Central European Journal of Economic Modelling and Econometrics

# Slowdown or Recession? Forecasts Based on Composite Leading Indicator

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Submitted: 24.02.2010, Accepted: 20.05.2010

**Abstract**

The economy of Slovakia experienced a turning point in the 1st half of 2008 and entered a phase of decline. The negative impacts of the global economic crisis became evident in the 2nd half of 2008 and led into a recession in the 1st quarter of 2009. The composite leading indicator was originally intended for forecasting of business cycle turning points between the decline and growth phases. The aim of this paper is to transform the qualitative information from composite leading indicator into quantitative forecast and verify whether the beginning of recession in Slovakia could have been identified in advance. The ARIMAX and error correction models are used for the composite reference series and GDP forecasts respectively. The final result shows that the composite leading indicator is useful not only for identifying turning points, but also for the prediction of recession phase.

**Keywords:** Global economic crisis, recession, composite leading indicator, ARIMAX model, error correction model

**JEL Classification**: C13, C22, C53, E32.

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# 1 Introduction

The growth of the Slovak economy reached its peak in the $1^{st}$ half of 2008, and then the economy entered the phase of slowdown. The negative impacts of the global economic crisis became evident in the $2^{nd}$ half of 2008 and led consequently into a recession. The business cycle analysis oriented at deviation cycles is not preferred in periods of classical cycle. Therefore the classical cycle analysis was introduced for the Slovak economy with the aim to construct a leading indicator. The composite leading indicator was originally intended for forecasting of business cycle turning points between the decline and growth phases. The aim of this paper is to verify whether the composite leading indicator (CLI) could be used not only for identifying turning points, but also for quantitative forecasting. This hypothesis is verified in the time period when the global economic crisis started and conventional modelling approaches had difficulties to make accurate forecasts of the future development. This is one of the reasons why it can be useful to find out whether the composite leading indicator is able to forecast the forthcoming crisis in advance. The focus is concentrated on the recession in Slovakia defined as the first year-over-year fall of real GDP on the quarterly basis. The beginning of recession in Slovakia is dated to the $1^{st}$ quarter of 2009. The analyzed period is set from the $1^{st}$ quarter of 2008 till the $2^{nd}$ quarter of 2009, i.e. all experimental forecasts are produced and verified for this period. The ARIMAX and error correction models (EC models) are used for the composite reference series and GDP forecasts respectively (with AR models as a benchmark for the second step of forecasting).
The $2^{nd}$ section contains a short introduction to the business cycle concept regarding the basic definition and distinction between the classical and deviation cycle. Also some examples illustrating the impact of the global economic crisis are presented – the classical cycles of Slovakia's main aggregates. The $3^{rd}$ section aims at the description of the single steps for construction of the composite leading indicator for Slovakia. Consequently the transformation of the qualitative forecast of the leading indicator into a quantitative forecast is outlined in the $4^{th}$ section including the presentation of some results.

# 2 The business cycle concept

In market economies the business cycle is understood as cyclical fluctuations of economic activities. There are two basic views at the business cycle. The first one views the cycles as repeating of growth and decline of the economic activities in their absolute levels and is often called classical cycle. The second view concentrates on the fluctuations of the economy around their long-term trend and is frequently referred to as deviation cycle (sometimes growth cycle). The deviation cycle view arose as a consequence of continuous long-term growth of many developed economies in the $20^{th}$ century.

The classical cycle includes 2 basic phases – expansion and recession and two additional phases – peak and trough. The interpretation of the basic phases is different the deviation cycle. The phase of decline is not called a recession but slowdown of the economy. The expansion phase in deviation cycle is called acceleration. The deviation cycles are more appropriate in historical context, whereas the classical cycle for real time forecasting (Dua and Banerji, 2006). The deviation cycle analysis is usable in the periods of long-term economic growth, the classical cycle analysis in the periods of classical recession.
Before the impact of global economic crisis the analysis of deviation cycle was sufficient (Kľúčik, 2009). Moreover, a reliable classical cycle analysis was not possible before the recent break in time series due to the global economic crisis. The Slovak economy experienced in its short history only one recession (1999/2000), so the business cycle analysis would rely only on one distinct turning point. But the recent impact of the global crisis on the Slovak economy brought another recession, which made the basis for the analysis much more reliable. In this context, this paper is concentrated only on the classical cycle analysis. Regardless of the cycle type, the leading indicators approach is the same for both cycles.

**The leading indicators approach**

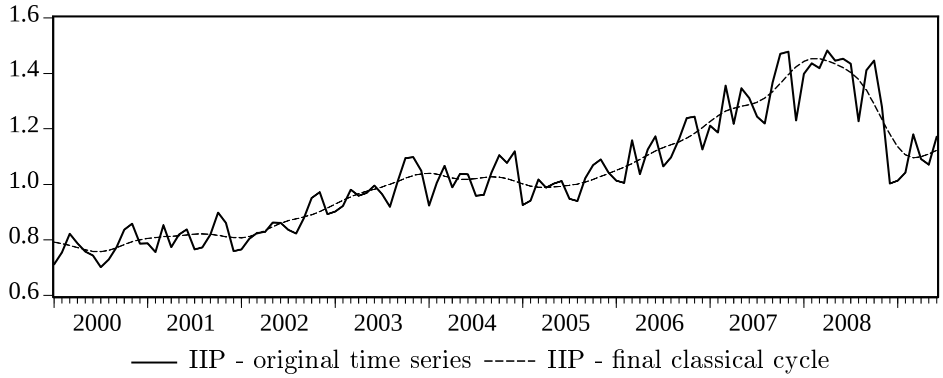
The cycles do not occur at the same time in all main aggregates of an economy. The timing of the cycles can differ between the aggregates and individual economic sectors or between the indicators of different aggregates or sectors. This is the basic notion of the CLI approach used in this paper (e.g. Nilsson and Gyomai, 2007; Zarnowitz and Ozyildirim, 2002): some of these individual indicators can enter the basic cycle phases with different lead/lag against other indicators. Consequently these indicators can be divided with regard to the time shift against the reference time series to three groups: leading, coincident and lagging. The reference indicator (reference series) is commonly used as an aggregate measure of the whole economy. There are more choices regarding the reference aggregate indicator: e.g. proxy individual indicator, i.e. the industrial production index as proposed by the OECD, or composite reference indicator. The industrial production driven in Slovakia mostly by the automobile and electrotechnical industry can explain the performance of the whole economy only partly. The composite reference indicator is more appropriate in the case of Slovakia. Gross domestic product (GDP) is widely used as a best approximation of economy in general. But it is available only with quarterly frequency. Regarding the relatively short time series of GDP and difficulties connected with quarterly to monthly data transformation, monthly data are more appropriate for analyzing business cycles in Slovakia.

**The classical cycle definition**

In this paper the classical cycle is approximated as seasonal adjusted and smoothed time series (index with the base year 2005).

The times series at current prices are first converted into constant prices. Then all time series are converted into an index with base year 2005. All the aggregates and individual time series are seasonally adjusted. The seasonal adjustment is carried out by the Tramo/Seats tool, which is one of the methods recommended by Eurostat (ESS Guidelines on Seasonal Adjustment 2009). The final classical cycle of all indicators is obtained by smoothing of the time series. The Henderson moving average method is used for the smoothing (included in the EViews software package). This method preserves the timing of the turning points and also ensures appropriate smoothness of time series. The Figure 1 compares the original time series and the final classical cycle of industrial production index of Slovakia.

Figure 1: Industry classical cycle (based on Industrial production index)




## 2.1 The impact of economic crisis

The Slovakia's main economic aggregates reached the peak of the classical cycle in the beginning of 2008. That was earlier than the distinct impacts of the global crisis were observed (last quarter of 2008). The performance of industry, construction and retail trade branch is depicted on Figure 2. All of the indexes represent the classical cycle of their branches. From the year 2005 the industry production showed high growth rates until the early 2008, where the cycle turned into decline in March 2008. Also the retail trade index has continuously risen from 2003 until its peak in April 2008. The construction production development was a bit different, because the cycle began to turn at the same time when the first clear impacts of the global crisis in Slovakia were evident. The clear impacts of the global crisis are dated to September 2008, where the industrial production, export and import of goods began to fall on the previous year basis. On the Figure 3 the performance of import, export and registered unemployment can be seen. The peak of export and import passed during February and March 2008. The unemployment rate growth is dated from May 2008 (inverted cycle).

Figure 2: Construction production, Turnover in retail trade, Industrial production of Slovakia - classical cycles

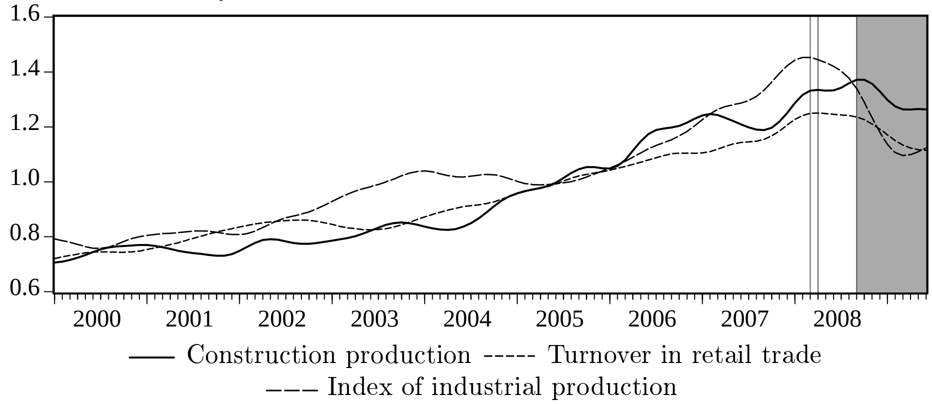



Figure 3: Export of goods, Import of goods, Unemployment rate of Slovakia - classical cycles


Clearly the whole economy passed the peak during the 1st half of 2008. The GDP growth rates (constant prices, chain - linked volumes with reference year 2000) indicate even an earlier time - the 4th quarter of 2007 (Table 1).
Monthly data indicated the fall of the whole economy into a recession already in the last quarter of 2008 - export and import of goods, which form together over 170% of GDP, and also industry with the largest share on GDP production (over 30% at constant prices), began to fall dramatically against the previous year already

Table 1: GDP growth rates in %

| | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| 1Q | 7.2 | 8.0 | 9.3 | -5.6 |
| 2Q | 7.2 | 8.5 | 7.9 | -5.3 |
| 3Q | 8.4 | 10.5 | 6.6 | x |
| 4Q | 11.1 | 14.3 | 2.5 | x |

in September 2008. But as for the GDP at constant prices, the recession began a quarter later - in the 1$^{st}$ quarter of 2009 as seen from the data in Table 1.

# 3 Leading indicator construction

## 3.1 Methodology

The database of monthly time series is composed of domestic and also foreign data. Slovakia as a very small and open economy depends on foreign market development. This is the main reason why also the foreign data are included in the business cycle analysis. Afterwards the construction of CLI succeeded in the following steps:

A. Transformation of the data (seasonal adjustment, smoothing)

B. Composite reference series construction

C. Correlation and turning point analysis

D. CLI construction

***A. Transformation of the data***

The transformation of the data follows the definition of the classical cycle mentioned in the second section. Firstly, all data are transformed into constant prices, except indicators as employment etc. Thereafter all data are converted into indexes with base year 2005. The Tramo/Seats tool is used for seasonal adjustment, including outliers' identification. The final step is smoothing via the Henderson moving average.

***B. Composite reference series construction***

It has been already mentioned that a single indicator is needed as a reference for searching of leading, coincident and lagging indicators. Although OECD uses industrial production as a proxy variable, in our view more comprehensive approach could be the use of composite reference series which covers a much larger part of economy. The monthly GDP as a reference series is not considered because of the shortness of time series and resulting difficulties with transformation of time series from quarterly to monthly frequency. The main aim is to cover most of the Slovakia's GDP with available monthly time series. The result should be some kind of monthly coincident indicator with quarterly GDP. There are available monthly data from different branches (turnover), monthly employment (unemployment) and export and import of goods. Data from monetary area are not available in the required length because of the lately changes in methodology. Employment and unemployment are generally viewed as lagging indicators but the aggregates proved to be coincident with industrial production and also with foreign trade aggregates (within 2 months time shift). Only employment in some branches (see Section C) is showing lags against coincident indicators.

Finally three kinds of indicators are chosen to be the components of the composite reference series - the monthly data on turnover of different branches, unemployment rate and net export of goods. In the first step the aggregate for turnover in different branches (industry, construction, retail trade, wholesale trade, information and communication, other services) is computed by adding the raw data from the branches together and subsequently transformed into seasonal adjusted and smoothed base index. The three final aggregates (turnover, unemployment, net export) are of different original measures, so a more complex method for composition of the final reference series is needed. The principal component analysis (PCA) offers simple and reliable results. This method can derive a common component from different time series depending on the absolute variance of the time series. The first two components are extracted from the PCA to cover over 80 % of absolute variance of the three time series. This new aggregate is used only as a proxy variable to derive weights (factor loadings) for three aggregates. This is done through the correlations analysis between the aggregate PCA component and the individual aggregates. The whole sample is used for the weights computation. The final weights of the components are the following (1):

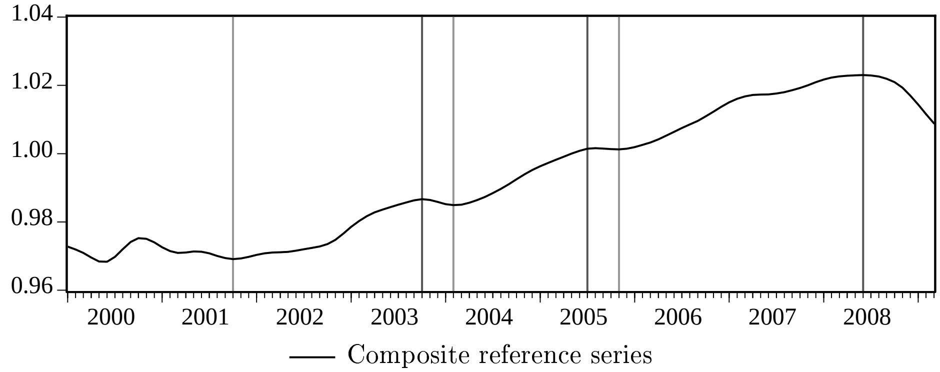
$$\text{CompRefSeries} = 0.287\cdot\text{branches}+0.309\cdot\text{unemploym.rate}+0.404\cdot\text{export} \tag{1}$$

On the Figure 4, the final composite reference series and its turning points are depicted. As it is seen from the figure, the timing of the last distinct turning point, which leads the economy into recession, is about the same time as indicated by the monthly time series in the second section (export, import, industry).

### *C. Correlation and turning point analysis*

A cross correlation is performed between the final composite reference series and all time series in the form of classical cycles in the database. To find a relation between them, the full sample is used (2000 - 2009). The lag or lead can differ between the full sample and extracted sample. The analysis based on full sample is simplified but more reliable. The relevant time shift of time series for the analysis is from 0 to 12 months. The lag or lead more than 12 months is not considered, because the economic interpretation of this case would be speculative and for a small and open economy very unrealistic. Time series with lead or lag more than 2 months is regarded as leading or lagging. All remaining time series are coincident. From the database of more than 1000 time series a half shows to be coincident and about 300 are leading (regardless

Figure 4: The final composite reference series turning points




of economic interpretation). The final database of over 300 leading indicators can be used for CLI components selection.

The analysis showed that most of the main Slovak economic aggregates are coincident, i.e. industry production, construction production, aggregate employment and unemployment, import and export of goods, production prices and consumer prices. Surprising is the coincidence of aggregate employment and average wages, but from the individual branches view, some of them are lagging and therefore more consistent with theory (non-elasticity of labour market), e.g. the wages and employment in construction and retail trade. Non surprising is among others the lagging behaviour of state budget revenues with lag of 7 months (lagged declaration of taxes) and state budget capital expenditures lagging with 4 months (delayed response of economic policies).

***D. CLI construction***

The best leading indicators suitable for the CLI have to satisfy the following criteria:

- economic interpretation of the lead against the reference series
- high coefficient of correlation with the reference series
- leading the reference series with more than 4 months
- timeliness of the time series
- correspondence with at least half of the turning points of composite reference series

The last criterion ensures the robustness of the analysis with regard to the relative short sample for correlation analysis. The correspondence with half of the main 6 turning points identified in the composite reference series (Figure 4) serves as a support for the above mentioned three basic criteria.

Finally the five time series named in the Table 2 are chosen as the leading indicator components.

Table 2: Final components of composite leading indicator

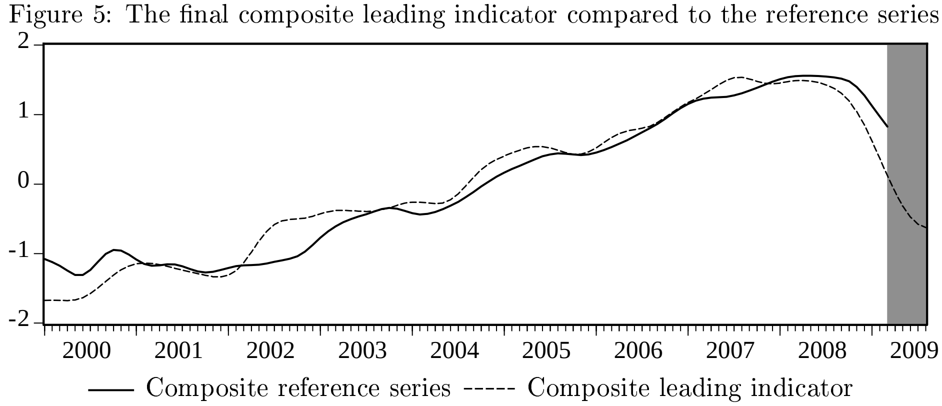
| Leading Indicator | Lead in Months | Coefficient of Correlation |
|---|---|---|
| Fin. account direct investments abroad (+ balance of payments, Slovakia) - fadi | +7 | 0.783 |
| Export of raw material (SITC 2 + 3 + 4, Slovakia) - exraw | +4 | 0.848 |
| New orders in industry (Slovakia) - ord | +4 | 0.935 |
| Industrial production (EU-27) - ipeu | +4 | 0.771 |
| Net external assets (Slovakia) - net | +4 | 0.785 |

Now a method is needed to combine five individual leading indicators into one composite indicator. Again the same method as for construction of composite reference series is used as described in this part. First by means of the principal components analysis the main component(s) of all five time series are identified to cover at least 80 % of the absolute variance. The weights for each individual indicator in the new composite series are derived from the correlation analysis between the main PCA components and the individual indicator. The weights of the components are (2):

$$\text{CompLead} = 0.180 \cdot \text{fadi} + 0.257 \cdot \text{exraw} + 0.194 \cdot \text{ord} + 0.192 \cdot \text{ipeu} + 0.177 \cdot \text{net} \quad (2)$$

On the Figure 5 the comparison between the final CLI and composite reference series is depicted.

Figure 5: The final composite leading indicator compared to the reference series



### 3.2 Forecasting

The CLIs were originally invented only for qualitative forecasting, i.e. they served only as signals for turning point predictions. E.g. the growth of the leading indicator after the turning point was considered as a signal for a turn of the economy from recession into expansion, or in the case of deviation cycle from slowdown into acceleration. But as previously mentioned the attempts to forecast the deviation cycle of Slovakia proved not to be useful in the case of classical cycle, specifically from March 2008 (peak of the economy) to the 1$^{st}$ quarter of 2009 when the economy entered the recession phase.

As it was seen e.g. in Kľúčik (2009), previous business cycles analyses were oriented only on the deviation cycle, mainly because of only one distinct turning point in the classical cycle analysis (classical recession in 2000). But the deviation cycle analysis was insufficient for indicating how deep the fall was going to be. Also the forecasts of OECD leading indicator for Slovakia (Nilsson and Gyomai, 2007) were based only on deviation cycle analysis. Both the author's and OECD leading indicators of the deviation cycle for Slovakia were right about the slowdown of the economy in the 2$^{nd}$ quarter 2008.

Let us take a look at the forecast of the final classical cycle leading indicator in the Figure 5. The forecast is presented as the gray shaded part. The leading indicator in the Figure 5 is computed with the last data of March 2009, i.e. the last estimation period for forecast (details later in the section 4). From the real-time perspective the aim is to find out whether, when and with what precision could be the beginning and development of the recession forecasted. The question asked in the title of the paper - *Slowdown or Recession?* - can be answered by transforming the qualitative forecasts of the leading indicator into quantitative ones.

## 4 Quantitative forecasting

As it has been already mentioned above, the CLI approximates the whole Slovak economy, i.e. this one specific indicator contains the development of all available and relevant indicators that characterize and influence the economy. It joins their development in one measure, but basically only qualitative information can be gained from this type of indicator. However its biggest advantage is that it provides very early information about possible expected development and therefore the attempt of transformation this knowledge into quantitative information can be reasonable.

The CLI is comprised exclusively on the basis of its relation with the composite reference series and has no real connection with GDP. That is the reason why the composite reference series is forecasted in the first step using the composite leading indicator and only subsequently the GDP is forecasted using composite reference series, which is an index approximating the Slovak economy and thus the GDP. In this way more precise model is ensured. The explanatory power of models based directly on composite leading indicator is largely lower (results of estimates are not presented in this study, since estimates of parameters for EC models based directly on CLI are not statistically significant at the level of 10%). Also the EC models (second step) require static long-term cointegration relations between dependent and exogenous variables, but the composite leading indicator is comprised of lagged variables, thus introducing dynamics into the long-term relationship.

The proposed and applied forecasting procedure consists therefore of two steps. In the first step, the CLI stands for an explanatory variable for the composite reference series. Consequently in the second step results (forecasts) from the first step are used for quarterly GDP forecasting. Considering the different nature of data and the different length of time series, also different (widely known) methodological approaches are used in both forecasting steps.

The first step regarding the forecasting of composite reference series is based on monthly time series; time series of 114 observations are available. In this phase a proper model tool was sought-after. In fact only one exogenous variable (CLI) is available and regression approach does not achieve satisfactory results for this specification. Moreover using regression approach leads into gaining model relations with autocorrelated residuals that are proved unstationary. In this case, the specification of regression models cannot be extended with seasonal dummies, because there is no seasonality in the CLI anymore. But it has been practically verified that ARIMAX models are the appropriate model tool. The empirical experience confirmed that it is possible to find proper ARMA terms for residuals gained from the classical regression relationship between endogenous and exogenous variables, but only after their transformation (for the purpose of gaining stationary residuals). In the second step forecasts produced in the first step are used for GDP forecasting, but on the quarterly basis. So the time series are shorter than in the first step, only 32 observations are available (in the case of model estimation for the period 2000-2007), which is according to the theory too short time series for ARIMA approach. But in this phase we could use also dummy variables, as the time series of GDP contains the seasonality.

## 4.1 Composite reference series forecasting

The first task of this experiment is to transform the information contained in the qualitative forecast into quantitative measure. The most suitable way is to project the knowledge from the composite leading indicator of Slovakia (CLI) into the forecast of composite reference series (COMPOSITE). Monthly data of composite reference series are available for the period from January 2000 up to June 2009, 114 observations together. The Figure 5 illustrates the similar development of composite reference series and composite leading indicator. The correlation coefficient confirms the strong dependency between these two series as well; it achieved 0.96 for the whole analyzed period.

The ARIMAX methodology applied in this step uses Box-Jenkins modelling approach

combined with exogenous variables (ARIMA models with input series). We can refer to this class of models as regression with ARMA errors or dynamic regression (Pankratz 1991) as well. These models use not only past values and past errors of the response series, but also the current and past values of other, exogenous series.
In the case of ARIMAX models the requirement of stationarity is being applied not directly to the response series, but to the noise (residual) series. The noise series is the error term of the regression model. So firstly, it is necessary to estimate the regression model with no ARMA terms for the errors and then consider the stationarity of residuals before identifying an ARMA model for the noise part. In the case of nonstationary residuals some transformations inducing stationarity (differencing, logarithms of data) can be used and after a proper transformation the whole procedure should be repeated: estimation of regression model and tests of residual series for the presence of a unit root (Hamilton 1994). The Augmented Dickey-Fuller (ADF) test of unit root is used for testing stationarity of residuals from the regression models and also the correlogram of residuals (development of their autocorrelation function). After achieving stationarity, the suitable ARMA model is identified on the basis of residuals' correlogram. All models are estimated by ordinary least squares (OLS) method.
Verification period is set from January 2008 up to June 2009. So the first model is estimated for the period January 2000 - December 2007 and the last one for the period January 2000 - March 2009. The model is updated after each 3 months and forecasts produced for every next 3 months (forecasts for next 4 months can be computed, but only 3 months are useful for GDP forecasting, because the finished quarter is needed). Altogether 6 regression models with ARMA errors are constructed and verified ex-post.
The analysis confirmed that regression between composite reference series (as an endogenous variable) and composite leading indicator (as an exogenous variable) gives unstationary residuals. But the regression model of first differences of both time series provides stationary residuals in all estimation periods. On the basis of results of ADF tests the hypothesis on the existence of unit root can be rejected at the significance level of 5% for each estimated time series of residuals with only one exception – the test for the AR model with constant and time trend for the period 2000m1 - 2009m3 (see results of testing in the Table 3).
For each time series of estimated residuals a suitable ARMA model was identified and included into the regression model based on differences of original time series. The best identified ARMA model for all analyzed residuals proved to be the model ARMA(3,1). Thus, the final form of ARIMAX models for each estimation period is gained. The most important estimation results of all estimated models are summarized in the Table 4. The models' characteristics are not changing significantly over time. The percentage of explained variability is still very high, above the level of 98% and Durbin - Watson statistics confirm no autocorrelation in residuals. All parameters of estimated ARIMAX models are statistically significant at the level of 5%.

Table 3: Critical values for the Augmented Dickey-Fuller test and ADF test statistic

| Estim. period | 00m1-07m12 | 00m1-08m3 | 00m1-08m6 | 00m1-08m9 | 00m1-08m12 | 00m1-09m3 |
|---|---|---|---|---|---|---|
| *AR model (random walk)* | | | | | | |
| ADF statistic | **-2.98** | **-2.97** | **-2.96** | **-3.09** | **-3.02** | **-3.00** |
| 1% level | -2.59 | -2.59 | -2.59 | -2.59 | -2.59 | -2.59 |
| 5% level | -1.94 | -1.94 | -1.94 | -1.94 | -1.94 | -1.94 |
| 10% level | -1.61 | -1.61 | -1.61 | -1.61 | -1.61 | -1.61 |
| *AR model with constant (random walk with drift)* | | | | | | |
| ADF statistic | **-3.63** | **-2.96** | **-3.51** | **-3.79** | **-3.74** | **-3.12** |
| 1% level | -3.50 | -2.59 | -3.50 | -3.50 | -3.50 | -3.49 |
| 5% level | -2.89 | -1.94 | -2.89 | -2.89 | -2.89 | -2.89 |
| 10% level | -2.58 | -1.61 | -2.58 | -2.58 | -2.58 | -2.58 |
| *AR model with constant and time trend (trend stationary)* | | | | | | |
| ADF statistic | **-4.39** | **-3.73** | **-3.73** | **-4.18** | **-3.96** | **-2.90** |
| 1% level | -4.06 | -4.06 | -4.06 | -4.05 | -4.05 | -4.05 |
| 5% level | -3.46 | -3.46 | -3.46 | -3.46 | -3.45 | -3.45 |
| 10% level | -3.16 | -3.15 | -3.15 | -3.15 | -3.15 | -3.15 |

Table 4: Model estimation - ARIMAX models for updated periods

| Estim. period | 00m1-07m12 | 00m1-08m3 | 00m1-08m6 | 00m1-08m9 | 00m1-08m12 | 00m1-09m3 |
|---|---|---|---|---|---|---|
| ARMA for residuals | AR(3),MA(1) | | | | | |
| R-squared (%) | 98.2 | 98.2 | 98.1 | 98.1 | 98.3 | 98.8 |
| D-W stat. | 1.75 | 1.80 | 1.80 | 1.81 | 1.81 | 1.81 |
| Schwarz cr. | -15.30 | -15.36 | -15.34 | -15.40 | -15.39 | -15.26 |

In estimation process the convergence is possible to achieve after 11 iterations for each regression model with ARMA terms for the residuals except for the last one (estimated for the period 2000m1 - 2009m3), where 13 iterations are needed.

For illustration one model program output is shown - estimated for the period January 2000 - March 2009 (Model 1). The results confirm that also the conditions of stationarity and invertibility are fulfilled (the inverted AR and MA roots lie inside the unit circle). And this is the case for each presented estimated ARIMAX model as well. Figure 6 contains the residuals of the estimated Model 1. Actual and fitted values are very close to each other, even at the end of the time series (at the time of beginning economic crisis in Slovakia).

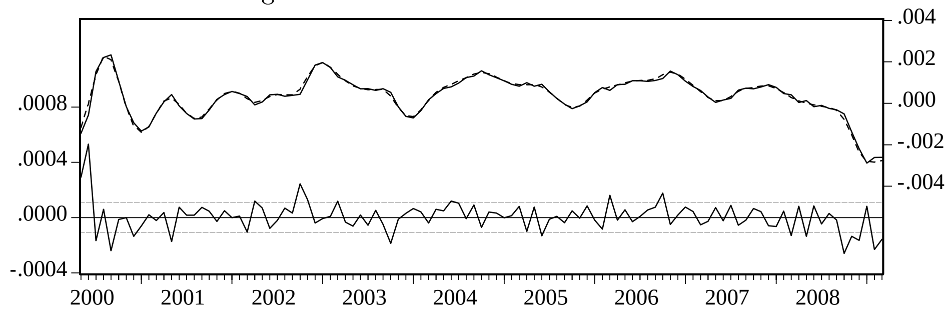
Each estimated ARIMAX model is used for forecasts for the next 3 months. The Figure 7 compares the real and forecasted values for composite reference series for the analyzed period January 2008 - June 2009. It is necessary to point out that the time series of forecasted values consist of 3-months forecasts produced by six updated models.

The accuracy of the forecasts produced by updated ARIMAX model is evaluated

Model 1. Estimation output for the period 2000m1-2009m3

| Dependent Variable: D(COMPOSITE) | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| D(CLI) | 0.023667 | 0.009397 | 2.518486 | 0.0133 |
| AR(1) | 2.206422 | 0.083457 | 26.43771 | 0.0000 |
| AR(2) | -1.956577 | 0.146142 | -13.38823 | 0.0000 |
| AR(3) | 0.708145 | 0.083951 | 8.435256 | 0.0000 |
| MA(1) | 0.480370 | 0.102092 | 4.705264 | 0.0000 |
| R-squared | 0.987627 | Mean dependent var | | 0.000366 |
| Adjusted R-squared | 0.987142 | S.D. dependent var | | 0.000953 |
| S.E. of regression | 0.000108 | Akaike info criterion | | -15.38180 |
| Sum squared resid | 1.19E-06 | Schwarz criterion | | -15.25691 |
| Log likelihood | 827.9265 | Durbin-Watson stat | | 1.814042 |
| Inverted AR Roots | .91 | .65-.60i | .65+.60i | |
| Inverted MA Roots | -.48 | | | |

Figure 6: Residuals of estimated Model 1

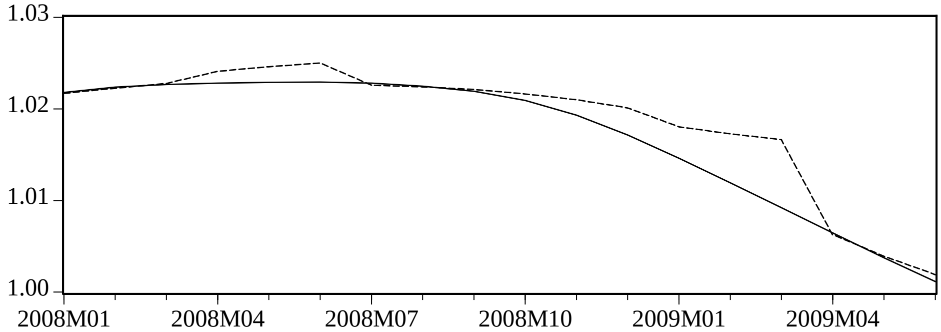



ex-post by two measures - mean percentage error (MPE - the average of percentage errors by which estimated forecasts differ from actual values of the quantity being forecasted) and mean absolute error (MAE - the average of absolute errors). The value of MPE (-0.15%) means that our models (estimated forecasts) very slightly overestimate the actual values (this fact is very obvious from the visual inspection of curves on the Figure 7 as well). MAE achieved the value of 0.002, which represents the average absolute deviation of real values from predicted values. So the conclusion of the first forecasting step is that transformation of qualitative information from CLI into quantitative measure provides very reliable results.

## 4.2 GDP forecasting

The second step of our forecasting procedure is focused on the forecasting of GDP itself. The composite reference series' forecasts from the first step are used for GDP forecasting. The time series of GDP is available only on the quarterly basis; therefore

Figure 7: Real and forecasted values for composite reference series



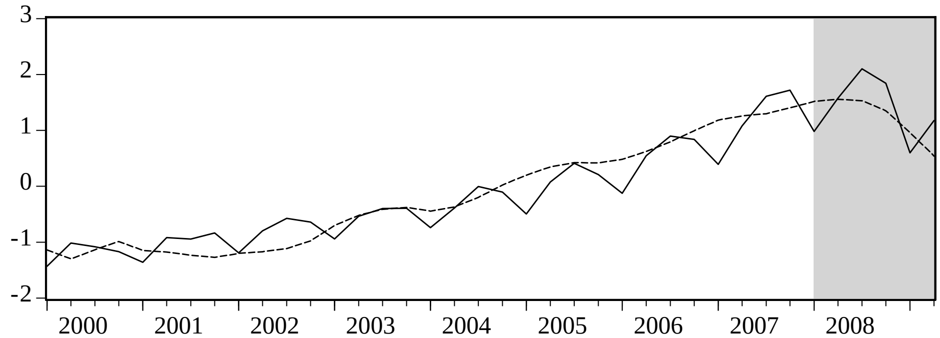

the monthly composite reference series have to be aggregated into quarterly time series (aggregation by average).

The dependency of GDP on composite reference series is verified by means of graphical analysis. The similar trend of both time series is illustrated on the Figure 8 (the grey area stands for the period being analyzed and forecasted). In the forecast of GDP later seasonally adjusted time series of the composite reference series are used. This is because the composite indicator is comprised of seasonally adjusted series and restoring seasonal components of several time series into one composite index would be not transparent with regard to the different seasonal pattern of each series. Also from the other point of view, the seasonal adjustment of the short time series of quarterly GDP would be not very reliable with reference to the end of the time series (trend break) and depends very much on subjective settings of seasonal adjustment tool parameters. The focus is set rather on the precision of quantitative forecasts.

Evidently, in the case of quarterly data the shorter time series are available; 37 observations at most (in the case of model estimation for the period 2000q1 – 2009q1). As it has been already mentioned above, ARIMA modelling approach requires a higher number of observations (minimally 50 – see Chatfield, 1996). For that reason the regression approach is used, specifically econometric model with error correction term (ECM – Error Correction Model). The advantage of ECM approach compared to the classical regression is that it explains separately the long-term and short-term influence of explanatory variable on dependent variable performance. The entire specification of ECM includes also the error correction term, which is an adjustment effect and shows how much of the disequilibrium from the previous period is being corrected in the next period. All EC models are estimated by the OLS method.

The potential terms of the long-term relationship (LT) are the following: constant, trend, one exogenous variable - composite reference series and seasonal dummies. If some of the mentioned terms proved to be as statistically significant, they are

Figure 8: Comparison of GDP and composite reference series




—— GDP index (constant prices, chain-linked), 2005=100
----- Composite reference series, index 2005=100

included in the final long-term relationship. Afterwards this relation is tested on co-integration. ADF test of unit root is applied on residuals of the estimated long-term relationship and the results of tests are shown in the Table 5. All identified relationships are co-integrated; the tests prove the stationarity of residuals (the hypothesis on existence of unit root can be rejected at the significance level of 5% for the test for pure AR model and AR model with constant with only one exception, where the significance level is 10%) and could be used in the next step in the short-term relationship.

Table 5: Critical values for the Augmented Dickey-Fuller test and ADF test statistic

| Estim. period | 00m1-07m12 | 00m1-08m3 | 00m1-08m6 | 00m1-08m9 | 00m1-08m12 | 00m1-09m3 |
|---|---|---|---|---|---|---|
| *AR model (random walk)* | | | | | | |
| ADF statistic | **-3.77** | **-3.71** | **-3.78** | **-2.84** | **-3.36** | **-3.39** |
| 1% level | -2.64 | -2.64 | -2.64 | -2.63 | -2.63 | -2.63 |
| 5% level | -1.95 | -1.95 | -1.95 | -1.95 | -1.95 | -1.95 |
| 10% level | -1.61 | -1.61 | -1.61 | -1.61 | -1.61 | -1.61 |
| *AR model with constant (random walk with drift)* | | | | | | |
| ADF statistic | **-3.71** | **-3.65** | **-3.73** | **-2.79** | **-3.30** | **-3.34** |
| 1% level | -3.65 | -3.65 | -3.65 | -3.64 | -3.63 | -3.63 |
| 5% level | -2.95 | -2.96 | -2.95 | -2.95 | -2.95 | -2.95 |
| 10% level | -2.62 | -2.61 | -2.62 | -2.61 | -2.61 | -2.61 |
| *AR model with constant and time trend (trend stationary)* | | | | | | |
| ADF statistic | **-0.57** | **-0.46** | **-0.64** | **-2.68** | **-3.28** | **-3.33** |
| 1% level | -4.30 | -4.31 | -4.30 | -4.25 | -4.24 | -4.23 |
| 5% level | -3.57 | -3.57 | -3.57 | -3.55 | -3.54 | -3.54 |
| 10% level | -3.22 | -3.22 | -3.22 | -3.21 | -3.20 | -3.20 |

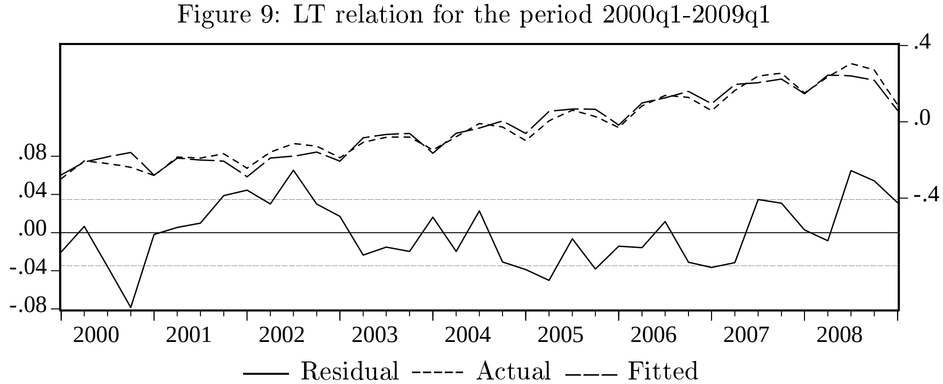
Again, as in the first step of the proposed forecasting procedure, six updated models are estimated in the final form of ECM and verified ex-post. Short-term relationships include the following terms: first differences of an exogenous variable - composite reference series, first differences of seasonal dummies and error correction term (whose estimated sign is negative in each case as it should be in accordance with the theory - e.g. Asteriou and Hall, 2007). The most important estimated statistical characteristics are given in the Table 6.

Table 6: Model estimation - EC models for updated periods

| Estim. period | 00q1-07q4 | 00q1-08q1 | 00q1-08q2 | 00q1-08q3 | 00q1-08q4 | 00q1-09q1 |
|---|---|---|---|---|---|---|
| R-sq. (%) (ST) | 86.9 | 88.4 | 88.9 | 87.8 | 87.5 | 88.9 |
| D-W stat. (ST) | 1.40 | 1.60 | 1.62 | 1.47 | 1.69 | 1.67 |
| R-sq. (%) (LT) | 97.3 | 97.0 | 97.3 | 97.6 | 96.2 | 97.3 |

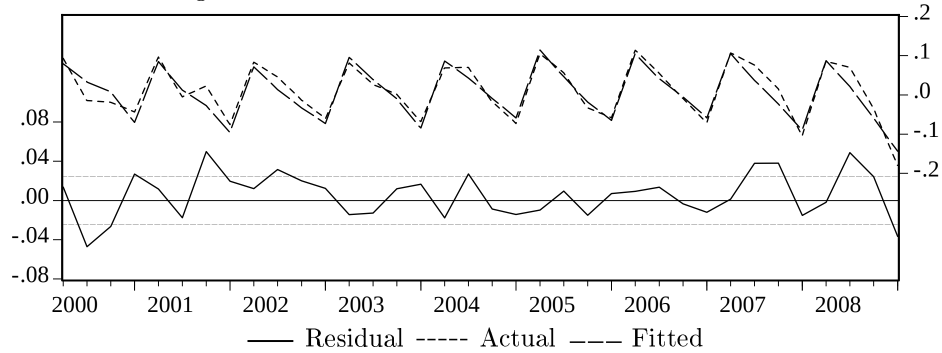
In the EC model the percentage of explained variance is very high for each updated model, it is very close to 90% and residuals from all estimated EC models contain no autocorrelation. For illustration some graphical outputs are shown for the EC model estimated for the period from the $1^{st}$ quarter 2000 to the $1^{st}$ quarter 2009. The residuals from the estimated long-term relationship are depicted on the Figure 9 and residuals from the estimated short-term relationship on the Figure 10.

Figure 9: LT relation for the period 2000q1-2009q1




All estimated EC models are verified ex-post. Every updated model is used for GDP forecast for the next quarter. The static simulation resulted in gaining year-on-year GDP growth rates, which are compared to the real GDP growth rates (Table 7). Forecasts are evaluated by means of the same accuracy measure as the models in the first forecasting step. The evaluation procedure is applied to absolute values of GDP index. Average absolute deviation of real values from forecasts achieved 2.01 and MPE reached 0.40%, which means that models very slightly underestimate the reality.

Figure 10: ST relation for the period 2000q1-2009q1




In addition AR models are used as benchmark models in the evaluation of the forecasting performance of the leading indicators. AR models are estimated for all six analyzed periods. The most suitable is proved a simple AR(1) model except for the shortest period (2000Q1 - 2007Q4), where the estimated AR process is nonstationary and AR(2) process with constant is used in this case. All AR models are estimated for seasonally differenced time series of GDP to meet the stationarity condition. Forecasting power of models based on CLI and simple AR models is compared by means of MSE - mean squared error computed in the following way (3):

$$\mathrm{MSE} = \frac{\sum_{i=1}^{n} \left(x_i - est(x_i)\right)^2}{n} \tag{3}$$

The forecasts of GDP growth rates based on CLI clearly outperform those from AR models. Forecasts from AR models and MSEs are given also in the Table 7.

Table 7: Compared real and forecasted GDP growth rates

| y-o-y GDP growth (%) | 2008q1 | 2008q2 | 2008q3 2008q4 | 2009q1 | 2009q2 | MSE | |
|---|---|---|---|---|---|---|---|
| real value | 9.68 | 7.34 | 6.76 | 1.63 | -5.73 | -5.53 | x |
| forecast - based on CLI | 9.54 | 8.22 | 5.93 | 4.92 | -0.43 | -7.13 | 7.16 |
| forecast - AR model | 10.44 | 8.94 | 9.23 | 9.61 | -1.06 | -6.70 | 16.02 |

As it can be seen in the Table 7 models based on CLI succeeded in forecasting the right direction of the GDP growth rate development. The first GDP fall was forecasted for the $1^{st}$ quarter of 2009 when the crisis started in Slovakia. To summarize the forecast for the $1^{st}$ quarter based on CLI was possible already in January 2009 when all data needed for CLI construction were available. This could be considered as an advantage of this approach, because GDP flash estimate for the $1^{st}$ quarter was officially published only in May 2009 for the first time.

## 5 Conclusions

The application of experimental forecasting procedure presented in this paper proved that composite leading indicator is useful tool not only for identifying turning points, but it can be successfully used for quantitative forecasting as well. The proposed forecasting procedure consists of two steps: composite reference series forecasting and GDP forecasting. In the first step the composite reference series is forecasted by means of composite leading indicator. Consequently forecasts of composite reference series are used in the second step for GDP forecasting.
Composite leading indicator was indicating a slowdown from March 2008 in Slovakia. The quantified forecast based on composite leading indicator showed that recession was going to start in the 1$^{st}$ quarter of 2009 and this information was available first in January 2009, ergo 4 months earlier than official GDP flash estimates are published. This could be the main advantage of quantitative forecasting of GDP based on the composite leading indicator. So the proposed approach could produce a relative accurate GDP forecasts or first estimates already 4 months before official GDP flash estimates.

## Acknowledgements

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0032-07.

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