Chapter 5
Examples of Experiments in Macroeconomics

Jerzy Boehlke and Magdalena Osińska

Abstract The considerations in the chapter are related to the examples of experiments that were conducted in macroeconomics in various economic areas, in different periods and under different conditions. Due to the specific characteristics of macroeconomics, these are mainly natural experiments and model-based experiments, comparable to laboratory experiments. The subject matter is very promising and gives some insights into the usefulness and possible applications of the so-called "experimental macroeconomics".

Keywords Experimental economics • Macroeconomics

5.1 Experiments in Macroeconomics

The development of behavioural economics observed in recent decades has caused a significant increase in the interest of economists in applications of psychology to explain the behaviour of economic entities not only at a microeconomic level, but also to try to strengthen the macroeconomic knowledge base on management processes. As is known, the greatest achievements of cognitive economics are noted in the area of macroeconomic research. However, since the creation of the Keynesian theory, the thesis about the accuracy of diversity of human behaviour at the macro level compared to the rules governing individual behaviour has been commonly accepted. Therefore, formulated macroeconomic theories may not constitute a sufficient basis for explaining individual behaviours and vice versa. In recent decades, attempts to connect macro and micro analyses were made on the grounds of macroeconomic psychology and experimental economics. Natural and

J. Boehlke
Department of Economics, Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń, Gagarina 13a, Toruń 87-100, Poland
e-mail: jurekbo@umk.pl

M. Osińska (✉)
Department of Econometrics and Statistics, Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń, Gagarina 13a, Toruń 87-100, Poland
e-mail: emo@umk.pl

K. Nermend, M. Łatuszyńska (eds.), *Selected Issues in Experimental Economics*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-28419-4_5

model-based (laboratory) experiments carried out within the latter area became an important source of cognitive successes in modern economics. The major objective of macroeconomic experiments, as defined by Tyszka—these are experiments carried out at an aggregated level (Tyszka 2004, 31), is testing abstract economic theories, rather than actual choices made by individuals or groups. The dominant group here are natural experiments. They are implemented under real market conditions and individuals being researched are not aware of their participation in the experiment. Macroeconomic experiments allow primarily determining the cognitive capacity of an economic theory, understood as resistance to projections for derogation from assumptions that were formulated on its basis.

5.2 Examples of Natural Experiments in Macroeconomics

Natural experiments in macroeconomics are typically used to verify the assumptions of the theory, the quantification of the parameters of economic models, as well as to identify the mechanisms whose effects are the observed macroeconomic factors (Fuchs-Schůndeln and Hassan 2015, 1). Macroeconomic experiments are, therefore, instruments of cognition. It should be remembered that they are not a way to verify the logical integrity of an economic theory.

The spectrum of examples of natural experiments in macroeconomics is very broad. For the purposes of the chapter the following examples will be discussed:

1. Multicultural interpretations of justice from the ultimatum and dictator games point of view, as described by Zaleśkiewicz (2011),
2. A Bitcoin case and Gresham law reflecting the money circulation and its stability discussed by Bergstra and de Leeuw (2013) and Smith (2013),
3. The impact of an institutional order and macroeconomic policy on economic outcomes (the cases of Ghana and Argentina during the post-war period) discussed by Acemoglu et al. (2003),
4. Migration flows from Central and Eastern European Countries after the EU enlargement in 2004 discussed in Pedersen and Pytlikova (2008) and extended in this chapter by the analysis of the unemployment rates in CEEC,
5. A case of regional development based on the Operational Programme Development of Eastern Poland realised in 2007–2013.

5.2.1 Social Justice in Different Countries: The Ultimatum and Dictator Games

An example of an experiment in macroeconomics, whose aim was to identify and compare the cultural, that is also institutional, determinants of ways of interpreting social justice in different countries is the ultimatum game. Its creators are W. Guth,

R. Schmittberger and B. Schwarze. The game is designed for two players. The first one (a) has at his/her disposal a certain amount of money which should be divided between himself/herself and the other anonymous player (b) in the proportions decided personally by him or her. The anonymous player may accept the amount assigned to him/her and then both players receive the amount of money proposed by the holder or reject it, which means that none of the players receives any money. This experiment showed that the behaviour of both players does not conform to a model in which individuals maximise their utility, because in their actions they seek to carry out a fair distribution. The ultimatum game was used to search for the answer to the question of intercultural stability of choices made by players in various countries which considered the criterion of equitable division. It turned out that studies, among others, by Roth in the USA, Japan, Israel and in Slovenia, showed a high level of sustainability of human behaviour in the ultimatum game. As turned out, the modal offer of type A players took the values ranging from 40 % of the initial amount (Israel and Japan) up to 50 % of the initial amount (Slovenia and the USA). As regards the percentage of rejections, the highest one was noted in Japan (29 %) and was followed by the USA and Israel (28 %); the lowest percentage was noted in Slovenia (22 %). Thus, the similarities are much greater than the differences, which leads to the conclusion that the quest for equitable distribution of wealth is more strongly conditioned by the nature of man than the culture in which he lives. In contrast, based on the review of studies made by Zaleśkiewicz (2011, 386–388) on using the ultimatum game, or its mutation, which is the dictator game (rules of the game are similar to those in the ultimatum game with one difference—player B cannot reject payments from player A), it can be considered that a way of understanding the concept of justice and an equitable distribution is culturally conditioned. This conclusion is consistent with the findings of the new institutional economics.

5.2.2 Bitcoin: New Money

The ultimatum and dictator games also proved to be useful in experiments conducted on electronic money which is Bitcoin. This very well-known money is defined as an example of technical informational money. It is very often classified in a more extreme way: exclusively information money (Bergstra and de Leeuw 2013). Bergstra and de Leeuw have experimented with the second notion of Bitcoin. They emphasise its experimental status, novelty as a software development project and business utility. The circulated quantity of Bitcoin is not controlled by any conventional money authorities. All Bitcoin software problems must be solved by the Bitcoin community which has its way to create and maintain a power hierarchy. Probably, the most important economic questions about Bitcoin as an example of informational money concern functionality and sustainability. Experiments based on the ultimatum and dictator games could be treated as a source of information about the participants' preferences to Bitcoin and conventional money.

Results of these games are also a base for Bitcoin's demise or acquire scenarios. Behaviour of participants depends on external Bitcoin's evaluation informational money. Assuming game participants full rationality (utility maximisation), if the external value is significant, the moment that it is estimated at zero euro means that this existing informational money will be replaced by euro. In experiments done by Bergstra and de Leeuw the external estimated value of a Bitcoin was at 50 euros.

5.2.3 The Gresham Law

The Bitcoin example presented above may also be considered in a more general way. Such an approach was adopted by Smith (Smith 2013, 76–77) who analysed Gresham's law as an example of an experimental market in which the theoretical predictions of Cournot–Nash equilibrium are incompatible with the effective results of its operations. He reminds us that for the two available currencies, A and B, of which A is a value in itself, and B is only a fiat currency, this theory predicts displacement of B by A. Assuming the rationality of behaviour of all subjects, it should be assumed that they will accept only money A, which will become the dominant medium of exchange money at the same time displacing B. As the Smith says, experimental studies have confirmed, in fact, the compliance of the rationalist (theoretical) behaviour model with a model of the observed ecological behaviour, but only for those cases in which both A and B currencies are available. However, in situations where economic entities first use money B, as the only available means of exchanging and obtaining the benefits of this exchange, then the fiat money will continue to dominate. This is a consequence of the faith of exchange participants that other entities will accept within this exchange money B. This trust is reinforced by their past experience. In addition, V. Smith states that the experiments conducted have shown that if currency B is the only currency, then it will be used in the exchange, even when it is replaced by another fiat currency over a specified time horizon. The collapse of the real economy occurs only in a situation where the public sector prints fictitious money (i.e. money without coverage) to acquire real goods from the private sector (Smith 2013, p. 77).

5.2.4 An Institutional Order and Economic Outcomes

A very interesting example of macroeconomic experiments was investigated by Acemoglu et al. (Acemoglu et al. 2003, 49–123). They interpreted the causal effect of an institutional order on economic outcomes in countries where European colonists faced high mortality rates more than 100 years ago. This colonial past influences high volatility and economic crises after post-war history. At the beginning Acemoglu et al. assumed that macroeconomic policies appear to have only a minor impact on volatility and crises, so that distortionary macroeconomic policies

are more likely to be only symptoms of underlying institutional problems rather than the main causes of economic volatility. To document this relationship, they used an instrument for investigating the historically determined component of institutions in a cross-section of countries. More specifically, they treated differences in mortality rates faced by European settlers during colonial times as a source of variation in the historical development of institutions among former colonies. It is very well-known that European colonisation processes starting in the fifteenth century comes close to a "natural experiment" in creating and shaping different institutions. Usually, in places where colonists faced high mortality rates, they followed a different colonisation strategy, with more extractive institutions, while they were more likely to set up institutions protecting private property and encouraging investments in areas where they settled (Acemoglu et al. 2003, 51).

To identify the relationship between institutions, macroeconomic policy and economic performance they decided to the consider the following three measures of macroeconomic policies: the average size of government consumption, inflation and real exchange rate evaluation. To measure institutions they tried to identify the extent of constitutional limits on the exercise of arbitrary power by the executive Historically determined component of institutions was analysed on based on the Ghana and Argentina cases. In their baseline regressions, the basic time period was from 1970 to 1997. Two main reasons for such an approach were important: data availability and a desire to start the analysis at a point in time where the countries for which they have data could be treated as all independent nation states. Finally, they documented a strong relationship between institutions and volatility (as well as a link between institutions and crises or growth).

5.2.5 *External Shocks and Economic Performance of Low-Income Countries*

Another example of a natural experiment in macroeconomics was described by C. Raddatz (Raddatz 2007). He decided to quantify the impact of comprehensive set of external shocks on the output and income in low-income economies and assess their ability to explain the large cyclical fluctuations, considering also internal circumstances. According to Raddatz, external shocks included terms-of-trade shocks, natural disasters, volatility of the international economy, international interest rates and changes in aid flows. Raddatz asked not only the question of the limit to which the changes of output in low-income economies could be attributed to external factors, but also which of these factors are the most important. According to his opinion, the effect and importance of different shocks was a reason for using a vector autoregression model. In this model external shocks were assumed to be exogenous to country-level variables. This approach considered the dynamics of all variables and, therefore, allows estimating overall variance of real GDP per capita. The results of this natural experiment showed that, on the one

hand, external shocks have a small but economically meaningful impact on low-income economies GDP per capita. On the other hand, it is necessary to know, that this kind of shocks could explain no more than 11 % of overall variance of real GDP per capita. It means that 89 % of overall variance must be associated with endogenous shocks. Raddatz (Raddatz 2007) formulated the following results of his experiment:

- A one standard deviation positive shock to either per-capita GDP of high-income countries, commodity prices (our main measure of terms of trade), or per-capita aid flows results in an approximately 1 % significant increase in the GDP per capita of low-income countries.
- Climatic disasters (which include floods, droughts, extreme temperatures and wind storms) and humanitarian disasters (which include famines and epidemics) result in declines in real GDP per capita of 2 and 4 %, respectively.
- Real interest rate shocks and geological disasters do not have a significant impact on real activity. Although these magnitudes may look modest in absolute value, they are significantly larger than the mean and median growth rates of low-income countries during the last decade (0.2 and 0.4 %, respectively).
- Among the external shocks, changes in commodity prices are the most important source of fluctuations (explaining 37 % of the 11 % explained by all external shocks), followed by aid shocks (25 %), climatic disasters (14 %), humanitarian crises (12 %), and fluctuations in the GDP of high-income countries and the international interest rate (10 and 3 %, respectively).

5.2.6 Migration Flows from CEEC After 2004

In recent years one of the wide scale natural experiments in the European Union has been observed. The experiment consisted in entering the EU structures by thirteen new member states between 2004 and 2013, mainly from Central and Eastern Europe (CEE). This resulted in opening labour markets all over the European Union which, in turn, caused large migration flows from the new member states to the Western and Northern parts of Europe. Figure 5.1 shows the unemployment rates in the EU15 and ten CEE countries. A significant decrease in the unemployment rate in each country can be seen between 2004 and 2008. The absolute difference between 2004 and 2008 amounted to −1.1 for the EU15 group of states, while in Poland the scale was apparently bigger and ranged almost twelve percentage points. The second biggest reduction of the unemployment rate in Slovakia reached 8.8 pp. In the Czech Republic it reached almost four percentage points. Only Hungary denoted an increase of 1.7 pp. in the unemployment rate in this period. Of course, the data although official can be biased because of a procedure of registration in labour offices while working abroad which was quite common, at least in Poland. That is why the evaluation of a "pure" unemployment rate in Poland in this period has been a challenging work.

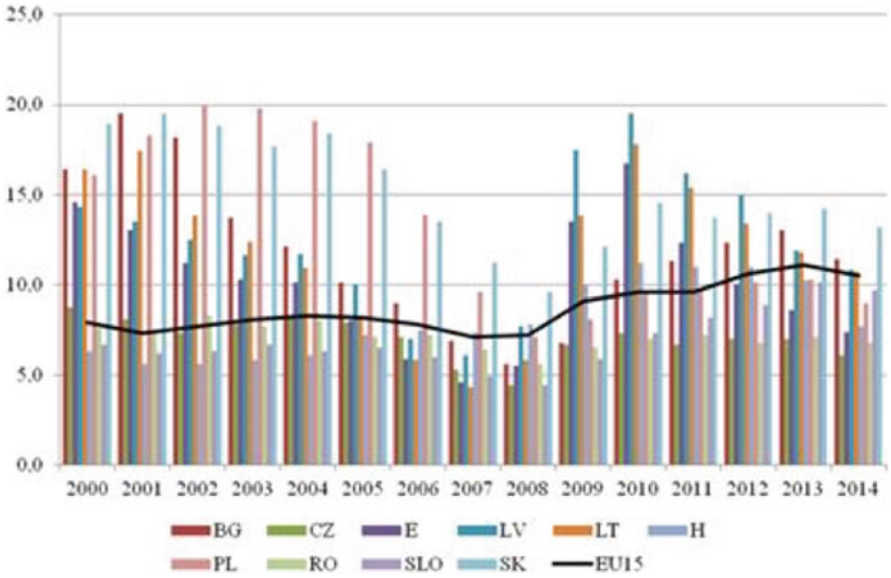

Fig. 5.1 Unemployment rate in CEEC and EU15 in 2000–2014 (source: data from Eurostat)

A positive impact of the EU enlargement on the unemployment rate indicator was particularly due to:

- An increase of investments including investments financed by the EU funds,
- Positive incentives for economic developing of the new member states thanks to an increase in foreign trade,
- Labour market openness and migration flows from Central and Eastern Europe to the "old" European Union and the European Economic Area members.

It is worth mentioning that some of the "old" EU members, such as Great Britain, Ireland and Sweden, have accepted new immigrants on their labour markets just at the moment of the EU enlargement, the others, i.e. Greece, Finland, France, Spain, Portugal, the Netherlands, Luxemburg, Italy and Iceland applied a 2 or 3-year transition period. Several countries such as Austria, Belgium, Denmark, Germany and Norway restricted their labour markets and opened it either conditionally or for selected professions only. The series of reports on migration flows from Poland after May 1st, 2004 prepared by researchers from the Centre for Migration Research in the University of Warsaw (see: Grabowska-Lusińska and Okólski 2008; Mioduszewska 2008) analyse different sources of the data to estimate the scale and directions of migration flows indicating that using different data sources can bring about various results. Thus, a very careful study considering the data and its interpretation is required. In general, after 2004, Poles immigrated mainly to Great Britain, Ireland, the Netherlands, Italy, Spain and Norway. The dynamics of migration to Germany decreased in this period.

Pedersen and Pytlikova (2008) considered a case of migration flows from 10 Central and Eastern European Countries (CEEC) to five Nordic countries which became one of the important destinations over the years 1985–2007. Assuming that the migration from CEEC to Nordic countries is job related, they characterised the Nordic labour markets. They particularly mentioned that the participation rates for married women were high, the public sector was a big employer, and unionisation was well above the European average which resulted in the coverage with collective agreements. Furthermore, the wage structure was fairly compressed, with relatively high minimum wages, and a social security system with more emphasis on universal rights and less emphasis on earnings history, compared with most other European countries. That is why Nordic countries were attractive for new "incomers". The authors indicated some problems with the actual data sets and emphasised the possible bias of the estimates while studying migration flows. However, the natural experiment based on the fact of full or restricted labour market opening by Nordic countries caused the interest in exploiting of this occasion. That is why they studied the eventual "opening" effect to explain the migration flows. They applied the DD estimator for the panel data econometric model of the following general form:

$$\begin{aligned} \text{lnmigr}_{ijt} = \beta_0 + \beta_1 \text{TreatCountry} + \beta_2 \text{PostTreatPeriod} \\ + \beta_3 \text{TreatCountry*} \ \text{PostTreatPeriod} + \varepsilon_{\text{ijt}} \end{aligned} \tag{5.1}$$

where lnmigr_{ijt} denotes flows of migrants from country i to country j divided by the population of the country of origin i at time t in natural logs. This model was a basic one, and it was extended by adding some economic variables such as GDP p.c. and distance in kilometres between the country of origin and the country of immigration. In their study, Pedersen and Pytlikova applied both gross and net migration flows. The net flows variable was defined as a difference in stocks of foreigners living in country j and coming from i country of origin, i.e. $\text{netmigr}_{ijt} = \text{stock}_{ijt} - \text{stock}_{ijt-1}$. The results using a differences-in-differences estimator showed that the estimated effect on migration of the opening of Swedish, Finish and Icelandic labour markets in the first round of EU enlargement towards the East was not significantly different from zero. However, the results regarding the opening towards the 2007 EU entrants were different. The estimated effect from opening of the Swedish and the Finish labour markets towards Bulgaria and Romania was positive and significantly differed from zero for both: gross and net flows model specifications.

Following analysis of migration flows we examine the changes in CEEC unemployment rates concerning three dates of the EU labour markets opening, i.e. 2004 and 2006 for the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia, and 2007 for Bulgaria and Romania. We compare it with the unemployment rates in EU25. The following dynamic panel model was then estimated:

Table 5.1 The DD estimates for the unemployment rate of CEE countries starting from 2004 to 2006 to 2007

Country group—EU25	2004	2006	2007
$\widehat{\beta}_0$	0.020 (0.031)	−0.043 (0.060)	−0.002 (0.034)
$\widehat{\beta}_1$	−6.609 (1.626)	−6.372 (1.166)	−3.476 (1.205)
$\widehat{\beta}_2$ (DD)	0.515 (0.140)	0.581 (0.120)	0.407 (0.099)
$\widehat{\beta}_3$	0.531 (0.127)	0.538 (0.104)	0.755 (0.052)

$$\begin{aligned} \mathrm{ur}_{it} = {} & \beta_0 + \beta_1 \mathrm{PostTreatPeriod} + \beta_2 \mathrm{TreatCountry}^* \mathrm{PostTreatPeriod} \\ & + \beta_3 \mathrm{ur}_{it-1} + \varepsilon_{it} \end{aligned} \tag{5.2}$$

where ur_{it}—is the unemployment rate in country i in time t, TreatCountry was defined as the group of 8: the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia since 2004 and 2006 and Bulgaria and Romania since 2007. PostTreatPeriod variables were defined as follows: 2004–2014, 2006–2014 and 2007–2014, respectively. Due to the fact that unemployment rate counts a stock of people who search for jobs and cannot find them, we lagged the endogenous variable to cover this part of unemployed people who did not find their jobs. The results of difference in differences estimator are given in Table 5.1.

An empirical analysis of the unemployment rates within the CEE countries confirms a significant decrease in three specified periods after the EU enlargement ($\widehat{\beta}_1$) but no permanent effect occurred in the longer time period ($\widehat{\beta}_2$). This impermanence resulted mainly from the recession that started in Europe in 2008 that worsen the conditions on labour markets in all European countries. The Baltic States registered a particular increase in the unemployment rates in 2010 (see Fig. 5.1). The average unemployment rate in the EU15 group of countries was also higher and in 2009 exceeded a limit of 9 %, while in 2013 it was above 11 %.

5.2.7 *Natural Experiment in a Regional Scale: Development of Eastern Poland*

Let us consider the case of the programme of regional development that was realised in Poland in 2007–2013. The programme was aimed to accelerate the social and economic growth ratio in the provinces (voivodships) of the so-called Eastern Wall of Poland (the lubelskie province, the podkarpackie province, the podlaskie province, the świętokrzyskie province and the warmińsko-mazurskie province). The projects realised as a part of the *Operational Programme Development of Eastern Poland* (OP DEP) are co-financed by the European Regional Development Fund. The funds granted for this aim amount to over 2.2 billion euros (see: http://en.parp.gov.pl/). Here we considered the effects of the programme

Table 5.2 DD estimator of treatment effect in Eastern Poland

Variable	East-Central	East-South	East-N-West	East-S-West	East-North
GDP pc	0.775	0.425	0.795	0.19	0.92
un_rate	0.87	0.925	2.265	2.64	2.12
Inv	−4,623,906	−701,865	2,204,505	6,573,294	891,931

held in the Eastern part of Poland in comparison to other regions. We applied DD estimator to compare two separate periods, i.e. 2004–2007 and 2008–2012, while the treated group was formed by Eastern region and non-treated groups consist of Central, Southern, North-Western, South-Western and Northern regions of Poland. The sub periods correspond to the business cycle phases, the former means the phase of economic growth and the latter is related to an economic recession. The following variables were taken into account: the regional GDP per capita, the unemployment rate and investment made. Chow test applied for the data shows significant structural breaks in all three series in Eastern region in 2008. The results of difference in differences estimator are shown in Table 5.2.

The results show positive effects of the programme aimed at the development of Eastern Poland taking into account both GDP p.c. and the unemployment rate. Only investment when compared with Central and Southern Poland was negative. The reasons of such a state of arts are complicated. The first one may be due to the fact that enterprises located in Eastern Poland are poorer than those located in Central and South regions and their investments are insufficient in comparison to Central and South regions. The second reason is that despite of pumping additional funds for the development of Eastern Poland, it still remains not very attractive for investment. There is yet another possible interpretation. Although the European Union is interested in the realisation of the cohesion policy covering all regions, it is insufficient for the incentives for investment in some regions, i.e. in Eastern Poland. And the final possible reason is related to the domestic policy for creating and supporting business in Poland, but this one is not diversified regionally. It is worth noting that in the period of the economic recession in the years 2008–2009, the incentives for investment were weaker than in the period of prosperity.

Analysing the case of the Programme Development of Eastern Poland, it is interesting to compare the results of the model based on the observations and the results of the natural experiment. To show the difference we considered the panel data model describing the unemployment rate conditionally on the magnitude of investment and regional GDP p.c. growth rate in six regions of Poland in the years 2004–2012. A fixed effect estimator was applied, since the regions exhibited significant diversity (see Tables 5.3 and 5.4).

Individual effects are shown in Table 5.4.

The observational perspective indicates that growth of investment and growth of the regional GDP per capita caused a decrease in the unemployment rate in Eastern Poland. Thus, the results of the Operational Programme may be thought as positive from the perspective of the desired changes. But when the level of the unemployment rate is considered, the results are not so optimistic. Individual effects show the

Table 5.3 The impact of treatment effect in Eastern Poland on the unemployment rate

	Estimate	Est. std error	t-Student	*P* value
Inv	−3.153e-07	5.199e-08	−6.064	2.32e-07
GDP p.c.	−0.265	0.111	−2.382	0.021
LSDV $R^2 = 0.701$ within $R^2 = 0.558$ DW = 0.64				

Table 5.4 Individual effects in the unemployment rate across the regions of Poland

Region	Central	South	East	N-West	S-West	North
Estimate	4.452	−0.791	−1.172	−0.967	−3.014	1.491

distance between average unemployment rates in particular regions in comparison to the average unemployment rate in Poland. Only two regions, i.e. Central and Northern, had lower unemployment rates in comparison to the average level, while four remaining regions had their unemployment rates above the average. In the case of Eastern region it was 1.17 % higher.

Applying the dynamic panel model for the unemployment rate gave the following results: better statistical characteristics of the residuals (no autocorrelation), insignificant effect of investment and GDP p.c. and adding lagged value of the unemployment rate which occurred significant. When the DD estimator was applied where y_i is the unemployment rate in treated and non-treated regions and w_i is a treatment variable, such as it takes the value 1 in the treatment period, i.e. 2008–2012 based on natural experiment was estimated for the case of Poland's Eastern region, the estimate of the parameter φ estimate was equal to –0.001 and it was significant at 10 % level. This may imply a slight efficiency of the Operational Programme Development of Eastern Poland and, also, the confounding impact of the economic recession of 2008–2009. Then the results of the regional experiment were lower than expected. Otherwise, the observational study gave an insight into regional differences.

All of the presented above results of natural experiments in macroeconomics show the importance of discussion developed by Hayek (Hayek 1978) on constructivist and ecological rationality in economics and the Duhem-Quine problem in methodology.

5.3 Model-Based Experiments in Macroeconomics

Econometric models constitute one of the most important backgrounds for experimentation and simulation in macroeconomics. Since the earliest models of the economy were constructed, these tools have developed significantly not only due to the improvement of economic theories but also as an effect of developing computers, packages and methods of analysis. In this part two types of experiments are considered. The first one is related to forecasting based on simulation using the

Table 5.5 Forecast errors comparison for MC method and simple extrapolation (source: Osińska (2007)

Series	MAPE for MC (median)	MAPE for extrapolation
WIGbanki	3.84	2.71
WIGbud	1.63	2.54
WIGinfo	1.27	2.66
WIG20	3.04	3.73

Monte Carlo method when the Stochastic Unit Root Model was used, presented in Osińska (2007). The second one covers the scenarios of Polish economy development prepared on the basis of the model W8D-2002 and published by Welfe et al. (2004).

5.3.1 *Forecasting Using Model-Based Experiment*

Osińska (2007) considered a stochastic unit root model for forecasting financial time series (see Granger and Swanson 1997). The simplest STUR representation is as follows.

$$y_t = \alpha_t y_{t-1} + \varepsilon_t, \tag{5.3}$$

where:

$$\alpha_t = \alpha_0 + \delta_t \tag{5.4}$$

$$\delta_0 = 0. \tag{5.5}$$

$$\delta_t = \rho\delta_{t-1} + \eta_t, \tag{5.6}$$

and $\alpha_0 = 1$ as well as $|\rho| \leq 1$. Furthermore, $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ and $\eta_t \sim N(0, \omega^2)$ are independent of each other. For the reason of time varying unit root, the model is fairly complicated for practical use.

The data came from the Warsaw Stock Exchange and covered the period from 02 January, 2001 to 15 November, 2005. The data set cover selected sub-indices of the WSE (called WIGx). The data were checked for the presence of a stochastic unit root and respective models were estimated. The forecast errors values based on the Monte Carlo experiments using 10,000 replications (the median was computed) and on simple extrapolation (daily data, in-the sample forecasts) are shown in Table 5.5. Lower (better) values of errors are bolted.

The illustration of the results for WIFinfo is shown in Fig. 5.2.

The results meet the expectation that reasonable results can occur only when the non-linear mechanism generating the conditional mean of returns is recognised. The STUR models seem to be one step closer to reaching this aim. The usefulness of the MC method in economic forecasting was then fully confirmed.

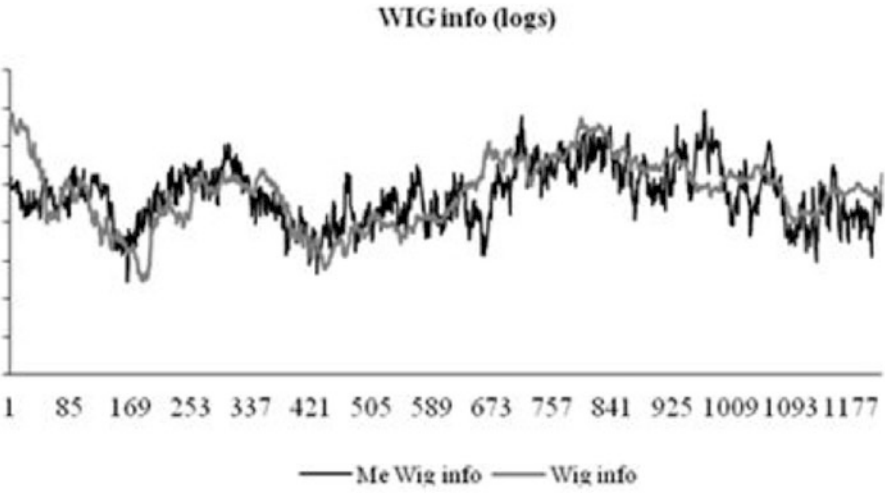

Fig. 5.2 Median of forecasts of WIGinfo series and the original series

5.3.2 Scenarios of the Economic Development of the Polish Economy in the Long-Run

Welfe et al. (2004) proposed an experiment concerning different scenarios of the development of the Polish economy after the EU enlargement. The macroeconomic model W8D-2002 was a basis of the analysis. The W8D-2002 model is a medium-sized model which in its simulation version includes 216 equations, i.e. 80 stochastic equations and 136 identities. The model allows generating final demand and its elements, and production potential and its determinants. Further, it enables analysing inflationary processes, financial flows and possible tensions in macro-balances. The full description of the model is given in Welfe et al. (2004).

Here the most meaningful assumptions that formed the basis of the simulations are presented. The assumptions of the long run values of the following variables were taken: the share of investments in GDP [%], share of FDI in GDP [%], net transfers from the European Union [billion USD], exports of goods and services [rate of change, %], share of expenses for education in GDP [%], share of expenses for R&D in GDP [%] and the elasticity of absorption from abroad changes [%]. Six scenarios were assumed taking into account different values of the mentioned variables. Two of them were optimistic, two other were moderate and the last two were really restrictive. An additional assumption of the growth supporting the long-run policy in Poland was taken despite of the political option represented by the government. At the same moment the expansionary fiscal policy was excluded and the neutrality condition of monetary policy was assumed. The assumptions were fully compatible with those of the Polish government policy assumptions presented in different documents.

The forecast horizon reached the year 2025, although shorter sub-periods were of the special interest, too.

The results proved quite realistic, though between 2004 and 2015 at least two scenarios were implemented. Till 2007 an optimistic scenario of fast growth was realised with the average yearly growth rate of 5.5 %, while starting from 2008 the pessimistic scenario became an empirical fact. The recession was planned in a pessimistic scenario between 2009 and 2011 but in practice it took place 2 years earlier. The average GDP growth rate in the years 2008–2012 was 3.4 %. In the pessimistic scenario its simulated value was 3.6 %.

The example of the scenarios of the long run development of the Polish economy shows that an appropriate macroeconomic model can be a useful in experimentation in macroeconomics in different periods of time: short, medium and long run. W8D-2002 proved its simulation utility. Yet another conclusion can be formulated. The model is based on a fair economic theory and related to economic policy assumptions. Thus, it captures a wide range of possible scenarios and it is very useful from the perspective of a macroeconomic decision-making process.

5.4 Conclusions

Experiments in macroeconomics are mainly an instrument of scientific cognition that allows examination of causality, quantification of model parameters and the identification of active social and economic mechanisms. A large number of experiments confirms the high utility of this tool. Examples of experiments conducted are provided also by Fuchs and Hassan (Fuchs-Schůndeln and Hassan 2015, 95–100). Experimenting in macroeconomics is undoubtedly the result of the development of economic psychology (usually being associated with behavioural economics), in particular, of macroeconomic psychology. Both natural and laboratory experiments find their applications. It should be noted that experiments in macroeconomics may concern both short and long term dependence. Resource, organisational, social and cultural dependence taken into account while conducting macroeconomic research constitutes the subject of experimentation.

References

Acemoglu D, Johnson S, Robinson J, Thaicharoen Y (2003) Institutional causes, macroeconomic symptoms: volatility, crises and growth. J Monetary Econ 50:49–123

Bergstra JA, de Leeuw K (2013) Questions related to Bitcoin and other Informational Money (2013) Informatics Institute. University of Amsterdam, Amsterdam

Development of Eastern Poland. http://en.parp.gov.pl/. Accessed 20 July 2015

Fuchs-Schůndeln N, Hassan TA (2015) Natural experiments in macroeconomics. http://www.hoover.org/sites/default/files/fuschs-schundeln-hassan-papernaturalexperimentsmacro_mar16.pdf. Accessed 8 Aug 2015

Grabowska-Lusińska I, Okólski M (2008) Migracja z Polski po 1 maja 2004 r.: jej intensywność i kierunki geograficzne oraz alokacja migrantów na rynkach pracy krajów Unii Europejskiej. CMR Working Paper 33/91

Granger CWJ, Swanson NR (1997) An Introduction to Stochastic Unit–root Process. Journal of Econometrics 80:35–62

Hayek FA (1978) New studies in philosophy, politics and the history of ideas. Routledge & Kegan Paul, London/Henley

Mioduszewska M (2008) Najnowsze migracje z Polski w świetle danych Badania Aktywności Ekonomicznej Ludności. CMR Working Paper, 36/94

Osińska M (2007) Prognozowanie na podstawie modeli STUR. In: Osińska M (ed) Procesy STUR. Modelowanie i zastosowanie do finansowych szeregów czasowych. Dom Organizatora TNOiK, Toruń

Pedersen PJ, Pytlikova M (2008) EU enlargement: migration flows from Central and Eastern Europe into the Nordic countries – exploiting a natural experiment. University of Aarhus Working Paper 08-29

Raddatz C (2007) Are external shocks responsible for the instability of output in low-income countries? J Dev Econ 84:155–187

Smith VL (2013) Racjonalność w ekonomii. Wolters Kluwer Polska S.A., Warszawa

Tyszka T (2004) Psychologia ekonomiczna. Gdańskie Wydawnictwo Psychologiczne, Gdańsk

Welfe W, Florczak W, Welfe A (2004) Scenariusze długookresowego rozwoju gospodarczego Polski. Wydawnictwo Uniwersytetu Łódzkiego, Łódź

Zaleśkiewicz T (2011) Psychologia ekonomiczna. Wydawnictwo Naukowe PWN, Warszawa