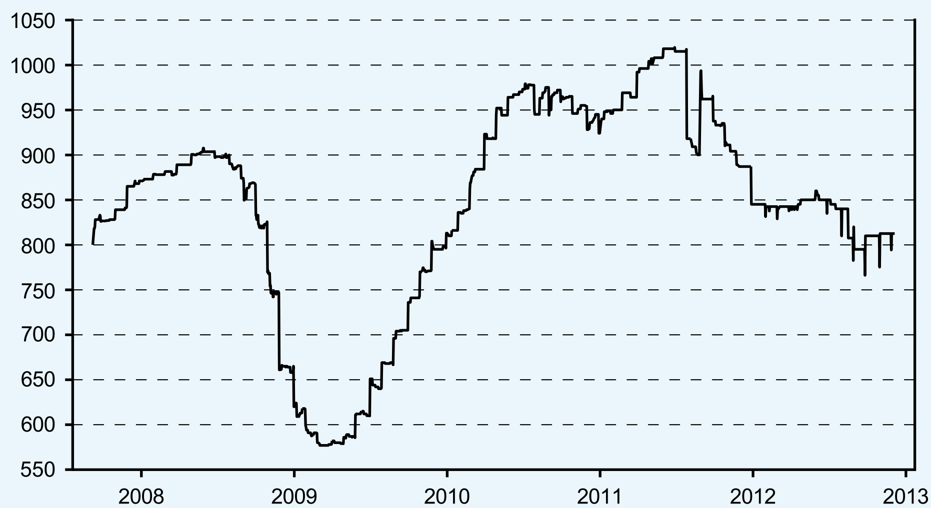
TESTS FOR THE PRICE OF TIMBER (WITH *P* VALUE VALID FOR THE ENTIRE DATA LINE)

Window (quarter) (number of tests)	With constant (0.661)			With constant and linear trend (0.910)			With constant and quadratic trend (0.976)		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
4 (1107)	94	70	16	225	159	95	240	192	86
6 (976)	189	109	5	124	91	81	64	7	2
8 (846)	144	64	6	57	52	37	9	5	1

Source: own calculations

Chart 9

DEVELOPMENT OF THE PRICE OF TIMBER (WPA1 COMDTY)



Source: Bloomberg

other potential outlook direction, something which *Narayan* (2005) also calls attention to, is the testing of structural fractures. The changes occurring in the structure and operation of the economy (and in the case of certain prices, in policy on a global level) may generate fractures in the data series as well, which might throw the validity of tests into doubt. However, for the aspect of conclusions, fracture points are technically just as unpredictable as the time series following random walks.

The evaluation of the data series suggests that predictability is uncertain in the case of several variables. Why can't prices and exchange rates be clearly predicted in advance? It is precisely the objective reasons of this that economists dealing with market efficiency and the random walk theory are researching. It is also doubtful whether the expectations of the players of the economy are permanent, and whether the change in these expectations can be described with sufficient accuracy. If this was the case, the prize awarded to the winner of the beauty pageant described by *Keynes* would be easy to win. (Keynes, 1965) In the case of the Hungarian economy – as a small open economy – a probably very wide range of input variables is difficult to predict. The uncertain forecasts regarding randomly walking variables can only provide an incidental foundation for correct decisions. Incorrect decisions, in turn, can lead to precisely those national economy losses that the operation of central banks is meant to avoid. When building models, it should be considered what input data is suitable to build on. We may ask the question: did the central bank practices of the first decade of the 21st century serve the development of the Hungarian economy the best it could?

Note

[1] In the case of a six quarter window for instance, we examined six quarterly periods at the same time, starting from the very first data available. After this, we shifted the starting point by one day, counting the six quarter period from this particular point. We kept performing these shifts, until the end of the six quarter period reached the time of the last observation of the available data series. The same method was applied by Ang et al. (2007), Pincheira – Medel (2012) or Tsyplakov (2010).

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