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Leading indicators of turning points of the business cycle: panel data analysis for OECD countries and Russia

1. Introduction

The subject of early identification of turning points of the business cycle is of great practical interest to both the business community and economic policy decision-makers. Since the 1946 study by W. Mitchell and A. Burns, in which a serious statistical analysis of business cycles was conducted for the first time, the dilemma of "predicting the future" has been holding an important place in macroeconomic analysis.

Over the past two decades, the debate on business cycle issues has become slightly different. This has to do with the extremely "smooth" macroeconomic trends in Western European countries and USA during the 1990s and the 2000s (excluding several short-term mild recessions in the beginning of the 1990s). Decrease in severity, occurrence and length of recessions in developed countries provided a reason for certain analysts and researchers to insist on the "end of a business cycle" (Weber, 1997).

However, these false perceptions were shattered by the recent global macroeconomic crisis, which happened at the end of the 2000s. All major European countries with the exception of Poland experienced recession in 2009 (based on their real GDP annual growth rate becoming negative). This means that the market economy continues to develop in cycles; the economic recovery and increase in the social welfare are inherently followed by crises adjusting the imbalance of the previous development stages.

Until recently, scientists and analysts speculated that the ongoing structural changes in the economies of developed countries (growth of service sector, technological shifts, globalization of production, changing government policy priorities, etc.) led to a decrease in the volatility of economic activity in these countries. However, long periods of expansions during the latest two decades were stipulated, to a large extent, by spurring demand which led to steady imbalance between revenue and expenditures of the economic agents resulting in dramatic increase of the debt burden. Furthermore, excessive liberality in regulating the financial sector resulted in "bubbles" inflating at the variety of markets (dot-coms, real estate, commodity markets, etc.). This determined the formation and sustaining of positive expectations for a long period of time. Artificial increase in demand has finally led to serious consequences, namely, that the financial bubble burst resulted in asset price decrease and escalated the problems with collateralized loans. An increase of debt-to-income ratio stipulated an increase in loan

defaults in the private sector and the formation of pre-crisis conditions in the government finance sector. In some cases, this resulted in the de facto debt crises in the European countries.

Currently there is a high risk that recession will re-emerge (or will continue for many OECD countries). This is linked to a range of the structural problems which remain unresolved, and which have prolonged the last crisis in a number of Southern and Eastern European countries, namely, difficulty in reducing government debt burden, issues with competitive weakness of national economies, inflexibility of job markets, low susceptibility to innovations, etc. Given these conditions, the interest lies in not only predicting a point of entry into recession but also in predicting points of recovery from a macroeconomic crisis.

This paper's main objective is to develop leading indicators of business cycle *turning points*[1] as pertaining to OECD countries and Russia, in order to reveal common factors of their macroeconomic processes over a long period of time. To predict cycle turning points, in this study we shall construct leading indicator models using a discrete dependent variable reflecting a business cycle phase (being recession or expansion in the simplest case).

2. Methodology and data description

The majority of existing empirical studies on leading indicators of macroeconomic crises (recessions) use a discrete dependent variable and are based on the time series data for one or several countries (e.g. Stock, Watson, 1992; Estrella, Mishkin, 1998; Moneta, 2005; Kauppi, Saikkonen, 2008; Ng, 2012, etc.). Most of these studies analyze the predictive power of government bond yield curve to predict recessions in the US and in other developed countries.

Leading indicators built on a single country's data have an important disadvantage: they are not "flexible", and cannot be directly applied to another economy. Furthermore, analysis of a single country's data is significantly constrained due to a low number of crisis situations in isolated countries. If the US economy experienced four or five dated recessions in the last thirty years depending on the dating methodology applied, the number of "market" crises in post-socialist economies would be much lower. For example, with respect to Russia, the comparable time series date back to the late 1990s, and from then until now only two recessions have been recorded. So, in order to construct a model capable to predict business cycle phase change in Russia and in other countries for which the comparable time series of the macroeconomic statistics are relatively low, we are going to apply cross-country panel data analysis. Taking into account business cycle records on a wide variety of countries increases the quality and the validity of constructed models, and conclusions achieved on their basis, as compared to the conventional research found in reference works, which is based on a single country's data.

[1] Forecasting of GDP dynamics or other macroeconomic indicators is not an objective of this work. The identification of business cycle phase change is presented below.

In order to date phases of a business cycle, this study uses a method of growth rate cycle [2], since it is simple in methodology, and because phases of macroeconomic dynamics based on this indicator are clearly identifiable. As a key indicator determining business cycle phases, we are using real GDP annual[3] growth rate as the most general and available for all countries economic activity indicator. In this case, the times when GDP experiences a steady decline (GDP growth rate is negative) can be classified as a recession, when it grows - as an expansion, respectively.

We use annual data of 25 OECD countries and Russia[4]. When compiling different nationwide statistics into a single panel, it is assumed that the reasons and characteristics of the change in their macroeconomic conditions are similar. A period of transition crisis (recession) experienced by post-soviet countries after abandoning planned economy and transition to market mechanisms of ensuring macroeconomic equilibrium is an exception. Therefore, the period of negative growth rate for these countries at the end of 1980s - beginning of 1990s was excluded from the analysis.

This paper pays particular attention to testing the predictive power of the variables for financial and credit markets, since the growing "financialization" of modern economy stipulates an increase in financial sector influence over the behavior of real sector, including the influence over business cycle phase rotation. Furthermore, the expertise of theoretical and empirical studies attests to the importance of financial factors when explaining cycle fluctuations. Financial variables are used not only as indicators of "early response" to exogenous shocks (procyclical financial indicators are accounted for in the majority of the empirical studies), but also as a "thermometer" reflecting the internal financial and macroeconomic imbalances which can lead to macroeconomic corrections in the future (countercyclical financial indicators).

In some studies dedicated to the leading indicators of financial crises, the authors noticed a post-crisis bias, which, if unaccounted for, can lead to biased assessments of an econometric model. The underlying issue is that factors leading to a crisis (or a recession) and factors responsible for its continuation are different. In particular, during crisis the macroeconomic variable behavior is extremely unstable due to the ongoing "crisis clearing", and as a result of adjusting to a new macroeconomic equilibrium. Therefore, if the events during the beginning of a crisis and the events during its continuation are treated as equal events, then unsatisfactory results may be obtained with respect to a model of leading indicators during the beginning of a crisis.

[2] Other types - classical business cycle and deviation or growth cycle.

[3] Other types of variable which reflect cyclical fluctuations in an economy: industrial production index (OECD, 2008); a range of synchronous indicators (NBER dates, after that - most of research on the US business cycles, including Estrella, Mishkin 1998; Kauppi, Saikkonen, 2008; Ng, 2012, and others); composite synchronous indices (Conference Board, 2000; Stock, Watson, 1989).

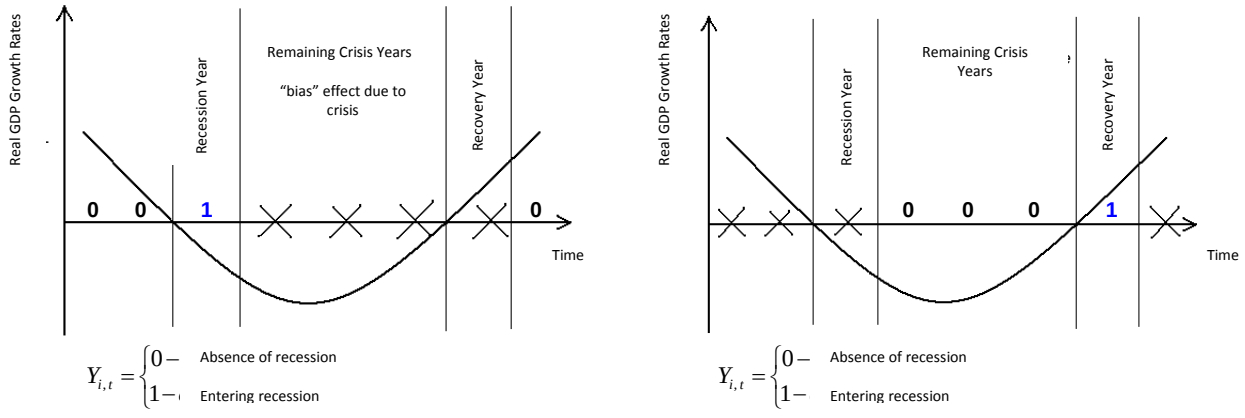
[4] Complete list of countries: Austria, Belgium, UK, Hungary, Germany, Greece, Denmark, Ireland, Spain, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, USA, Turkey, Finland, France, Czech Republic, Sweden, Estonia.

The issue of a post-crisis bias in the empirical studies on predicting financial crises was being resolved within the framework of two options. Demirguc-Kunt, Detragiache (1998) suggested that all post-crisis observations (periods of crisis continuation) be excluded from the sampling. Bussiere, Fratzscher (2006) considered post-crisis observations as separate events, which resulted in their dependent variable having 3 status scenarios, as follows: absence of crisis, pre-crisis, and crisis (multiple choice models).

Using the approaches and methods adopted in reference works with respect to leading indicators of financial crises, the issue of "post-crisis bias" was taken into consideration when developing recession and recovery models (this problem has not been resolved in the existing business cycle studies). In particular, two different binary choice models were evaluated (the first one - on entering recession, the second one - on recovering from recession). To prevent bias of estimate coefficients, when calculating the probability of an event of interest (entering recession or recovering from it), we have excluded all observations during the time when the event was not feasible (per the approach described by Demirguc-Kunt, Detragiache, 1998).

Taking into account the above notes on considering "post-crisis bias", the dependent variable of a binary *recession model* was specified, as follows (See Figure 1):

- absence of recession (status "0") - real GDP positive growth rates, with the exception of the recovery year;
- first year of a recession (status "1") - first year of real GDP negative growth rate;
- the remaining crisis years and the year of recovery are excluded from the sampling.



A) Recession model B) Recovery model

Figure 1 - Constructing dependent variables of binary choice recession and recovery models

Specification of a dependent variable for a binary *recovery model* is outlined, as follows (see Figure 1):

- absence of recovery (status "0") - real GDP negative growth rate, with the exception of the first year of crisis;

- year of recovery (status "1") - the first year, in which the real GDP growth rate shifts to the positive side, and, at the same is at least half the mean value of pre-crisis rates. This position excludes probability of an L-shaped recovery ("technical" recovery with low positive growth rates);
- the remaining crisis years and the year of recovery are excluded from the sampling.

Below is a brief outline of the technical details involved in an assessment of a binary choice model. Suppose a dependent variable Y takes value 1, if country i at time t is in recession (for recession model, for recovery model value "1" will be a value of dependent variable at the time when the crisis is over – see Figure 1). In this case the probability formula for the event of interest (change of mode in macroeconomic dynamics) is as follows (binary choice logit model):

$$\Pr\{Y_{i,t}=1 \mid X_{i,t-1}\} = F(X_{i,t}^{'}\hat{\beta}) = \frac{\exp(X'_{i,t-1}\beta)}{1+\exp(X'_{i,t-1}\beta)}, \text{ where}$$

$X_{i,t-1}$ – set of explanatory variables for country i for a year $(t-1)$

β – vector of parameters which are subject to assessment

F(z) – logistic distribution function (logit model).

This model can be estimated using maximum likelihood estimation (MLE) method.

The majority of works mentioned above are based on monthly US economy statistics, which allowed the authors to use the following leading economic indicators: data on workforce movement (employment indices), sales, stock, and orders figures, real estate indicators, etc. It should be noted that for these indicators there are no comparable data for any wide range of countries. Same problem lies with an important predictor of recessions in the US - government bond yield curve. We are unable to use this indicator since the only comparable data available for a wide range of countries are average rates of government securities for all maturity dates.

As consistent with the analysis of empirical and theoretical studies, and, given that this paper is based on low-frequency (annual) data of a wide range of countries, we have come up with a set of indicators which are possible predictors of business cycle phase changes:

- Indicators of domestic macroeconomic dynamics:
  - Leading indicator of economic activity in OECD methodology;
  - Confidence indices of economic agents in OECD methodology;
  - Other macroeconomic variables (investment behavior, inflation, GDP growth rate).
- Domestic financial sector variables:
  - Dynamics of stock indices;
  - Interest rates and spreads between them;
  - Bank lending trends;
  - Bank liquidity scale;

- General level of systemic risk in the financial sector in CMASF methodology[5].

- Indicators of foreign economic conditions and the balance of foreign operations:
  - US business cycle phase;
  - Current account balance to GDP ratio;
  - REER (real effective exchange rate) index.

Next, we support the incorporation of the indicators as the leading indicators based on the analysis provided in the theoretical and empirical studies.

Confidence of Economic Agents. In the context of dynamic models for macroeconomic fluctuations based on a general economic equilibrium with rational expectations of agents under specific conditions it is possible to gain several equilibrium paths (Mankiw, 2006; Zarnowitz, 1996). At the same time switching between "favorable" and "unfavorable" output occurs as a result of a sharp change in the expectations (confidence in future positive macroeconomic dynamics). When modeling, these expectations can easily become self-fulfilling. One possible mechanism is to adjust returns from investments calculated based on the expectations of future profits. If agents are able to forecast worsening of the economic situation, they will cut current costs (including investment costs), which will result in a decreased output. From a non-modeling perspective, this logic was first described by Keynes in 1936, whose studies outline the speculative expectations of the profits by the investors as one of the attributes of investment.

Investments. The role of the investments in producing fluctuations of aggregate output is mentioned both in the majority of early business cycle theories (dating back to the first half of the last century, see overview by Zarnowitz, 1996), and in the real business cycle modern theories (technological shocks, cause by a flurry in investment activity - see overview by Rebelo, 2005). The Keynesian theory, which dominated the minds of the economists in mid-1920s, assigned a significant role in explaining crises to the investments, driven by spikes in the marginal efficiency of capital (Keynes, 1936). Let's also point out a famous multiplier-accelerator investment model, suggested in the studies by Samuelson (1939) and Hicks (1950), which observes recurring fluctuations in production, a result of investment and output interaction.

Inflation. Inflation dynamics within business cycles had been studied aggressively in the pre-war theories: e.g. inflation-deflation cycle in Hawtree theory. A build-up of inflation pressure within the scope of expanding fluctuations also had been noted in early dynamic models of general equilibrium (Lucas, 1976), in which random (unexpected) shocks of monetary policy caused change in relative pricing at first, and fluctuations of general pricing later.

GDP Growth Rates. Economy slowdown (GDP growth rate decline) prior to recessions is associated rather with an empirical fact, and a reader's intuition is, therefore, called upon. Indeed, if the

[5] See Solntsev et el. (2011)

economic activity peaks before recession, then when moving towards this peak, the economy growth declines.

Influence of Global Factors. Significant empirical data which confirms the increase in synchronism of the business cycles for the key players in the global economy have been gathered over the past decades (Stock, Watson, 1999; Zarnowitz, 1996). Among the reasons is an increase in the integration of countries into global economy leading towards an increased dependence of the economies on one another, as well as to an increase in the impact of general shocks. This explains the need to account for the global factor in business cycle models for certain countries.

Current Account Balance. In his studies, Hawtree spoke of the importance of the foreign economic balance indicators in the interpretation of business cycles. In his theory, monetary by nature and developed, among other things, for open economies, the reduction in trade balance (the main component in current account balance) leads to an outflow of gold and currency reserves, and, under otherwise equal conditions, to a decline in money supply and recession. In Altug's theories, when listing the empirical regularities, observed as part of business cycles, it is noted that the behavior of trade balance is countercyclical, since import is more prone to cyclical fluctuations than export (Altug, 2009). This justifies the need to track the current account balance as an indicator of foreign economic imbalances when developing leading indicators of business cycle phase change.

Dynamics of national currency REER as part of a business cycle can be associated with the fluctuations of inflation rates. Under otherwise equal conditions, acceleration of inflation as part of a business cycle upward phase leads to strengthening of the real exchange rate, which undermines national trade balance, and, thereby, reduces a country's profit (output).

Bank Lending and Interest Rates. The influence of financial market variables is examined in several monetary theories of a business cycle. For example, as part of the pre-war theories by Hawtree and Hayek, bank lending instability was considered a source for cyclical fluctuations in the economy (Zarnowitz, 1996). The same theories counted interest rate as a variable which reacts to change in credit activity. This made it possible to connect financial and real variables through the availability of financial resources to investment. The importance of credit financing when implementing innovations in production was noted by Schumpeter (Zarnowitz, 1996). In his theory, output fluctuations are stipulated by the innovations of various lengths.

Stock Indices. Asset price shocks are considered an important factor, capable of causing macroeconomic fluctuations through a mechanism of financial acceleration (impacting cost of loan collaterals and, respectively, loan availability, which stipulates demand for assets and asset prices) (Bernanke, Gertler, Gilchrist, 1999).

Liquidity and Availability of Credit on the Interbank Market. In the study by Gertler and Kyotaki (2011), the authors based their conclusions on a dynamic stochastic general equilibrium model with

financial intermediaries. They concluded that liquidity shocks of certain banks in conjunction with market imperfections of the interbank lending lead to strengthening of a recession. The mechanism for that would be a decline in loan availability by the banks affected by recession, given the conditions of limited access to liquid resources. The calculations done by the authors also show that Central Bank policies regarding availability of refinancing may lower the negative effect that financial instability has on the output.

Impact of Financial Crises. In the study by Cardarelli it is demonstrated that the periods of financial instability are accompanied by significant socioeconomic losses (Cardarelli et al, 2011). The authors examined 113 episodes of financial instability in 17 developed countries which occurred between 1980 and 2007, and concluded that the output growth rate decline and recession preceded by the episodes of financial instability were more significant as compared to macroeconomic slowdowns without financial stresses (based on the cumulative losses in GDP output, in percentage).

3. Results of constructing leading indicators of business cycle turning points:

3.1. Basic models of recession and recovery.

The assessment of binary recession and recovery models was carried out in three stages.

Fisrt. At first we evaluated business cycle phase variables regressing only by a GDP leading indicator in OECD methodology. We were interested in finding out the degree of quality with which this single indicator is able to predict the state of an economy (if it turns out to be the best predictor, then constructing and using other models will not be practical). Comparing models on the basis of the best predictor set selected by us which utilizes only those models constructed on the basis of the existing OECD leading indicators will enable us to evaluate the extent to which the proposed models of probable switching between business cycle phases are more useful than the existing ones.

Second. We then evaluated a model which used only the real sector variables, without using a GDP leading indicator. The possible regressors may have been the consumer and producer expectations as an indirect estimation of future macroeconomic dynamics, as well as other non-financial indicators.

The following indicators were assigned to *the block of real sector variables*: indicators of domestic macroeconomic dynamics (GDP leading indicators in OECD methodology, consumer and business confidence indices, investment dynamics and GDP), and indicators of foreign economic conditions (REER, current account balance, etc.).

Third. In this phase, we added financial sector indicators to models using real sector variables, in order to determine whether accounting for them would lead to an increase in model predictive power.

The block of financial sector variables includes stock indices, various interest rates and their spreads, lending and bank liquidity dynamics, and systemic risk level in the financial sector (methodology for the latter can be found in Solntsev et el*., 2011*).

We conducted a preliminary analysis of the individual predictive power for certain indicators. In order to do that, paired regressions of the binary choice for variables of recession and recovery were reviewed with respect to each separate indicator (see Table P1 in the Appendix). The quality of approximation was assessed based on the pseudo-R^2 indicators for paired models, as well as the significance of coefficients over a corresponding indicator. The final results are outlined in Table P1 in the Appendix; they are listed based on a level of recession probability approximation.

The analysis demonstrated that the GDP leading indicators in OECD methodology bear the most information among the individual predictors. In addition to this, an extremely high level of the forecasting power was demonstrated by the indicators which describe consumer and business community expectations. Investment dynamics is an important predictor of switching between business cycle phases. Slowdown of real GDP growth rates and their deep decline serve as predictors of both recession and recovery. Current account balance to GDP ratio growth significantly reduces the probability of recession and increases the probability of recovery. A financial crisis indicator demonstrates particularly encouraging results. Interbank market rate and credit boom indicators are also important predictors.

The results of assessing a binary recession model are outlined in Table 1.

Descriptive data for dependent and explanatory variables which are included in the final recession model are outlined in Table P2 in the Appendix.

Table 1 - Binary Recession Model Assessment Results

	Dependent variable - recession probability		
Explanatory variables (lag = 1 year)	Model using OECD GDP leading indicator only	Model using real sector indicators only	Model using real and financial sector indicators
Country GDP leading indicator, per OECD methodology, year by year	–1.191*** (0.235)		
Real sector indicators			
Business confidence indicator growth rate		–0.326** (0.142)	–0.442*** (0.143)
US GDP leading indicator, per OECD methodology, year by year		–0.340** (0.141)	–0.422*** (0.141)
Current account balance to GDP ratio		–0.119* (0.063)	–0.176** (0.082)
GDP growth rate, annually		–0.579*** (0.193)	–1.024*** (0.277)
Financial sector indicators			
Composite leading indicator of banking sector systemic crisis (zero lag), per			6.788* (3.904)

CMASF methodology (Solntsev et al., 2011)			
Loan to deposit ratio (LTD)			0.008*
			(0.005)
Interbank lending market interest rate			0.131***
			(0.029)
Constant	–0.899***	–0.141	–1.713*
	(0.323)	(0.662)	(0.945)
Number of observations	246	247	247
Number of countries	20	20	20
LR-test on the importance of equation as a whole (*P*-value)	89.33	51.46	77.88
	(0.000)	(0.000)	(0.000)
LR-test on the absence of random effects (*P*-value)	0.370	0.000	0.000
	(0.273)	(1.000)	(1.000)
Value of likelihood logarithmic function	–36.2	–55.2	–42.0
Pseudo-R^2 (Efron[6])	0.394	0.362	0.459

Notes. * – significance at 10%; ** – significance at 5%; *** – significance at 1%**.**

Source: author's calculations

Interpretation of collected results. All variables were significant for equations with expected coefficient signs. Current year increase of the OECD leading indicator values for a reviewed country and for the global economy leader (US) lowers the probability of recession in the next year. An increase in expectations of businesses has the same impact. Low numbers of current account surplus or its shift to a negative side suggest that a macroeconomic crisis is forthcoming. The risk of recession increases during the slowdown of GDP growth rates, and when financial sector systemic risks increase, the probability of a negative output growth rate will also increase. Interbank market rate growth signals of an approaching crisis. Substantial growing of a loan-to-deposit ratio up to an excessively high level may imply that significant credit risks have accumulated, which are not compatible with the continuation of a business cycle expansion.

The predictive power of a model using the Pseudo-R^2 criterion is worse when the real sector indicators are being used, than when real and financial sector variables are being used. This shows that it is important to account for the latter. A model which uses OECD leading indicators only is more precise than a model which uses real sector indicators only, however, it concedes to a model using a complete set of predictors (related to both real and financial sectors). Thus, our calculations show that if financial sector variables are considered, the onset of a recession can be better predicted.

According to a test on random effects, the combined data model (without accounting for panel structure) is preferred for all three specifications. Thus, a hypothesis of a country's "inherited" recession probabilities is not confirmed by the existing data. The conducted tests show that, for a sample set of

[6] Computation formula: $R^2 = 1 - \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(Y_{i,t} - \hat{\pi}_{i,t})^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}(Y_{i,t} - \overline{Y}_i)^2}$, where $Y_{i,t}$ - real value of dependent variable (value "1", if recession is recorded, value "0" - if otherwise), $\hat{\pi}_{i,t}$ - model value of recession probability

developed economies, there is no exogenously preset vulnerability to macroeconomic crises; the vulnerability is more likely determined by a set of established domestic and foreign factors.

Next, in order to assess the forecasting power of a model, a cut-off threshold is chosen which separates signal sending by a model from its normal state.

This inevitably raises a question about the rule, according to which a continuous series of adjusted recession probability values should be converted to a discrete scale in order to assess the adjustment quality (since only two discrete variables can be compared). A standard cut-off threshold equals 0.5. However, there are many deviations from this rule in reference works.

A study by Birchenhall closely examines an issue with choosing a threshold for recession probability model values, exceeding which is considered a signal of recession (Birchenhall et al., 1999). The authors suggest that the unconditional probability of an analyzed event should be used as threshold. They consider the probability range from 0.5 to the unconditional probability as ambiguous.

In the available references on financial crisis leading indicators (e.g. Bussiere, Fratzscher, 2006) it is suggested to choose the optimal threshold based on the minimization of the regulator loss function, which results from balancing between errors of the first (missed event) and second type (false signal):

$L(\Theta)= \Theta * C / (A+C) + (1- \Theta) * B / (B+D)$, where A, B, C and D are calculated per classification outlined in Table 2 below.

Table 2 - Classification of Events and Their Signals

	Y=1 The event occurs in the course of the next year	*Y=0* The event does not occur in the course of the next year
S=1 indicator sends a signal (exceeding threshold)	*A*	*B* (error of type 2)
S=0 indicator does not send a signal (not exceeding threshold)	*C* (error of type 1)	*D*

Source: Kaminsky, Reinhart (1998)

As the threshold increases, so does the error of type 1, while the error of type 2 decreases. This means that there is a certain optimum, where the weighted total of these errors is minimal. These weights (Θ, $1-\Theta$) are directly dependent on choosing a parameter of regulator sensitivity to errors of type 1 as compared to errors of type 2.

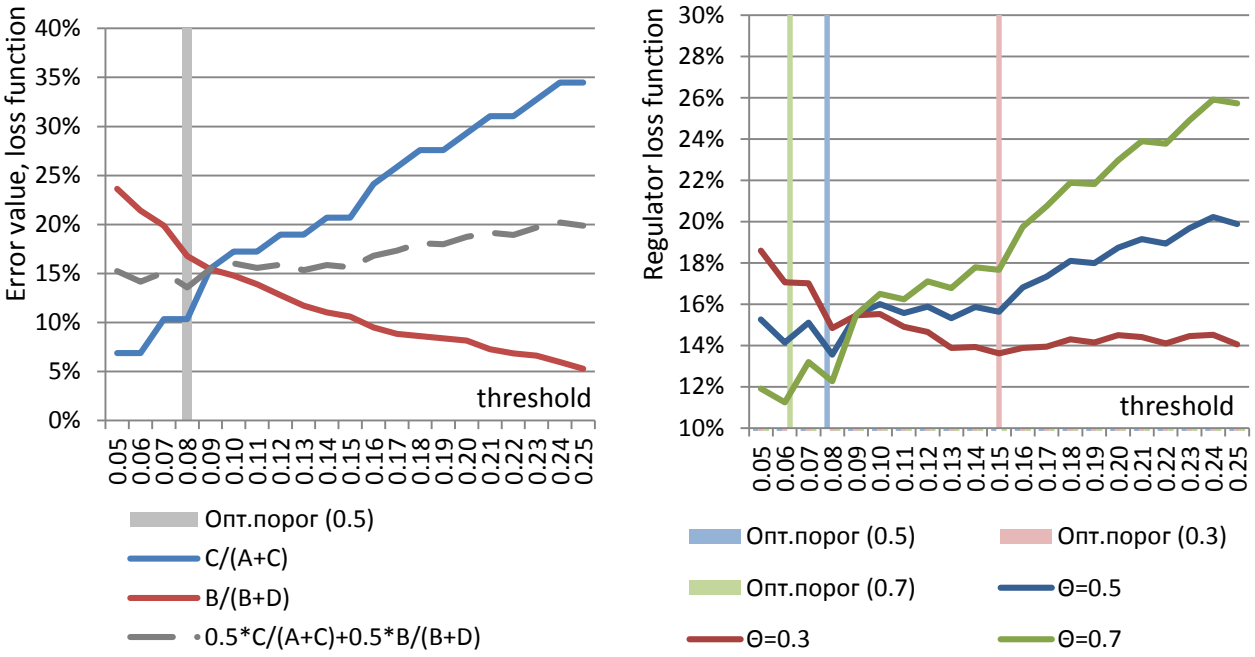
With any values of parameter Θ (parameter of regulator sensitivity to errors of type 1 as compared to errors of type 2), this function will have a minimum point, since the ratio of type 1 errors grows with an increase in threshold values, while the ratio of type 2 errors drops (see Fig. 2-a).

However, optimization results depend on a choice of parameter Θ. So, we have considered several values of parameter Θ: 0.5, 0.3, and 0.7. As seen from Figure 2-б, the choice of optimal threshold directly depends on parameter Θ: the higher the parameter (regulator concerns with respect to missing events), the lower the optimal threshold.

Figure 2 - Choosing recession model optimal threshold using OECD GDP leading indicator only.

a) Errors of type 1 and 2 depending on their threshold and their total including weights = 0.5

b) Choosing optimal threshold depending on a parameter for regulator loss function



Source: author's calculations

Table 3, based on a recession model using OECD leading indicators only, presents the main indicators, upon which we assess the forecasting power of models depending on parameter Θ. We also show, for monitoring purposes, the values of model quality characteristics for the thresholds used in reference works which are equal to the unconditional probability of the event and the value of 0.5.

As evident from the data in Table 3, the threshold of 0.5 leads to a drop in a "noise/signal" parameter all the way down to negligibly low levels. However, in this case the quality of predicting analyzed events drops in the following way: the ratio of correctly predicted events drops below 50% (see last column of Table 3 for all model specifications). At the same time, the threshold, which is equal to the unconditional probability of the event, lies close to its "optimal" value in all models, meaning that its forecasting power is highly attractive. This means that this rule may be applied to choosing a threshold. From now on when comparing models we will be choosing a threshold based on regulator loss function with a 0.5 sensitivity value to missed crises, since it's unlikely that a better determination of its actual value will be made.

Table 3 - Indicators of recession model quality using OECD leading indicators only, as related to the cut-off threshold, %

Parameter of regulator loss function	Θ = 0.7	Θ =0.5	Θ =0.3	*P* (*Y* = 1) 0.11	0.5
Optimal threshold	0.06	0.08	0.15		
Complete Sampling					
Noise/signal	23.0	18.7	13.4	16.9	5.4
Events correctly predicted	93.1	89.7	79.3	81.0	44.8
Missing events correctly predicted	78.6	83.2	89.4	86.3	97.6
Russia					
Noise/signal	0.0	0.0	0.0	0.0	0.0
Events correctly predicted	100.0	100.0	100.0	100.0	50.0
Missing events correctly predicted	100.0	100.0	100.0	100.0	100..0

Source: author's calculations

Table 4 shows values of the predictive power for various previously evaluated recession models with respect to parameter Θ = 0.5. The results of the calculations show that a real sector indicator only model gives way to OECD GDP leading indicator only model, namely, that it carries less predictive power with a higher noise level. At the same time, the model using real and financial indicators predicts recession almost as precisely, as the model using only OECD GDP leading indicator (with respect to Russia, for instance, both models predict 100% of recessions), but at the same time, the level of "noise/signal" is twice as low. The latter confirms the need of constructing probability models on achieving business cycle turning points, which are based not only on the existing leading indicators, but also on a specially selected predictor set with both real and financial sector variables.

Table 4 - Quality indicators for recession models, optimal threshold is based on regulator loss function, Θ=0.5%

	Model using OECD GDP leading indicator only	Model using real sector indicators only	Model using real and financial sector indicators
Optimal threshold	0.08	0.13	0.18
Complete Sampling			
Noise/signal	18.7	20.7	**8.2**
Events correctly predicted	89.7	79.1	**88.0**
Missing events correctly predicted	83.2	83.7	92.8
Russia			
Noise/signal	0.0	0.0	0.0
Events correctly predicted	100.0	50.0	100.0
Missing events correctly predicted	100.0	100.0	100.0

Source: author's calculations

The results of assessing the binary recovery model are presented in Table 5Table 5 (logic and sequence of the assessment correspond to recession model). Descriptive data for dependent and explanatory variables included in the final recovery models are outlined in Table P3 in the Appendix.

In the recovery equations most indicators turned out to be of significant value at the level of 1%. A composite leading indicator of financial sector systemic crisis turned out to be an exception - not a significant value at the level of 10%. Inclusion of this statistic has been stipulated by a high level of its forecasting power.

GDP leading indicators in OECD methodology as well as business confidence growth rate (less implicitly) are helpful when predicting recovery. Maintaining foreign economic imbalances (low or negative current account balance) keeps the economy from ending its decline and switching to growth. From the perspective of monetary policy, it is important to make a conclusion on how the depth of national currency real effective exchange rate depreciation impacts the speed of recovery from macroeconomic crisis. The higher the depreciation of the real exchange rate (negative growth rates), and the stronger it pushes the start of export-oriented economy growth, the more probable is the end of a macroeconomic crisis.

Table 5- Binary Recovery Model Assessment Results

	Dependent variable - probability of recovery from recession		
Explanatory variables (lag = 1 year)	Model using OECD GDP leading indicator only	Model using real sector indicators only	Model using real and financial sector indicators
Country GDP leading indicator, per OECD methodology, year by year	0.621*** (0.155)		
Real sector indicators			
Business confidence indicator growth rate		0.087 (0.100)	0.208* (0.129)
US GDP leading indicator, per OECD methodology, year by year		0.872*** (0.330)	1.284*** (0.470)
Current account balance to GDP ratio		0.286** (0.115)	0.351** (0.151)
REER growth rate, annually		–0.113* (0.062)	–0.153** (0.074)
Financial sector indicators			
Composite leading indicator of banking sector systemic crisis (zero lag), per CMASF methodology (Solntsev et el., 2011)			–5.095 (7.407)
Loan to deposit ratio (LTD)			–0.015* (0.008)
Bank liquid assets to total assets ratio			–0.321***

			(0.116)
Constant	–1.428***	–3.084**	–0.850
	(0.421)	(1.234)	(1.838)
Number of observations	77	77	77
Number of countries	21	21	21
LR-test on the importance of equation as a whole (*P*-value)	42.39 (0.000)	47.63 (0.000)	57.8 (0.000)
LR-test on the absence of random effects (*P*-value)	0.000 (0.499)	0.000 (0.500)	0.000 (1.000)
Value of likelihood logarithmic function	–29.3	–26.7	–21.5
Pseudo-R^2 (Efron)	0.439	0.356	0.602

Notes. * – significance at 10%; ** – significance at 5%; *** – significance at 1%**.**

Source: author's calculations

Insufficient adjustment of borrowed and invested capital in the banking system (LTD indicator) can become an agent in the continuation of a recession. The ability of parameter which reflects the speed of disposing the post-crisis banking liquidity "overhang" to predict recovery from recession is worth noting. The higher the accumulated volume of the banking system liquidity in percentage of total assets, the slower is credit thawing by the banks, and the less likely is the probability of recovery.

In general, the conclusions pertaining to ranking of recovery model specifications are repetitive of those made with respect to a recession model (see pseudo-R^2 values in Table 5 and calculations in Table 6). Assessment results confirm higher utility of a model based on a wide range of financial and real predictors as compared to alternate specifications.

Table 6 - Quality Indicators for recession models, optimal threshold is based on regulator loss function, Θ=0.5%

	Model using OECD GDP leading indicator only	Model using real sector indicators only	Model using real and financial sector indicators
Optimal threshold	0.35	0.35	0.35
Complete Sampling			
Noise/signal	19.9	30.4	**16.9**
Events correctly predicted	83.0	81.1	**96.4**
Missing events correctly predicted	83.5	75.4	83.7
Russia			
Noise/signal	0.0	50.0	0.0
Events correctly predicted	50.0	100.0	100.0
Missing events correctly predicted	100.0	50.0	100.0

Source: author's calculations

3.2. Analysis of benefits derived from eliminating the post-crisis bias

In this section we present a test for the need to eliminate the post-crisis bias, which we mentioned earlier. For that we will compare the predictive power of two models which assess recession probability. The first model, which comes with the selected by us set of financial and real sector predictors and the elimination of the post-crisis bias per the scenario described above (assessment results are fully identical to the model, presented in the last column of Table 1). The second model comes with the same explanatory variables, but with a simpler dependent: periods of recession continuation are not eliminated, as before. In this case the dependent variable takes two values: "0", if real GDP growth rates were positive (expansion), and "1", if they were negative (recession). The assessment results for these models are outlined in Table 7.

Table 7 - Assessment Results of Binary Recession Models

Explanatory variables (lag = 1 year)	Model where post-crisis bias is eliminated	Model where post-crisis bias is not eliminated
Real sector indicators		
Business confidence indicator growth rate	–0.442*** (0.143)	-0.228** (0.114)
US GDP leading indicator, per OECD methodology, year by year	–0.422*** (0.141)	-0.399*** (0.123)
Current account balance to GDP ratio	–0.176** (0.082)	-0.125** (0.063)
GDP growth rate, annually	–1.024*** (0.277)	-0.211** (0.089)
Financial sector indicators		
Composite leading indicator of banking sector systemic crisis (zero lag), per CMASF methodology (Solntsev et el., 2011)	6.788* (3.904)	2.905 (3.109)
Loan to deposit ratio (LTD)	0.008* (0.005)	0.008** (0.004)
Interbank lending market interest rate	0.131*** (0.029)	0.036** (0.017)
Constant	–1.713* (0.945)	-2.628*** (0.738)
Number of observations	247	280
Number of countries	20	20
LR-test on the importance of equation as a whole (*P*-value)	77.88 (0.000)	76.97 (0.000)
LR-test on the absence of random effects (*P*-value)	0.000 (1.000)	0.000 (1.000)
Value of likelihood logarithmic function	–42.0	-61.0
Pseudo-R^2 (Efron)	0.459	0.378

Notes. * – significance at 10%; ** – significance at 5%; *** – significance at 1%.

Source: author's calculations

Based on Table 7 data one may note that there are more observations included in a model which does not eliminate the post-crisis bias than in a model that does, which is supported by the elimination of 33 crisis continuation points (for the model which eliminates post-crisis bias it is considered that the factors are different with respect to crisis start and crisis continuation). According to assessment results, when these points are added to a model, for the majority of coefficients their significance remains unchanged (except for an indicator of banking crisis). All coefficients preserve their correctly identifiable signs, and, with respect to their values, many come even closer to the model of post-crisis bias elimination. However, since the beginning and the continuation of a recession are treated as equal events, the quality of adjustment declines significantly for the following model: R^2 (Efron) in a model which does not eliminate the post-crisis bias, see below.

Table 8 compares predictive powers of models with and without the elimination of the post-crisis bias. It should be noted that eliminating the post-crisis bias allows the increase of model predictive power by 10% (ratio of correctly predicted recessions), and, at the same time, bring the "noise" level down by threefold (from 23.2% to 8.2%). Thus, the methodology of post-crisis bias elimination suggested in this chapter allows for significant increase in model quality, and, therefore, shall be considered as successful.

Table 8 - Quality indicators for recession models, optimal threshold is based on regulator loss function, Θ=0.5%

	Model where post-crisis bias is eliminated	Model where post-crisis bias is not eliminated
Optimal threshold	0.18	0.10
Complete Sampling		
Noise/signal	8.2	23.2
Events correctly predicted	88.0	78.1
Missing events correctly predicted	92.8	81.9
Russia		
Noise/signal	0.0	18.2
Events correctly predicted	100.0	50.0
Missing events correctly predicted	100.0	90.9

Source: author's calculations

3.3. Analysis of model predictive power outside of sampling: OECD countries short-term macroeconomic perspectives.

In order to assess the quality of created recession and recovery models, we have compared probabilities of business cycle phase change per statistics of key European countries, which were based on calculating the leading indicators of 2013 with respect to actual 2012 data, and forecasts of GDP trends for these countries, published by the IMF for year 2013 and released in April and October of 2013. (IMF World Economic Outlook). In case economy positive growth rate was observed in 2012 for

any particular country, we excluded values of recession indicators, and in case a negative rate was observed, we provided recovery probabilities - see Table 9 9.

Analysis of data in Table 9 shows that the extent of consistency between the behavior of leading indicators for business cycle phase change and IMF forecasts is, generally, high. At the same time, the calculation of leading indicators may be done even earlier than the release of the IMF forecast for 2013 (taking into account possible lags of statistics' publication). Having said so, it is worth to mention that between April and October forecasts, an update on economy perspectives for Czech Republic and Finland was made with respect to the behavior of the leading indicators, as follows: if the April IMF forecast called for the positive output growth rates in these countries, the October forecast was lowered all the way down to the negative rates. In addition to the above, the behavior of recovery leading indicator was pointing to that back at the end of 2012.

Indicator behavior and IMF forecasts disagree with respect to two other cases: according to a recession leading indicator, in France there is a high risk of GDP negative growth rates in 2013, however, the latest IMF forecast version point to the opposite (WEO April edition forecast showed recession start in 2013). Furthermore, the indicators and the forecast disagree on the assessment of Netherlands economy perspectives, as follows: leading indicator behavior projects recovery in 2013, however, the IMF is strongly pessimistic in their forecasts.

Table 9 - Using leading indicators to analyze short-term perspectives for OECD countries (for 2013)

	Real GDP growth rate, % (2012, actual)	Recession CLI* (for 2013, using data of 2012)	Recovery CLI* (for 2013, using data of 2012)	IMF GDP growth rate forecast for 2013, % (WEO, April 2013)	Conclusion	IMF GDP growth rate forecast for 2013, % (WEO, October 2013)	Conclusion
Austria	0.9	0.098		0.8	corresponds	0.4	corresponds
Belgium	-0.3		0.272	0.2	corresponds	0.1	corresponds
Czech Republic	-1.2		0.017	0.3	does not correspond	-0.4	corresponds
Denmark	-0.4		0.051	0.8	corresponds	0.1	corresponds
Finland	-0.8		0.001	0.5	does not correspond	-0.6	corresponds
France	0.0	0.277		-0.1	corresponds	0.2	does not correspond
Germany	0.9	0.049		0.6	corresponds	0.5	corresponds
Greece	-6.4		0.196	-4.2	corresponds	-4.2	corresponds
Italy	-2.4		0.178	-1.5	corresponds	-1.8	corresponds
Netherlands	-1.2		0.587	-0.5	does not correspond	-1.3	does not correspond
Poland	1.9	0.178		1.3	corresponds	1.3	corresponds
Portugal	-3.2		0.141	-2.3	corresponds	-1.8	corresponds
Russia	3.4	0.016		3.4	corresponds	1.5	corresponds
Spain	-1.6		0.178	-1.6	corresponds	-1.3	corresponds
Sweden	1.0	0.110		1.0	corresponds	0.9	corresponds

Note: * - threshold value, which separates low and high probability of recession – 0.18

** - threshold value, which separates low and high probability of recession – 0.18

Source: IMF data (WEO, April 2013, October 2013), author's calculations

4. Conclusion

To the best of our knoledge, in this study leading indicators of switching between business cycle phases were constructed for the first time on the basis of panel data. This made it possible to account for business cycle historical data as pertaining to a wide range of countries, which has significantly increased the quality and the validity of models and conclusions derived from them.

Using the approaches and methods adopted in the literature with respect to leading indicators of financial crises, the problem of the "post-crisis bias" was addressed when developing recession and recovery models. In particular, two different binary choice models were estimated (the first one - on entering recession, the second one - on recovering from recession). For the first time in known empirical literature, the post-crisis bias was accounted for in a study on macroeconomic crises. The elimination of the post-crisis bias leads to a significant increase in model predictive power (ratio of correctly predicted recessions has grown by 10%), and, at the same time, a threefold decrease in "noise" levels.

We have applied advance analysis of cut-off thresholds for leading indicator models of business cycle turning points based on the optimization of regulator loss function. This method is widely used in the literature on financial crises, and was for the first time applied to leading indicators models of the sharp changes in macroeconomic conditions.

We have compared the leading indicator models, created by us, in terms of the best predictor set using models with only OECD existing leading indicators, and we have concluded that OECD indicators are not able to predict business cycle turning points accurately in developed countries and in Russia. Despite the satisfactory predictive characteristics of the models the noise-to-signal ratio is approximately 20%. Constructed models using only the real sector variables turned out to be even worse than models using only the OECD leading indicators. However, adding financial sector variables allows for significant increase in the quality of the constructed models; it results in either predictive power growth, or significant "noise" decline, as compared to models using only the OECD leading indicators.

The empirical analysis conducted in this study showed that for leading indicator models of business cycle phase change it is important to account for financial sector variables that are responsible for domestic financial "overheating" (endogenous crisis and recovery factors), to which little attention has been paid in the majority of studied works. The point is that the existing studies use only those indicators of "early response" (stock indices trends, yield curve, etc.), which is keeping the predictive power from climbing to higher levels within long forecasting horizons. Such approach views the financial sector as a segment of increased response to exogenous shocks. This study showed that using financial overheating indicators increases assessment accuracy and widens the forecasting horizon of business cycle turning points.

The econometric analysis identified the key factors - leading indicators of a country's recession. Among these are: business confidence indicator, expected US macroeconomic trends, financial sector risk indicator, stability of current account balance, bank loan-to-deposit ratio, interbank market credibility. The ratio of correctly predicted recessions is 88% with noise-to-signal ratio being 8%.

In the best estimated model of recovery, five indicators which are leading indicators for both recovery and recession models, as well the REER dynamics and bank liquidity are identified as the key factors. The ratio of correctly predicted recoveries is 96% with noise-to-signal ratio being 17%.

We have conducted an analysis of model predictive powers outside of the sampling set. Values of the business cycle phase change leading indicators were calculated with respect to OECD key countries for 2013. We compared the predictions of leading indicators about the probability of business cycle phase change in those countries with IMF forecasts for 2013. The results of the analysis showed high consistency between the behavior of leading indicators for business cycle phase change and the IMF forecasts. The update of the IMF forecasts in October 2013 as compared to the April edition took place in accordance with the predictions of leading indicators at the end of 2012.

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6. Appendix

Table P1 – The predictive power of individual leading indicators of the business cycle

Explanatory variables - X_{t-1}	Recession model		Model of recovery from recession	
	Pseudo-R^2	P-value (z-stat)	Pseudo-R^2	P-value (z-stat)
Leading indicator of GDP, in OECD methodology, growth rate year by year	0.41	0.00	0.37	0.00
Consumer confidence indicator, in OECD methodology, growth rate, per year	0.28	0.00	0.19	0.00
Business confidence indicator, in OECD methodology, growth rate, per year	0.16	0.00	0.23	0.00
Leading indicator of US GDP, in OECD methodology, growth rate year by year	0.16	0.00	0.15	0.00
GDP growth rates, per year	0.04	0.00	0.07	0.00
Investment in fixed capital, growth rates, per year	0.04	0.00	0.05	0.00
Current account balance to GDP ratio	0.03	0.00	0.02	0.04
Composite leading indicator of systemic financial crisis (in CMASF methodology)*	0.03	0.01	0.04	0.08
Unemployment rate	0.02	0.01	0.07	0.00
Bank loans to GDP ratio	0.02	0.01	0.01	0.26
External debt to international reserves ratio	0.01	0.06	0.03	0.21
Interbank market interest rate	0.01	0.03	0.01	0.20
Import to export ratio	0.01	0.02	0.01	0.29
Bank loans to deposits ratio	0.01	0.02	0.02	0.06
REER, growth rates, per year	0.01	0.05	0.05	0.00
Monetary policy interest rate	0.01	0.09	0.00	0.47
CPI inflation, per year	0.01	0.09	0.01	0.27
Government bond interest rate	0.01	0.16	0.01	0.31
Spread between money market interest rate and government bonds interest rate	0.01	0.30	0.01	0.29
Electricity production growth rates, per year	0.00	0.20	0.01	0.11
Stock price index, growth rates, per year	0.00	0.41	0.01	0.38
Spread between interbank market interest rate and monetary policy interest rate	0.00	0.44	0.03	0.16
Bank liquid assets to total assets ratio	0.00	0.94	0.00	0.47

Note: * - taken without lag, since this indicator by construction has one-year lead of the financial crisis (see Solntsev et al., 2011)

Source: author's calculations

Table P2 – Descriptive statistics of indicators used in the recession models

Variables	Number of obs.	Mean	Stand. dev.	Min.	Max
Dependent variable:					
Binary indicator of the onset of the recession*), unitless	247	0.10	0.30	0	1
Explanatory variables:					
Leading indicator of GDP, in OECD methodology, growth rate year by year, %	280	2.9	3.5	-14.6	16.2
Composite leading indicator of systemic financial crisis (in CMASF methodology), unitless	280	0.04	0.06	0.00	0.59
Bank loans to deposits ratio (LTD), %	275	129.4	59.5	38.3	399.7
Interbank lending market interest rate, %	277	7.1	10.0	0.2	92.0
Business confidence indicator, in OECD methodology, growth rate over previous year, %	279	0.2	3.0	-16.4	16.7
Leading indicator of US GDP, in OECD methodology, growth rate over previous year, %	280	2.6	2.4	-5.4	8.1
Current account balance to GDP ratio, %	279	0.1	5.3	-16.4	18.0
GDP growth rates, per year, %	279	2.8	3.0	-13.9	10.6

Note: * – 1 corresponds to the first year of the recession, 0 - all remaining observations (except for those years when country is still in a recession or country has recovered from it, which are excluded from consideration).

Source: author's calculations

Table P3 – Descriptive statistics of indicators used in the recovery from the recession models

Variables	Number of obs.	Mean	Stand. dev.	Min.	Max
Dependent variable:					
Binary indicator of the recovery from the recession*), unitless	77	0.36	0.48	0	1
Объясняющие:					
Leading indicator of GDP, in OECD methodology, year by year, %	77	2.5	4.6	-14.6	16.2
Composite leading indicator of systemic financial crisis (in CMASF methodology), unitless	77	0.08	0.12	0.00	0.59
Business confidence indicator, in OECD methodology, growth rate over previous year, %	76	1.6	3.9	-12.8	16.7

Bank liquid assets to total assets ratio, %	75	5.0	4.3	0.2	15.9
Leading indicator of US GDP, in OECD methodology, year by year, %	77	2.4	2.9	-5.4	8.1
Bank loans to deposits ratio (LTD), %	76	136.4	67.6	38.3	399.7
Current account balance to GDP ratio, %	77	-0.4	4.6	-14.8	12.6
REER, growth rates, per year, %	77	-0.3	6.9	-31.3	15.9

Note: * – 1 corresponds to the first year of the recovery from the recession (when real GDP growth rate shifts to the positive side, and, at the same is at least half the mean value of the seven pre-crisis year rates), 0 - all remaining observations (except for those years when country entered a recession or was in an expansionary phase, which are excluded from consideration).

Source: author's calculations