ARTICLES

A BRAND NEW CROLEI – DO WE NEED A NEW FORECASTING INDEX?

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Abstract

The aim of this paper is to determine whether the existing leading indicators system CROLEI (CROatian Leading Economic Indicators) and its derivative, the CROLEI forecasting index, predict overall Croatian economic activity reliably. The need to evaluate the CROLEI system and the index stems from the modification of the barometric method on which the system and the index are founded on in its application in Croatia. The evaluation of the forecasting power involved the construction of six alternative forecasting indices, which not only challenge the original CROLEI index, but also enable comparisons of forecasting power. The construction of the alternative forecasting indices is also based on the barometric method. The authors then proceed to adjust more complex measurements i.e. forecasting power evaluation matrix, in order to obtain credible forecasting power estimates. Forecasting power is also estimated using two regression models that allow for the forecasting of reference series and yield measurements of forecasting power. The results of both approaches indicate not only that the original CROLEI has by far the greatest forecasting power, but also that it is able to predict the turning points in the economic cycle with the highest probability.

Key words: CROLEI (CROatian Leading Economic Indicators), forecasting indicator, barometric method, signaling method.

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Introduction

CROLEI (CROatian Leading Economic Indicators) is a composite leading index constructed of eleven leading indicators (leads) the main purpose of which is to forecast the direction of the Croatian economy's movement six months ahead (Ahec-Šonje et al., 1994; 1996; Ahec-Šonje, 1995). In 1995, CROLEI became the first forecasting indicator of domestic economic activity in the country and was constructed using *the barometric method* of the National Bureau of Economic Research (NBER)[1] (USDC/BEA, 1977; Zarnowitz and Boschan, 1975; Gapinski, 1982; Shiskin, 1961; Moore and Shiskin, 1967). The barometric method is based on the leading indicators approach, the methodological steps of which include building a database and techniques of updating, forecasting, dating and confirming cyclical changes in an economy. CROLEI movements are published regularly, the main purpose being to forecast the direction of economic trends in a timely manner. The ability of the index to provide monthly values is one of the most important advantages of using the barometric method. The movement of Croatian economic activity is approximated by the seasonally adjusted series volume of industrial production, according to the method referred to as the reference series.

The main task of this paper is to construct alternative forecasting indices, using the barometric method but treating the time series from CROLEI database differently (a list of series is provided in appendix 1). In so doing, we wish to determine whether time-series transformations may significantly change the results of Granger causality tests. These test results are then used as criteria for which leads to include in the composite forecasting indicator. Since this methodological step is an innovation in the application of the barometric method in Croatia, we found it necessary to investigate further the implications of its introduction. The goal is to establish whether forecasting indices based on time series differently treated and therefore built of different leads will provide a better forecast of economic activity than the existing, original CROLEI index.

The paper consists of three parts. After the introduction, where the adjustment of the barometric method is explained in detail, comes the empirical part of the paper. It starts by testing out potential indicators as original series, as seasonally adjusted series, seasonally adjusted and logarithmic series, and seasonally adjusted series in first differences, with the use of the Granger causality test. The outcome of this was lists of different potential indicators, candidates for entering the original CROLEI system and the alternative CROLEI systems. We then evaluate the forecasting properties of all potential indicators using the scoring method, which is inherent to the barometric method. Indicator scores are used to choose indicators in alternative forecasting indices. The first part of the paper ends with the construction of alternative forecasting indices according to the NBER algorithm, and their subsequent plotting. In the second part of the paper we try to evaluate the forecasting power of the original CROLEI index and of the alternative indices using the evaluation matrix from the signalling method, adjusted for the present purpose. Additionally, we try to evaluate indices performance by evaluating two regression models for in-the-sample forecasting of reference series. In the third and final part of the paper, we

[1] The credibility of the method was confirmed by the OECD's publication of forecasting indicators of many countries calculated pursuant to the barometric method. In addition, the OECD itself uses the NBER method for predicting economic activity trends in the area of OECD member countries.

try to comment on a forecasting system proposed by the Cerovac (2005). The paper ends with conclusion.

1 Should a well-functioning system be altered?

Since the methodological revision of the CROLEI system in 2004, entailing the application of the barometric method to raise forecasting quality, the index has comprised eleven components coming from four sectors of the economy – real, monetary, international and fiscal. Component dynamic is used to forecast total economic activity approximated by industrial production up to six months in advance. In the course of the revision, the research team recognized four turning points in the reference series in the period 1995-2004 (Bačić et al., 2004:12). The CROLEI system has successfully forecasted turning points and has been constructed on the basis of a widely accepted method; this being the case, why should we try to alter a well-functioning system?

The need to examine and assess the system does not stem from uncertainty about the method, but from a modification produced by a methodological step taken when the method was applied for the first time in Croatia. Specifically, the Granger bi-variate causality test was introduced for two random variables, the results of which were introduced by Ahec-Šonje (1995) and Ahec-Šonje et al., (1994;1996) as substitutes for two criteria from the original method in the evaluation of the forecasting power of potential components, in what is called scoring (Moore and Shiskin, 1967: 22-28). Two of the several criteria in the scoring process are *conformity to the business cycle* and *timing*. Within the criterion *conformity to the business cycle*, series are scored according to subcriteria: a) conformity probability, b) extra turning points, c) recent lapses, and d) amplitude. Within the criterion *timing*, series are scored according to the consistency with which timing comparisons of the same type occur at successive business cycle turning points. Both criteria make 40 percent of the total score for a series. While it is possible to determine the level of *conformity to the business cycle* with the help of *the conformity index* that represents a type of correlation coefficient (Ahec-Šonje et al., 1994:29), *timing comparisons* with real occurrences are more complex. In order to apply these two scoring criteria, a sufficient number of turning points in the business cycle and a longer time series would have to be available. For illustration, the US composite leading system was revised in the 1990s with series dating back to 1948 (Green, 1993), while in the last CROLEI revision, the series dated back to 1995.

In the methodological study in which the system of composite leading indicators is presented, the author and her research team point out that the original scoring procedure from the literature is based mostly on judgments of the researchers and not so much on sophisticated empirical analysis (Ahec-Šonje et al., 1994). That is why the introduction of the Granger causality test as an exact criterion for scoring series represents a creative and desirable adjustment in the application of the method in Croatia. This adjustment was later similarly applied in Slovenia (Jagrič, 2001; Jagrič, Boršič and Strašek, 2003). On the other hand, this type of modification, although justified by the state of statistical databases and Croatia's economic circumstances, calls for empirical verification.

The modification of the method in its application in Croatia is based on an expanded use of the Granger bi-variate causality test (Granger, 1969; 1988). The main advantage of using the Granger bi-variate causality test is that it provides several items of relevant information about the relation of the two random variables, X and Y. Firstly, the test can be used to determine whether lagged Y Granger causes X, as well as whether at the same time lagged X Granger causes Y. Secondly, the existence of the relationship can be identified at a certain lag. Thirdly, if modeled as a regression equation, the test will provide a coefficient of determination and the sign of coefficient next to the explanatory variable. All elements may be used in the scoring. Variables may be expressed with the help of Granger test as:

$$Yt = c_1 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{p} \beta_i X_{t-i} + u_t \tag{1}$$

where t stands for the period with lags from 0 to 12, and c_1, α_1 and β_1 are parameters to be estimated. The choice of lags has to be left to the researcher's judgment and is a widely accepted research rule.

The main weakness of the test is its sensitivity to time-series transformation (Ashely, Granger and Schmalensee, 1980). The series of potential indicators used in the CROLEI system during testing with the Granger bi-variate causality test were seasonally adjusted, as was the reference series – seasonally adjusted volume of industrial production. Trend-cycles of both potential indicators and industrial production were also tested. Opting for this approach ensured a large number of potential indicators and provided information about their forecasting quality, as well as a large number of potential series – candidates for the scoring procedure. However, Granger-testing time-series differently treated will possibly provide different results (Granger, Huang and Yang, 2000; Sander and Kleimeier, 2003; Rousseau and Vuthipadorn, 2005). Since this type of testing has not yet been performed it seems useful to perform it at the present time. If the results prove to be quite different from the existing results, they may lead to a completely new CROLEI index or indices. We will try to determine whether alternative indices would be better than the existing index with the help of complex measures of forecasting power from the literature in the field of economic forecasting. Nonetheless, these measures will have to be adjusted for the purposes of this paper.

1.1 Results of causality testing of treated time series

Where necessary, potential indicators from the database were adjusted for inflation[2] at the beginning of the testing of the CROLEI system. Subsequently, all potential indicators were seasonally adjusted. Then, the plotting method was used, the potential indicator and the reference series being plotted against each other – both as seasonally adjusted series and as trend-cycles. The figures are used for judgments concerning the sorting of indicators into groups of lagging, coincident and leading indicators or into the group

[2] Several deflators were used for this purpose, some as original, other were derived. These were the deflator calculated from the consumer price index, then the deflator calculated from the producer price index, and then both deflators were used to obtain a new, complex deflator.

of irrelevant indicators (Bačić et al., 2004). The result narrowed the selection of potential indicators to 69.

Due to the fact that literature about the Granger causality test points out that the results may vary depending on the treatment of time series, we decide to test the potential indicators on three sets of differently treated time series. These sets are: a) original time series i.e. untreated time series; b) series in differences depending on the results of stationarity tests, and c) series in logarithms. The reference series – volume of industrial production – is treated in the same manner as the potential indicators.

Criteria for entering the list of potential indicators are the same for three sets of series and were applied during scoring using the results of the Granger causality test in the CROLEI revision in 2005. These criteria were: a) p-value below 0.05; b) high level of coefficient of determination (R^2); and c) t-statistics above or close to |2,00|. Granger causality testing was carried out for the period January 1995 – April 2004. Following these criteria, we obtained a list of potential indicators for the original CROLEI system and for the alternative forecasting systems (table 1).

Table 1 List of potential indicators

a) Seasonally adjusted series - the original CROLEI from revision in 2004	
S 43	Average monthly paid net earnings of persons in paid employment
S 48	Registered employed persons in the course of the month
S 51	Recipients of unemployment benefit
S 54	Tourist industry bed-nights, total
S 55	Tourist industry bed-nights, foreign
S 58	Retail trade, real
S 76	Export of chemical products
S 92	Import machinery and transport equipment
S 95	Nonconsolidated revenues of state, county and municipality budgets
S105	Money M1
S106	Money M1a
S107	Broadest money M4
S109	Cash
S113	Deposit money, bank savings and time deposits in foreign currency
S114	Deposit money, bank savings and time deposits in foreign currency (f/c) - households
S115	Deposit money, bank savings and time deposits in f/c - enterprises
S116	Credits
S123	Deposit money, bank reserves with the CNB in f/c - savings and time deposits
S136	Money market interest rates on other credits
S146	Revenues of the government budget from VAT
S155	Revenues of the government budget from excises on motor vehicles
S157	Expenditures of the government budget, total
S112	Deposit money, banks savings and time deposits in kuna
S164	Expenditures, capital
S165	The government budget surplus/deficit

b) Original series	
S 02	Industrial production volume index – mining and quarrying
S 33	Industrial production volume index – manufacture of other transport equipment
S 43	Average monthly paid net earnings of persons in paid employment
S 52	Unemployed persons due to enterprises and employers going out of business
S 56	Tourist industry bed-nights, domestic
S 72	Export of beverages and tobacco products
S 85	Import of food products and live animals
S 90	Import of chemical products
S 91	Import of manufactured goods classified mainly by material
S121	Deposit money, banks reserves with the CNB in f/c, total
S137	Money market interest rates on overnight credits
S140	Revenues of the government budget, total
S143	Revenues of the government budget from taxes, total
S144	Revenues of the government budget from corporate income tax
S164	Expenditures, capital
c) Series in differences depending on the results of Unit Root Tests[a] (URT)	
S 05	Industrial production volume index, energy
S 06	Industrial production volume index, intermediate goods
S 20	Industrial production volume index, publishing and printing
S 24	Industrial production volume index, manufacture of other non-metallic mineral products
S 43r	Average monthly paid net earnings of persons in paid employment
S 47	Persons seeking employment for the first time according to the end of the month state
S 54	Tourist industry bed nights, total
S 86r	Import of beverages and tobacco products
S 94r	Import of commodities and transactions, n. e. c.
S109r	Cash
S120r	Foreign assets, Croatian National Bank (CNB)
S122r	Deposit money, banks reserves with the CNB in f/c - demand deposits and foreign currency deposits
S123r	Deposit money, bank reserves with the CNB in f/c - savings and time deposits
S146	Tax revenue from VAT
S148r	Tax revenue from customs, customs and import duties
S157r	Expenditures of central government, total
S159r	Expenditures on gross wages of employees
d) Series in logarithms	
S 03	Industrial production volume index, manufacturing
S 09	Industrial production volume index, non-durable consumer goods
S 11	Industrial production volume index, extraction of crude petroleum and natural gas
S 13	Industrial production volume index, manufacture of food products and beverages
S 24	Industrial production volume index, manufacture of other non-metallic mineral products
S 49	Registered demand for employees in the course of the month
S 67r	Export of merchandise, total

S 71r	Export of food products and live animals
S 74r	Export of mineral fuels and lubricants
S 75r	Export of animal and vegetable oil and fats
S 79r	Export of various finished goods
S 81r	Import of merchandise, total
S105r	Money M1
S118r	Credits to enterprises
S122r	Deposit money, bank reserves with the CNB in f/c - demand deposits and foreign currency deposits
S129	The CNB interest rates on lombard credits
S140r	Revenues of the government budget, total
S148r	Tax revenue from customs, customs and import duties
S149r	Revenues from excises, total
S150r	Revenues from excises on petroleum products
S162r	Expenditures on current transfers

[a]Remark: Augmented Dickey-Fuller and Phillips-Peron tests were used for this purpose, and the optimal number of lags was determined with Schwartz information criterion; results of URT are available from the authors upon request.

Source: for a) Bačić et al., (2004) and authors' calculations for b), c) and d).

The results of Granger causality tests (following equation 1) for potential indicators and volume of industrial production confirmed the findings from the empirical literature that test results may be sensitive to time series treatment[3]. Each testing set resulted in a list of indicators different from other sets of tests. Lists of indicators overlap in one or two series. The set of testing series in logarithms gives the highest possible number of potential indicators, when the original CROLEI from 2004 revision is excluded. This result is not surprising as this testing set involves series that have been entirely "smoothened" and therefore the probability of finding causality stemming from the potential indicator towards the reference series is higher. That, coupled with the fact that most series are integrated I(1) can explain the high coefficients of determination[4] in the last set of testing, when compared to the other sets of testing where coefficients of determination are quite low, except in the case of the original CROLEI.

1.2 Scoring

Scoring of series is a procedure that follows identification of the potential indicators (leads) and consists of giving scores to each series according to the criteria: *economic significance*, *statistical adequacy*, *conformity to the business cycle*, *smoothness* and *cur-*

[3] The objective is to determine whether there is any causality between the potential indicator and the reference series. Following this approach, we hypothesise that there are additional explicatory variables that are not included in the model, the influence of which however can be seen in the residuals. Hence the results of diagnostic tests of residuals were not considered.

[4] Results of the Granger causality test are available from the authors upon request.

rency. The assigned scores are then weighted and summed into the total score of a series. The highest score can amount to 100 points. The choice of weights assigned for each criterion is the result of the assessment of the research team (Ahec-Šonje et al., 1994), but in the Croatian case, the choice is very close to the choice made by the NBER (see Zarnowitz, 1992). We have decided to use the same criteria for scoring that were used in the revision in 2004 to enable comparability of the original and the alternative CROLEI systems.

The five criteria can be further explained:

- *Economic significance* is used for determining whether the series is an aggregate (for example *tourist industry bed-nights*), a subaggregate (for example foreign tourist bed-nights), or a still more narrowly defined indicator (for example Austrian tourist bed-nights). Aggregates are more desirable than subaggregates and there aggregates are given a higher score.
- *Statistical adequacy* encompasses the quality of statistical measurement, and therefore series that are measured as whole populations as well as series with no significant changes in the methodology are more desirable.
- *Conformity to the business cycle* refers to strength of the relationship between the potential indicator and the reference series. Coefficient of determination or R^2 (obtained from the Granger causality test) is used as the measure of strength of the relationship and the higher it is, the higher the score.
- *Smoothness* refers to the confidence in regular movement of a series. That is why series where the cyclical component dominates are more desirable than series with a dominating irregular component. A measure that is used in the process of seasonal adjustment is also used for scoring according to this criterion, and this measure is MCD or months-for-cyclical-dominance. It is the number of months where the average change of the cyclical component dominates the average change of the irregular component (Bačić et al., 2004: 19).
- Finally, *currency* refers to the prompt availability and accuracy of statistical releases. With regard to the monthly calculation of the index, all data need for this purpose have to be available at a specified date in the month. Series with delays in their release are given lower scores.

Conformity is given the highest weight in the total score (30 percent), while *currency* is given the lowest score (10 percent). The key criterion for choosing indicators is the economic significance of a series (Bačić et al, 2004: 15). It is crucial that potential indicators have a longer lead time in relation to the reference series. Accordingly, indicators with a lead time shorter than 4 months are dismissed during the scoring. The scores of indicators both in the original and in the alternative CROLEI systems are given in table 2.

Table 2 Potential indicators ranked by their total score

a) Seasonally adjusted series (D11) - the original CROLEI from revision in 2004		total score
S136	Money market interest rates on other credits	92
S112	Deposit money bank savings and time deposits in kuna	92
S109	Cash	92

S 48	Registered employed persons in course of the month	88
S123	Deposit money banks' reserves with the CNB in f/c - savings and time deposits	88
S 43	Average monthly paid net earnings of persons in paid employment	87
S 58	Retail trade, real	87
S 54	Tourist industry bed-nights, total	84
S 55	Tourist industry bed-nights, foreign	80
S 51	Users of unemployment benefit	79
S 95	Nonconsolidated revenues of state, county and municipality budgets	75
S107	Broadest money M4	75
S116	Credits	75
S105	Money M1	71
S106	Money M1a	71
S113	Deposit money, bank savings and time deposits in foreign currency	71
S114	Deposit money, bank savings and time deposits in foreign currency (f/c) – households	67
S 92	Import of machinery and transport equipment	66
S115	Deposit money, bank savings and time deposits in f/c – enterprises	63
S157	Expenditures of the government budget, total	55
S165	The government budget surplus/deficit	55
S164	Expenditures, capital	51
S 76	Export of chemical products	48
S155	Revenues of the government budget from excises on motor vehicles	48
S146	Revenues of the government budget from VAT	46

Source: Bačić et al. (2004).

b) Original series (A1)		total score
S121	Deposit money, bank reserves with the CNB in f/c, total	83
S137	Money market interest rates on overnight credits	79
S 43	Average monthly paid net earnings of persons in paid employment	78
S 52	Unemployed persons due to cease of work of the enterprise and employer	75
S143	Revenues of the government budget from taxes, total	66
S 33	Industrial production volume index– manufacture of other transport equipment	63
S 91	Import of manufactured goods classified-mainly by material	58
S 02	Industrial production volume index- mining and quarrying	55
S 90	Import of chemical products	54
S140	Revenues of the government budget, total	54
S 56	Tourist industry bed-nights, domestic	51
S164	Expenditures, capital	51
S144	Revenues of the government budget from corporate income tax	51
S 85	Import of food products and live animals	46
S 72	Export of beverages and tobacco products	37

Source: Authors' calculations.

c) Series in differences depending on the results of URT		total score
S 47	Persons seeking employment for the first time according to the end of the month state	66
S 24	Industrial production volume index, manufacture of other non-metallic mineral products	62
S109r	Cash	62
S120r	Foreign assets, Croatian National Bank (CNB)	62
S123r	Deposit money, bank reserves with the CNB in f/c - savings and time deposits	58
S 43r	Average monthly paid net earnings of persons in paid employment	57
S 20	Industrial production volume index, publishing and printing	54
S 54	Tourist industry bed-nights, total	54
S 05	Industrial production volume index, energy	50
S 06	Industrial production volume index, intermediate goods	50
S122r	Deposit money banks' reserves with the CNB in f/c - demand deposit and foreign currency deposits	50
S159r	Expenditures on gross wages of employees	49
S157r	Expenditures of the central government, total	46
S 86r	Import of beverages and tobacco products	37
S 94r	Import of commodities and transactions, n. e. c.	37
S146	Tax revenue from VAT	37
S148r	Tax revenue from customs, customs and import duties	37

Source: Authors' calculations.

d) Series in logarithms		total score
S 49	Registered demand for employees in course of the month	86
S105r	Money M1	86
S118r	Credits to enterprises	85
S129	The CNB interest rates on lombard credits	81
S 24	Industrial production volume index, manufacture of other non-metallic mineral products	74
S122r	Deposit money banks' reserves with the CNB in f/c - demand deposits and foreign currency deposits	74
S162r	Expenditures on current transfers	74
S 03	Industrial production volume index, manufacturing	73
S 13	Industrial production volume index, manufacture of food products and beverages	73
S140r	Revenues of the government budget, total	72
S 09	Industrial production volume index, non-durable consumer goods	71
S 11	Industrial production volume index, extraction of crude petroleum and natural gas	70
S 67r	Export of merchandise, total	68
S 81r	Import of merchandise, total	66
S149r	Revenues from excises, total	66

S 71r	Export of food products and live animals	64
S 74r	Export of mineral fuels and lubricants	64
S150r	Revenues from excises on petroleum products	62
S 79r	Export of various finished goods	61
S148r	Tax revenue from customs, customs and import duties	61
S 75r	Export of animal and vegetable oil and fats	58

Source: Authors' calculations.

From table 2, where scores of individual indicators in different systems are shown, it can be seen that series in the original 2004 CROLEI system have been scored high, and then follow series in logarithms and original, non-treated series. As expected, series in differences ended with the lowest scores due to their coefficients of determination turning out low, because this is the case when series of I(1) are Granger tested. However, individual characteristics of indicators on the four lists are more important than a comparison of scores among systems.

When the results of the CROLEI system based on the original series (table 2 - b) are compared to the original 2004 CROLEI system, it can be noticed that the alternative systems contain more series that are subaggregates than the original system. Comparisons with the other two alternative systems are very similar. Scores in the system with the original series are lower because these series were not treated. The original 2004 CROLEI system has undergone the process of seasonal adjustment including averaging by the method of moving averages, these series thus being smoother than the original series.

In the system of series in differences depending on the results of URT, more series have entered the scoring process than in the system with the original series. Lower scores are a consequence of a lower coefficient of determination, which is a result of differentiating non-stationary series, aimed at eliminating the deterministic trend component and avoiding spurious regression. On the other hand, the system with series in logarithms has obtained higher scores thanks to its high coefficients of determination. Interestingly, the series *nominal net wage,* which can be found in all other systems, is not included in this system.

1.3 Choosing elements of the forecasting systems

Scoring series has enabled us to see clearly which indicators are more desirable in forecasting systems and has made it possible to rank potential indicators according to their total score. However, as the choice of elements of the forecasting system follows and it is these elements that will eventually be components of the forecasting expression, how do we choose which of these series should enter the index? Naturally, they should be indicators with the highest possible total scores. Then again, it is possible that series with the highest grades all come from one sector, for example the monetary sector. In such a case, not all of these series can be included. The optimal choice would be equally to include series from all sectors of the economy. In the 2004 revision (Bačić et al., 2004:26) indicators were chosen if:

- they had an ignorable irregular component,
- their total score equaled or exceeded 70 points,

- their lead time was long enough,
- priority was given to economic aggregates (Bačić et al., 2004: 26).

Respecting the criteria of 2004 outlined, eleven series – components of the CROLEI system – were chosen, as follows: nominal net wage per employee, employed with the help of the Croatian Employment Agency, total tourist industry bed-nights, real retail trade, machinery and transport equipment import, unconsolidated revenues of state, county and municipal budgets, broadest money M4, reserve money, time and savings deposits with deposit money of banks in domestic currency, reserves on time and notice deposits and daily money market rate (table 3). An exception to these rules is the series *Import of machinery and transport equipment*. This series' total score is lower than 70 points, but it is still included in the index because of its high score based on the *economic significance* criterion. This choice of components is optimal not only because we have respected all the criteria but also because the series included come from four different sectors of the economy. Including series from different sectors is not always possible as series from some sectors have not necessarily shown to be good leads. However, when one of the sectors is not represented, a lower quality of forecasting expression is not necessarily implied.

Criteria from the 2004 revision unfortunately cannot be fully implemented in the choice of elements of the alternative forecasting systems. The reason is the dominating lower level of total scores as well as a lower number of series that passed Granger testing and were then scored. The choice of indicators had therefore to be made according to simpler criteria. Given the lower number of series in the alternative systems, the choice of indicators is self-determining: series with higher total scores enter the alternative systems with as good representation of all sectors of the economy as possible.

In tables 3 – 6 chosen indicators that will be used as a base for alternative indices are shown. Out of three alternative systems, the first two (tables 4 and 5) are based on 11 series – components, while the remaining system is based on 9 components (table 6). The literature does not specify a rule for determining the necessary number of components, so a lower number of components in the last alternative system does not represent an obstacle to further construction of the forecasting system. Tables also contain elements needed for further development of the systems: lead time as an average number of months that an indicator leads the reference series, total scores of individual components (Si) that are also used to obtain significance weights (Wi). These weights will be used when calculating the index values as a measure of participation of a component in the system in relation to the other components in the system.

Table 3 Original CROLEI system from 2004

Series	Lead time	Total score (Si)	Weight (Wi)
S 43	-4	87	1.03
S 48	-4	88	1.05
S 54	-9	84	1.00
S 58	-8	87	1.03
S 92	-8	66	0.78
S 95	-4	75	0.89

S107	-4	75	0.89
S109	-5	92	1.09
S112	-4	92	1.09
S123	-8	88	1.05
S136	-5	92	1.09
Total		926	11.00
Average	-5.7	84.2	

Source: Bačić et al., (2004).

Table 4 CROLEI system constructed on original time series

Series	Lead time	Total score (Si)	Weight (Wi)
S 02	-11	55	0.85
S 33	-11	63	0.97
S 43	-12	78	1.20
S 52	-6	75	1.16
S 56	-11	51	0.79
S 90	-11	54	0.83
S 91	-12	58	0.89
S121	-12	83	1.28
S137	-12	79	1.22
S143	-12	66	1.02
S164	-6	51	0.79
Total		713	11.00
Average	-10.6	64.8	

Source: Authors' calculations.

Table 5 CROLEI system constructed on series in differences depending on the results of URT

Series	Lead time	Total score (Si)	Weight (Wi)
S 05	-8	66	1.20
S 06	-8	50	0.91
S 20	-8	54	0.99
S 24	-8	62	1.13
S 43	-10	57	1.04
S 47	-11	66	1.20
S 54	-7	54	0.99
S 86	-12	37	0.67
S109	-9	62	1.13
S157	-8	46	0.84
S159	-8	49	0.89
Total		603	11.00
Average	-8.8	54.8	

Source: Authors' calculations.

Table 6 CROLEI system constructed on series in logarithms

Series	Lead time	Total score (Si)	Weight (Wi)
S 24	-8	74	1.00
S 49	-10	86	1.17
S 81	-12	66	0.89
S 74	-7	64	0.87
S118	-5	85	1.15
S150	-6	62	0.84
S129	-9	81	1.10
S140	-7	72	0.98
S162	-8	74	1.00
Total		664	9.00
Average	-8.0	73.8	

*Remark on tables 3- 6: Si – total score of a component: Wi – significance weight of a component; average lead time of the CROLEI index = ∑((t-m)i *Wi)/k, where m is the number of lead months, i=1,2,... k where k is the total number of index components, and Wi is a weight of an individual indicator i. Wi is obtained as a ratio of each indicator's score and average score of all indicators (Bačić et al., 2004:27).*

Source: Authors' calculations.

When results in tables 3-6 are compared, the 2004 CROLEI score Si (84.2) stands out as the highest; it is followed by that of the CROLEI founded on series in logarithms (73.8). A lower average score of some indicator in this phase of development of the alternative systems should not imply that the system is therefore less reliable or weaker than the other. The system of weighted averaging will enable the weaker indicators i.e. indicators with a lower total score to participate in the index with a lower share (Wi) than stronger indicators, which will result in an automatic balance between weaker and stronger indicators being achieved. From the perspective of seeking timely and the earliest possible forecast of movement of the reference series, the most desirable CROLEI is founded on the original series. However, the quality of this and other alterative systems will be thoroughly assessed with the help of several measures of the indices' forecasting strength.

1.4 Calculation of the composite forecasting index

Like the method used for distinguishing potential leading indicators, the method for calculating and constructing the index continues to be the *barometric* method. Thus the original CROLEI index from 2004 was calculated according to NBER/BEA methodological instructions and the same methodology was to be applied for the calculation of the six alternative CROLEI indices. *The barometric* method involves five methodological steps yielding the final composite index (USDC/BEA, 1977; Zarnowitz and Boschan, 1975; Gapinski, 1982; Shiskin, 1961).

- Computing symmetric (Shiskin's) percentage changes means using the equation with expected average growth rate of 0%, thus ensuring symmetry of positive and negative changes:

$$c_{it} = 200(X_{it} - X_{it-1}) / (X_{it} + X_{it-1}) \quad (2)$$

where X_{it} is value of the leading indicator in time t and t-1, and c_{it} is its symmetric monthly percentage changes (i=1,2,3,…,k, where k is total number of series entailing composite index; t=2,3,4,…,n).

- Standardization of the amplitude means that the so-called standardization factor (mean absolute percentage change) is calculated for every leading indicator:

$$A_i = \sum_{t=2}^{n} |c_{it}| / (N-1) \quad (3)$$

where N is the total number of monthly observations. After calculation of the standardization factor A_i for each index component, the following step is to standardize symmetric monthly percentage changes (amplitude) for each component and:

$$s_{it} = c_{it} / A_i \quad (4)$$

where A_i is fixed standardization factor in observed period. The aim of this step is to prevent dominant influence of certain indicators in composite index movement.

- Weighting of the standardized changes is based on best leading indicators scores, whereby their significance weights, reflecting behavior of the series in regard to reference series, are calculated:

$$W_i = S_i / \sum_{i=1}^{k} (S_i / k) \quad (5)$$

Weight is the ratio of the score of a certain indicator (S_i) and the average score of all indicators (k = number of composite index components). Weights serve for weighting of the standardized monthly percentage changes of indicators s_{it}:

$$R_t = (\sum_{i=1}^{k} s_{it} W_i) / (\sum_{i=1}^{k} W_i) \quad (6)$$

- Standardization of R_t is performed with help of the standardization factor of a group of leading indicators (F) calculated according to the equation:

$$F = \left[\left(\sum_{t=2}^{n} |R_t| \right) / (N-1)) / \left(\sum_{t=2}^{n} |P_t| \right) / (N-1) \right] \tag{7}$$

where P_t is obtained from same procedure as series Rt, just based on a group of leading indicators. Standardization of the R_t series enables adjusting R_t series to the average change of leading indicators:

$$r_t = R_t / F \tag{8}$$

where r_t represents adjusted weighted monthly changes in the group of leading indicators.

- Turning monthly changes into the index is the last step in index calculation. A (non) standardized average changes series is expressed in form of index using following equation:

$$I_t = I_{t-1} \left[(200 + r_t)/(200 - r_t) \right] \tag{9}$$

where the starting value is usually set to 100. This procedure brings back symmetric percentage changes to the conventional mode of application. The forecasting index – composite index of leading indicators I_t - can be recalculated to any other base by dividing each monthly value of index (I_t) by the new base period index. Detailed explanation can be found in Bačić et al. (2004). Following the methodological instructions for index calculation, along with original CROLEI from 2004, we obtain six alternative CROLEI forecasting indices stemming from three alternative forecasting systems. In the next paragraph we describe all indices obtained from the original and alternative systems:

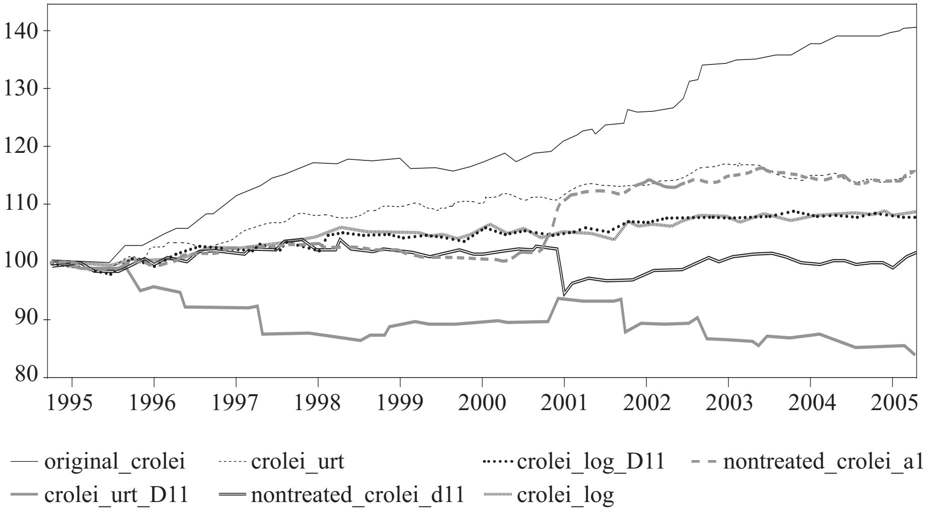
- *The original 2004 CROLEI index* was calculated using seasonally-adjusted series. In this paper the index is calculated and presented in the same way as in the last revision of forecasting system in 2004. The reference series "industrial production" is also seasonally adjusted.
- *CROLEI system based on the original, i.e.* deflated series. This means that the Granger test was conducted on deflated and not seasonally adjusted series. After selection of index components, the index was calculated either using series in the original form or using seasonally adjusted series. Thus this system yields two indices. The same principle applies to the other two forecasting systems and their resulting indices. For the first index, the reference series industrial production is in the original form. For the second index it is seasonally adjusted.
- *CROLEI system based on series in differences,* according to results of unit root tests, is obtained from the Granger test applied to seasonally adjusted series in differences. The Granger test was applied only to those series that are nonstationary in levels and stationary in first difference, thus aiming to eliminate spurious regression

problem. Such system for one, can produce index calculated using series in differences. In this case industrial production is also tested for stationarity and later appears as reference series in first difference. Secondly, such system can produce an index using seasonally adjusted series, and in that case reference series – industrial production – is seasonally adjusted.

- Accordingly, the *CROLEI system based on series in logarithm* yields an index based on seasonally adjusted series in logarithms and an index based on seasonally adjusted series. For the first index, the reference series is the volume of industrial production in logarithms, and for the second index, the reference series is the seasonally adjusted volume of industrial production.

One must emphasize that a reference series does not take part in the calculation of the forecasting index in any way, but it serves as an approximation for total economic developments. Including industrial production in the index calculation would create a strong bias since past values of industrial production could explain its present values. Additionally, we need industrial production to check the forecasting power of all the forecasting indices – the original and alternative.

Figure 1 Original and alternative CROLEI forecasting indices[a], January 1995=100



[a] Remarks: Crolei_urt stands for CROLEI index based on series in differences. Crolei_urt_D11 is CROLEI index based on seasonally adjusted series from CROLEI system based on series in differences. Crolei_log is CROLEI index based on series in logarithms. Crolei_log_D11 is CROLEI index based on seasonally adjusted series from CROLEI system based on series in logarithms. Nontreated_crolei_a1 is CROLEI index based on original series. Nontreated_crolei_d11 is CROLEI index based on seasonally adjusted series from CROLEI system based on original series.

Source: Authors' calculations.

As first and basic measure of statistical relation between two variables, we use cross-correlation coefficient for industrial production and lagged CROLEI index. The results are displayed in Table 7. The original CROLEI index has the highest cross-correlation coefficient, followed by CROLEI system based on series in logarithms (column 6 and 7). The result of the CROLEI index based on the original series is also acceptable.

The Granger causality test can also be used as an indicator of forecasting system reliability. Lagged CROLEI indices are causally related to the relevant volume of industrial production in three cases. The first case is the original CROLEI index for which the test persistently indicates causality on all lags from -12 to -4. Causality was also established for the CROLEI based on the original series and for the CROLEI based on series in logarithms. Since the results of causality tests and cross-correlation coefficients coincide (indices that do cause reference series are the indices with high correlation coefficients) the credibility of those three forecasting indices is thus additionally confirmed.

Table 7 Grange tests results and cross-correlation coefficient

Forecasting system CROLEI	Original from 2004	Based on original series		Based on series n differences according to unit root tests		Based on series in logarithms	
Forecasting index CROLEI based on	seasonally adjusted series	original series	seasonally adjusted series	series in differ-ences	seasonally adjusted series	series in loga-rithms	seasonally adjusted series
	1	2	3	4	5	6	7
Lead time (in months)	-5.7	-10.6	-10.6	-8.8	-8.8	-8.0	-8.0
Cross-correlation coefficient	0.70	0.46	-0.08	0.01	-0.47	0.64	0.58
Granger test results	yes	yes	no	no	no	yes	no
Time lags on which causality was confirmed	from -12 to -4	from -6 to -4	/	/	/	-4	/

Note: tested variables are lagged CROLEI index and relevant reference series – industrial production volume index.

Source: Authors' calculation.

2 Evaluation of indices using signaling method

One of the emerging difficulties during this research was how to identify and select several complex measures for evaluating the forecasting power of original and alternative forecasting indices. For this reason the authors were forced to look within the economic forecasting field for auxiliary measures indirectly related to the barometric method. The measures found stem from the application of the barometric method to the signaling method and its application in forecasting crises and disturbances[5]. Similar to the barometric method, the signaling method assumes selecting of the best leading indicators of economic disturbances, and for that purpose the matrix containing several measures serving as criteria for indicator selection is used (Kaminsky, Lizondo and Reinhart, 1997; Nierhaus, 2000).

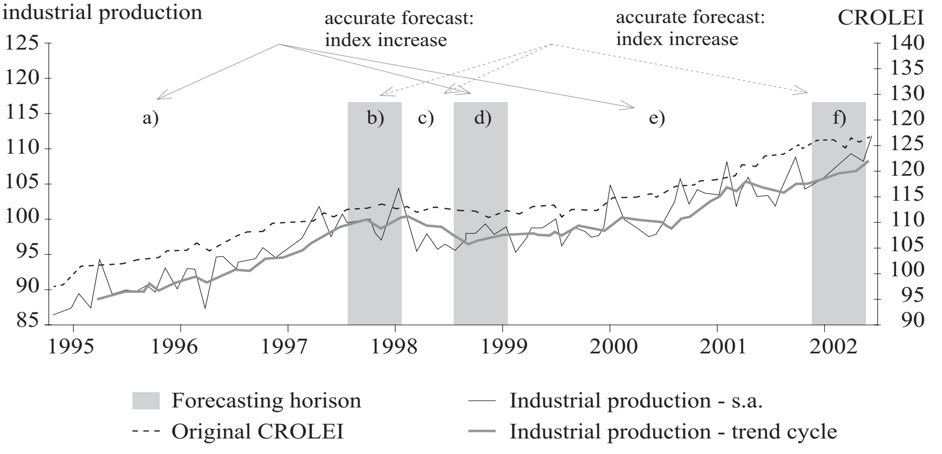
But, before we explain the measures, it is necessary to explain in brief the principles according to which the signaling method functions, as well as the most important terms. As the name of the method implies, the basis of the method consists of derived signals from potential indicators, produced when the indicators exceed their critical value or threshold in a certain period before the turning point arises. It is thereby crucial to distinguish between two kinds of periods. There are calm periods, i.e. periods during which no turning point is expected and there are periods leading to a turning point which are called signaling horizons. A good indicator in a calm period will not produce signals, meaning that its value will stay below the threshold. In the signaling horizon a good indicator will create signals by exceeding its critical value thus warning of an approaching turning point. In the signaling method application, the authors themselves can decide on the duration of signaling horizons, relying on economic laws and logic.

How can the described evaluation of indicators be applied to forecasting indices? The task of a forecasting index is to forecast turning points in economic activity. But as a consequence of the adjustment of NBER method, the CROLEI index, besides being able to predict turning points, can continuously forecast developments in economic activity approximated by the volume of industrial production index. In the course of the last CROLEI revision, turning points in the industrial production series during the period 1995-2004 are identified as local minima and maxima. They are: August 1995, August 1998, August 1999 and September 2002 (Bačić et al., 2004).

Signaling horizons from the signaling method are forecasting horizons in the barometric method, which is actually the lead time in relation to the reference series. Lead time has already been determined for each index (see Tables 3 – 6). Determining forecasting horizons represents an advance as compared to the signaling method because timing is determined exactly by calculation, while in the signaling method the authors themselves decide what the horizon will be. But, due to this, a stricter criterion for identification of accurate forecasts is established because, for example, there is a chance that the index will forecast a turning point right before the beginning of a forecasting horizon. Time periods outside forecasting horizons are called calm periods or periods without turning points in economic activity, and they are displayed as areas a), c) and e) in Figure 2.

[5] Mainly foreign exchange disturbances.

Figure 2 Forecasting horizons for the original CROLEI index in the period August, 1995 – September, 2002



Source: Central Bureau of Statistics, 2004 and authors' calculation.

One can notice from figure 2 that the forecasting horizons before the first turning point of the economic activity in August 1995 are not included. This is because there are not enough observations before that point. Although six observations would be enough for forecasting horizons of original CROLEI index, the alternative CROLEI indices have longer forecasting horizons (-11, -9 and -8 months), and for this reason these horizons could not be included in the evaluation process.

Since every monthly value of CROLEI, in the context of the previous values of the series, represents a basis for forecast, according to the signaling method, the monthly values of CROLEI can be considered as forecasts that release signals. Following the logic of the signaling method, the number of accurate and inaccurate forecasts within forecasting horizons and within calm periods is determined in the following way: a) forecasts which predict turning point in the forecasting horizons are given the value 1, while forecasts which do not predict the turning point are given the value 0; and b) forecasts which predict the turning point in the calm period are given the value 0, while forecasts that do not predict the turning point are given the value 1.

In order to know what value to assign to the forecast in the forecasting horizons, we firstly must know the kind of turning point, and that is already determined in the last revision of the index (Bačić et al., 2004). The first turning point - August 1998 – is the peak of the cycle, followed by the turning point in August 1999, which is the bottom of the cycle, and September 2002 represents the peak of the cycle. Thus we expect that index value to drop within forecasting horizons before first turning point, thus forecasting an economic downswing, while in the forecasting horizons before the next turning point we expect the index to rise, thus forecasting an upswing in the economic activity. Before the last turning point in September 2002, the decrease in the index value is expected. In the calm period a) and e) the index value should increase, while in the calm period c) it should decrease. Forecasting power will be evaluated using the matrix displayed in table 8.

Adjusted noise to signal ratio is an indicator of the indices' ability to produce accurate forecasts and of the ability not to offer any inaccurate forecasts. Thus, this measure will serve as the main indicator of forecasting power. The closer the ratio is to zero, the more successful is the index in accurate forecasting.

Table 8 Evaluation of index's forecasting power matrix[a]

	Forecasting	Calm period	Total
forecast predicts turning point ($P_t = 1$)	A	B	A+B
forecast does not predict turning point ($P_t = 0$)	C	D	C+D
total forecast	A+C	B+D	A+B+C+D
accurate forecasts	A	D	A+D
inaccurate forecasts	C	B	C+B
accurate forecast as % of total forecasts	A/(A+C)	D/(B+D)	(A+D)/(A+B+C+D)
inaccurate forecasts as % of total forecast	C/(A+C)	B/(B+D)	(B+C)/(A+B+C+D)
Adjusted noise-to-signal ratio or NTS	B/(B+D)/A/(A+C)		

[a] According to Kaminsky, Lizondo and Reinhart (1997) and Nierhaus (2000).
Source: Adjusted according to Ahec-Šonje, Babić and Bačić (2003).

If the index yields inaccurate forecasts, i.e. it forecasts turning points in a calm period, the ratio will be closer to one, so that indices with a value close to or over one are not trustworthy for forecasting economic activity. According to the matrix, forecasting power measures are calculated for original and alternative CROLEI indices (Tables 9-15).

Table 9 Original CROLEI from 2004

Number of observations:			85
Number of observations before turning point			18
Number of observations in calm period			67
	Forecasting horizons before turning point	Period without turning points	Total
p = 1	7	13	20
p = 0	11	54	65
Total	18	67	85
Accurate forecast	7	54	61
Accurate forecast/total	0.39	0.81	0.72
Inaccurate forecast/total	0.61	0.19	0.28
NTS	0.50		

Table 10 CROLEI system based on the original series, based on the original series

Number of observations			85
– before turning point			33
– in calm period			52
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	12	18	30
p = 0	21	34	55
Total	33	52	85
Accurate forecast	12	34	46
Accurate forecast/total	0.36	0.65	0.54
Inaccurate forecast/total	0.64	0.35	0.46
NTS	0.95		

Table 11 CROLEI system based on original series, based on seasonally adjusted series

Number of observations			85
– before turning point			33
– in calm period			52
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	11	17	28
p = 0	22	35	57
Total	33	52	85
Accurate forecast	11	35	46
Accurate forecast/total	0.33	0.67	0.54
Inaccurate forecast/total	0.67	0.33	0.46
NTS	0.98		

Table 12 CROLEI system based on series in difference according to unit root tests, based on series in differences

Number of observations			85
– before turning point			27
– in calm period			58
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	14	20	34
p = 0	13	38	51
Total	27	58	85
Accurate forecast	14	38	52
Accurate forecast/total	0.52	0.66	0.61
Inaccurate forecast/total	0.48	0.34	0.39
NTS	0.67		

Table 13 CROLEI system based on series in difference according to unit root tests, based on seasonally adjusted series

Number of observations			85
– before turning point			27
– in calm period			58
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	16	30	46
p = 0	11	28	39
Total	27	58	85
Accurate forecast	16	28	44
Accurate forecast/total	0.59	0.48	0.52
Inaccurate forecast/total	0.41	0.52	0.48
NTS	0.87		

Table 14 CROLEI system based on series in logarithms, based on series in logarithms

Number of observations			85
– before turning point			24
– in calm period			61
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	13	27	40
p = 0	11	34	45
Total	24	61	85
Accurate forecast	13	34	47
Accurate forecast/total	0.54	0.56	0.55
Inaccurate forecast/total	0.46	0.44	0.45
NTS	0.82		

Table 15 CROLEI system based on series in logarithms, based on seasonally adjusted series

Number of observations			85
– before turning point			24
– in calm period			61
	Forecasting horizon before turning point	Period without turning points	Total
p = 1	11	29	40
p = 0	13	32	45
Total	24	61	85
Accurate forecast	11	32	43
Accurate forecast/total	0.46	0.52	0.51
Inaccurate forecast/total	0.54	0.48	0.49
NTS	1.04		

Source for tables 9 -15; Authors' calculation.

According to the results obtained from the matrix, the original CROLEI achieved the lowest noise-to-signal ratio (0.50). CROLEI in differences is the second-best index with a noise-to-signal ratio 0.67. Despite such results, the signaling method would not accept CROLEI in differences because 39 percent of its forecasts are not accurate, while that ratio in the original CROLEI is significantly lower.

2.1 Using regression forecasting models for evaluation of indices

Since we obtained matrix results by modifying the signaling method, we wanted to verify those results with a method that does not need to be adjusted to the needs of this research, which was thus the method that is applied in original form. Two regression models are chosen and they will be used in two empirical steps. In the first step, evaluating two models will enable comparison of forecasting power between original and alternative CROLEI indices. In the second step regression analysis is conducted and according to this, it will be possible to forecast in-the-sample industrial production applying regression on sample ranging from January 1995 to April 2003. Models used for evaluation of all CROLEI indices, including original, are following:

$$INDUSTRY_t = \alpha_0 + \alpha_1 CROLEI_{t-1} + \alpha_2 CROLEI_{t-2} + ... + \alpha_n CROLEI_{t-n} + \varepsilon_t \quad (10)$$

$$INDUSTRY_t = \alpha_0 + \beta_i CROLEI_{t\,n} + \varepsilon_t \quad (11)$$

where $INDUSTRY_t$ is industrial production volume index[6] in time t, $CROLEI_t$ is value of CROLEI composite index in time *t-1,* and *n* is average lead time of CROLEI forecasting index. By evaluating model (10), the CROLEI system based on the original series with a lead time of 11 months will have 11 independent variables and a constant. In model (11) the only independent variable will be the CROLEI index with an 11 month time lag accompanied with a constant. The same logic applies to all other CROLEI indices i.e. for other regression equations that will be evaluated.

Evaluation of regression models (10) and (11) for all seven CROLEI forecasting indices will serve for forecasting industrial production. The forecasts will be made for each period between May 2003 – April 2004. The advantage of this method is that forecasts of industrial production can be compared with their actual values – industrial production volume index. Based on difference between forecasted and actual value of industrial production three indicators of forecasting power are calculated:

[6] Transformation of INDUSTRY is the same as transformation of related CROLEI forecasting system components on the right side of the models.

• root mean squared error

$$RMSE = \sqrt{\sum_{t=T+1}^{T+h} (\hat{y}_t - y_t)^2 / h} ; \tag{12}$$

• mean absolute error

$$MAE = \sum_{t=T+1}^{T+h} \left| \hat{y}_t - y_t \right| / h ; \tag{13}$$

• mean absolute percent error

$$MAPE = 100\, x \sum_{t=T+1}^{T+h} \left| \frac{\hat{y}_t - y_t}{y_t} \right| / h ; \tag{14}$$

where t= $T+1, T+2, ..., T+h$ is forecasted time period, h total number of observations envisaged for in-the-sample forecasting, and y_t and $\hat{y}$ actual and forecasted value of industrial production. According to these tests, the best forecasting system is the one that achieves the lowest values in three tests. But if one compares the described measures, one can notice that first two measures depend on the absolute value of series, while the third indicator does not. In the third measure – mean absolute percent error, the difference between forecasted and actual value is averaged by actual value of time series for each point in time period.

Table 16 Evaluation of ability of CROLEI index for in-the-sample forecasting of industrial production – model (10)

Forecasting system CROLEI	original from 2004	based on original series		based on series n differences according to unit root tests		based on series in logarithms	
Forecasting index CROLEI based on	seasonally adjusted series	original series	seasonally adjusted series	series in differ-ences	seasonally adjusted series	series in loga-rithms	seasonally adjusted series
	1	2	3	4	5	6	7
Lead time (forecasting horizon)	-6	-11	-11	-9	-9	-8	-8
Root mean squared error	3.146	8.92	16.78	9.301	10.85	1.05	1.29
Mean absolute error	2.659	7.31	16.52	8.75	10.65	0.98	1.18
Mean absolute percent error	2.185	5.33	13.66	7.22	8.801	0.98	1.14

Source: Authors' calculation.

Mean absolute error is the most appropriate indicator for comparing the forecasting power of all the CROLEI forecasting indices, while first two indicators are suitable for:

- comparing the differences in forecasting power between CROLEI indices within the same systems: between indices in columns 2. and 3.; between indices in column 4. and 5.; and between indices in columns 6. and 7. in Table 17. This is due to fact that the only difference between these indices pairs appears in the construction of indices, where the indices are based on either seasonally adjusted series or transformed series;
- comparing the forecasting power of each CROLEI index evaluated by model (10) and model (11).

The results displayed in Tables 16 and 17 suggest that CROELI index in logarithms has the highest forecasting power (column 6). Such a result without any doubt was expected for the first two indicators of forecasting power, because series in logarithms will have a smaller difference between actual and forecasted value than other seasonally adjusted or transformed series. However, the value of the third indicator – mean absolute percent error – points to the fact that the CROLEI system based on series in logarithms has a better ability to forecast than the two other alternative CROLEI systems and the original CROLEI index. The CROLEI system based on the original series exhibited the lowest forecasting power. Ranking of indices according to their forecasting power did not appear sensitive to choice of forecasting model (10) or (11), which makes our findings even more robust.

Table 17 Evaluation of ability of CROLEI index for in-the-sample forecasting of industrial production – model (11)

Forecasting system CROLEI	original from 2004	based on original series		based on series n differences according to unit root tests		based on series in logarithms	
Forecasting index CROLEI based on	seasonally adjusted series	original series	seasonally adjusted series	series in differ-ences	seasonally adjusted series	series in loga-rithms	seasonally adjusted series
	1	2	3	4	5	6	7
Lead time (forecasting horizon)	-6	-11	-11	-9	-9	-8	-8
Root mean squared error	3.078	7.91	17.68	8.17	12.76	1.05	1.18
Mean absolute error	2.600	6.19	17.52	7.61	12.55	1.01	1.11
Mean absolute percent error	2.14	4.55	14.50	6.27	10.38	0.97	1.07

Source: Authors' calculation.

However, one needs to stress that a final conclusion that the CROLEI system based on series in logarithms is the system with the highest forecasting power might not be reached. If we evaluate models (10) and (11) in such a way that the CROLEI index serves as an independent variable, while industrial production index in logarithms becomes dependent variable, then the original CROLEI index exhibits the best results in all three indicators of forecasting power. Because of that, the original CROLEI index still has a certain advantage when compared to CROLEI system based on logarithm values[7].

The results obtained lead to conclusion that the original CROLEI, besides being a good predictor of seasonally adjusted industrial production, is even better at predicting industrial production logarithm values. The opposite does not hold. Indices stemming from CROLEI system based on logarithm values only forecast well the movements of industrial production in logarithms, while their power to forecast the movement of seasonally adjusted industrial production is negligible.[8]

Further on from the results displayed in tables 16 and 17 one can notice that all alternative CROLEI indices have stronger forecasting power if they are constructed using not only seasonally adjusted, but also seasonally adjusted and transformed series. For example, the CROLEI index based on series in differences has a higher forecasting power than the CROLEI index based on seasonally adjusted series from the CROLEI system based on series in differences. This difference is most evident in the CROLEI system based on the original series. This result can be explained with seasonal adjustment of the data. By using the program for seasonal adjustment X11ARIMA, some of the information content of the series gets eliminated because the series is smoothed (Enders, 1995). Lost information content is significant since it can enhance the forecasting power of any model, which is quite evident in this research. Thus when developing forecasting models researchers avoid negative consequences of seasonal adjustment by using seasonal dummy variables (Campos and Ericsson, 1999).

Results presented in this part of the research do not suggest that original CROLEI index is a worse predictor of future developments than alternative indices. Quite the opposite, the three forecasting error indicators unanimously show that there is no ground for replacing original CROLEI index with one of the offered alternative indices. This part of the research has thus confirmed conclusions reached in previous section – and they suggest that we do not need a brand new CROLEI.

3 Review of forecasting system proposal from 2005

In Holland six forecasting indices are being published, in Germany at least five (Reijer, 2006; Dreger and Schemata, 2005), and for now in Croatia only one, CROLEI. But progress has been made in Croatia. In 2005 a proposal for a new composite forecasting indicator was published (Cerovac, 2005). According to information available to the authors, this is the first and so far the only paper on cyclical indicators since the development of CROLEI system. Since the paper was published as a working paper and since the movement of the composite index is still not being published, one can only review the choice

[7] RMSE for model (10) in which original CROLEI index in independent variable, and logarithm value of industrial production inxed dependent variable is 0.59, MAE 0.39, and MAPE 0.37. The value of these indicators for model (11) with the same independent and dependent variables is 0.60, 0.39 i 0.38.

[8] Model (10): RMSE: 8.44; MAE: 8.04, MAPE: 6.63; model (11).: RMSE: 8.00; MAE: 7.61, MAPE:6.28.

of methods within the methodological framework and perhaps it will be possible to review the results in the year of publishing.

Cerovac uses a combination of different methodological steps, which can be assigned to the NBER methodological framework. He begins his paper by identifying industrial production index as a reference series and determining turning points for a longer time period (1992-2004) with the help of the *Bry-Boschan algorithm*[9]. Then Cerovac moves to identification of leading, lagging and coincident indicators. He calls the entire process the method of elimination and with it he replaces procedure for indicator evaluation. However, the author uses NBER criteria given in the evaluation procedure, but for the purpose of eliminating inadequate series. Moreover, the author tries to use cross-correlation analysis in order to measure the harmonization of cycles between reference series and the indicator, along with its leading tendencies. With this analysis, Cerovac determines lead time, which is the time where the value of correlation coefficient is the greatest, while the sign of the coefficient tells whether the indicator is leading, lagging or coincident[10].

The result of elimination method application is an extremely low number of series in the leading composite indicator. Leading composite indicator consists of three components (based, it seems, on five series): retail markup, the ratio of deposits and loans to enterprises and the industrial production to inventories in manufacturing ratio. Our conclusion is that the elimination approach did not yield in a satisfactory choice of components. The first component, retail markup, was evaluated by the author, which would result in zero point within the NBER scoring criterion for statistical significance. In turn this would mean that this series could not be included in the index. The third series, the industrial production to inventories in manufacturing ratio, is especially problematic. Since industrial production is the reference series of the system, the decision to include it in the third component of the forecasting index means that the possibility that the future movement of reference series might be influenced by its past values was ignored. Disregarding the choice of method, including reference series in deviated component must be completely avoided since it creates spurious non-random statistical causation between the component of index and reference series.

What is new when compared to CROLEI, is that the author has constructed a composite index of lagging indicators and a composite index of coincident indicators, with the purpose of providing additional information about current and past economic developments. All three composite indices are calculated according to TCB algorithm, which does not include averaging by significance weights obtained from scoring procedure. This resulted in greater monthly volatility of the index, recognized by the author (Cerovac, 2005: 23). This feature makes identification of index turning points harder and most probably creates more noise when forecasting. When one displays CROLEI and the index proposed by Cerovac on a graph, it becomes clear that their cyclical behavior is very similar, with

[9] By applying this method he gets almost identical turning points for period 1995 – 2004 as the authors of CROLEI who used local minimum and maximum to determine turning points. There are two differences in results: authors of CROLEI identified one turning point more within the same period and they dated the turning point in 1999 few months later than Cerovac.

[10] Time series are not stationary, but have trend – cycle component included.

CROLEI being a much smoother series. The harmonized movement of these two indices can confirm their quality.

4 Conclusion

The main aim of this paper was to evaluate the forecasting power of the CROLEI index. For this purpose, authors have constructed six alternative forecasting indices following the barometric method used for the construction of original CROLEI index. According to the components entailed, these six indices are completely different. At first glance, if the main criteria for index construction is level of aggregation of series, then the original CROLEI index stands out. But, as the authors started with a more sophisticated analysis such as correlation analysis and bi-variate Granger causality test the later conclusion still remains confirmed. Then the authors used evaluation of the forecasting indicator matrix, which stems from the signaling method. From the results obtained it was concluded that the matrix is functioning well when applied to our indices and it confirms our expectations. The original CROLEI, according to the most important matrix indicator, noise - to – signal ratio, has the best result. CROLEI in differences achieved the second best result, but its result is unacceptable since 39 percent of its forecasts are not accurate, as against the original CROLEI, where the corresponding percentage is significantly lower – 28.

Since the evaluation of the forecasting indicators matrix is an adjusted method, the authors wanted to verify the obtained results by applying other methods, in their original form. For this purpose two regression models were chosen, with the forecasting index as independent variable and industrial production as the dependent variable. Both models yielded stable and even equal results suggesting that models with the *CROLEI system based on logarithm values have the best performance, followed by the original CROLEI.* How can such a result be explained? The answer is simple – in the CROLEI system based on logarithm values, all series are smoothed, including referent industrial production. However, the CROLEI system based on logarithm values does not predict seasonally adjusted industrial production that well. The situation is the opposite with the original CROLEI index, which when evaluated with industrial production in logarithms becomes the best predictor. The authors concluded that the barometric method, with respect to the potentials of available statistical data and the economic conditions in Croatia, has been applied in an acceptable way.

In this paper the authors reviewed a new forecasting indicator proposal (Cerovac, 2005) which is excellent news because it offers new insights on forecasting future economic activity. As well as some new, interesting series having been included in the research, the author also constructed a composite lagging indicator and a composite coincident indicator. The author was the first to apply the Bry-Boschan algorithm as an objective method for identifying turning points. The greatest problem in this research is the choice of problematic components in composite leading indicator. However, when the author upgrades and confirms his methodological framework and results of its application, it would be useful to publish the index on regular basis.

In this research the authors intended to inform the public about how valuable the CROLEI forecasting system is, referring to possibilities deriving from the use of it, together with its advantages and disadvantages. This research will serve as a starting point for development and application of methods for precise identification of turning points in the economic cycle, as well as for new testing new methods on available time series. With every new monthly observation, we are one step closer to applying newer and more sophisticated forecasting methods. Until then, it is our recommendation that CROLEI should be retained in its original form.

Appendix 1 List of series in CROLEI database

Industrial production volume index

01 total industrial production
02 mining and quarrying
03 manufacturing
04 electricity gases and water supply
05 energy
06 intermediate goods
07 capital goods
08 durable consumer goods
09 non-durable consumer goods
11 extraction of crude petroleum and natural gas
12 other mining and quarrying
13 manufacture of food products and beverages
14 manufacture of tobacco products
15 manufacture of textiles
16 manufacture of wearing apparel, dressing and dyeing of fur
17 tanning and dressing of leather, manufacture of luggage, handbags, harness and footwear
18 manufacture of wood and of products made of wood, except furniture
19 manufacture of pulp papers and paper products
20 publishing and printing
21 manufacture of coke, refined petroleum and nuclear fuel
22 manufacture of chemicals and chemical products
23 manufacture of rubber and plastic products
24 manufacture of other non-metallic mineral products
25 manufacture of basic metals
26 manufacture of fabricated metal products, except machinery and equipment
27 manufacture of machinery and equipment
28 manufacture of office machinery and computers
29 manufacture of electrical machinery and apparatus
30 manufacture of radio, television and communication equipment and apparatus
31 manufacture of medical, precision and optical instruments, watches and clocks
32 manufacture of motor vehicles, trailers and semi-trailers
33 manufacture of other transport equipment

34 manufacture of furniture, manufacturing n.e.c.
35 recycling
36 electricity, gas, steam and hot water supply
37 collection, purification and distribution of water
38 number of employees in industrial production index
40 total producers' inventories of industrial finished products
41 labour productivity index in industrial production

Employment and wages

42 number of persons in paid employment
43 average monthly paid net earnings of persons in paid employment
44 average monthly paid gross earnings of persons in paid employment

Unemployment

45 newly registered due to employment in course of the month
46 unemployed persons according to end of the month state
47 persons seeking employment for the first time according to the end of the month state
48 registered employed persons in course of the month
49 registered demand for employees in course of the month
51 users of unemployment benefit
52 unemployed persons due to cease of work of the enterprise and employer

Construction and tourism

Tourist industry bed-nights,

54 total
55 foreign
56 domestic
53 construction work net orders
530 total volume index of construction work

Trade

57 retail trade
58 retail trade inventories

Merchandise trade with other countries

Exports

67 merchandise, total
71 food products and live animals
72 beverages and tobacco products
73 raw materials, except fuel
74 mineral fuels and lubricants
75 animal and vegetable oil and fats

76 chemical products
77 manufactured goods classified mainly by material
78 machinery and transport equipment
79 various finished goods
80 commodities and transactions, n. e. c.

Imports

81 merchandise, total
85 food products and live animals
86 beverages and tobacco products
87 raw materials, except fuel
88 mineral fuels and lubricants
89 animal and vegetable oil and fats
90 chemical products
91 manufactured goods classified mainly by material
92 machinery and transport equipment
93 various finished goods
94 commodities and transactions, n. e. c.

Non-financial transactions

95 nonconsolidated revenues of state, county and municipality budgets

Monetary statistics

105 money M1
106 money M1a
107 broad money M4
108 primary money
109 cash
110 money on deposit
111 central government deposits at the CNB

Savings and time deposits at commercial banks

112 domestic currency
113 foreign currency
114 foreign currency - retail
115 foreign currency - corporate
116 credit

Loans

117 total
118 corporate loans
119 retail loans

Foreign currency reserves of commercial banks

120 CNB foreign assets
121 total

122 current accounts and deposit accounts, foreign currency savings
123 time deposits and notice deposits
124 Foreign currency foreign liabilities of commercial banks

CNB interest rate

125 on funds of the mandatory reserves
127 on voluntarily subscribed treasury bills of the CNB, 35 days
129 on Lombard credits

Commercial bank interest rates

132 interest charged on domestic currency loan, no foreign currency clause
133 interest charged on domestic currency loans with foreign currency clause, overall mean
134 interest allowed on foreign currency deposits, overall mean
135 interest allowed on savings and time deposits with a foreign currency clause

Interest rates on the money market

136 day market
137 overnight market

Revenue and expenditure of the central government budget

Revenue

140 government budget, total
143 tax, total
156 non tax, total
140a capital, total
144 tax, corporate income tax
145 tax, personal income tax
146 tax, turnover tax
147 tax, value added tax
148 tax, customs, customs duties, customs and import fees
149 total excises
150 mineral oils excise
151 alcohol excise
152 beer excise
153 non-alcoholic beverages excise
154 tobacco excise
155 coffee excise
155 a motor vehicle excise

Expenditure

157 of the government budget, total
158a total and debt servicing
159 gross wages of governmental employees
160 expenditures for other goods and services
161 interest payments

162 current transfers
163 subsidies
164 capital investment
158 net lending
165 surplus or deficit of the government budget

Financing budgetary surplus or deficit

66 total
167 domestic
168 foreign

Costs of living and prices

Consumer price index

170 total
171 goods
172 services

Price indices

173 industrial products, total
183 construction materials (1993=100)
174 industrial products, power
175 industrial products, intermediate products
176 industrial products, capital products
177 industrial products, consumer durables
178 industrial products, consumer non-durables
179 industrial products, mining and extraction
180 industrial products, processing industry
181 industrial products, supply of electricity, gas and water

REFERENCES

Ahec-Šonje, A. [et al.], 1994. *Metodološki okvir za izradu sustava prethodećih ekonomskih pokazatelja.* Osnovna studija, prilog 2. Zagreb: Ekonomski institut.

Ahec-Šonje, A. [et al.], 1996. *Navješćujući pokazatelji hrvatskog gospodarstva.* Onovna studija. Zgreb: Ekonomski institut.

Ahec-Šonje, A., 1995. "Metode predviđanja ekonomskih fluktuacija s naglaskom na 'pristup indikatora'" *Ekonomski pregled*, 46 (11-12), 820-837.

Ahec-Šonje, A., Babić, A. and Bačić, K., 2003. "Determinants of currency disturbances in transition economies of Central and Eastern Europe" in: Z. Reić. *The 5th International Conference 'Enterprise in Transition'.* Split: Ekonomski fakultet, 308-311.

Ashely, R., Granger, C. W. J. and Schmalensee, R., 1980. "Advertising and Aggregate Consumption: An Analysis of Causality". *Econometrica*, 48 (5), 1149-1168.

Bačić, K. [et al.], 2004. *Usavršavanje prognostičkog indeksa hrvatskog gospodarstva.* Završna studija. Zagreb: Ekonomski institut.

Campos, J. and Ericsson, N., 1999. "Constructive data mining: modeling consumers expenditure in Venecuela". *Econometrics Journal*, 2 (2), 226-240.

Cerovac, S., 2005. "Novi kompozitni pokazatelji za hrvatsko gospodarstvo: prilog razvoju domaćeg sustava cikličkih pokazatelja" [online]. *Istraživanja*, I-16. Zagreb: Hrvatska narodna banka. Available from: [http://hidra.srce.hr/arhiva/68/2445/www.hnb.hr/publikac/istrazivanja/i-016.pdf].

Dreger, C. and Schumacher, C., 2005. "Out-of-sample Performance of Leading Indicators for the German Business Cycle - Single vs Combined Forecasts". Journal *of Business Cycle Measurement and Analysis,* 2 (1), 71-88

Enders, W., 1995. *Applied Econometric Time Series*. New York: John Wiley and Sons, Inc.

Gapinski, J. H., 1982. *Macroeconomic Theory: Statics, Dynamics, and Policy*. New York: McGraw-Hill.

Granger, C. W. J., 1969. "Investigating Causal Relations by Econometric Methods and Cross-Spectral Methods". *Econometrica*, 37 (3), 424-438.

Granger, C. W. J., 1988. "Some Recent Developments in Concept of Causality". *Journal of Econometrics,* 39, 813-836.

Granger, C. W. J., Huang, W.-N. and Yang, C.-W., 2000. "A bivariate causality between stock prices and exchange rates: evidence from the recent Asian flu". *The Quarterly Review of Economics and Finance,* 40, 337-354.

Green, R. G., 1993. "Business cycle indicators: upcoming revision of the composite indexes". *Survey of Current Business,* (October).

Jagrič, T., 2001. "Sistem vodilnih pokazateljjev gospodarske aktivnosti za Slovenijo (SLOLEI)" *Prikazi in Analiz,* IX/2. Ljubljana: Banka Slovenije.

Jagrič, T., Boršič, D. and Strašek, S., 2003. "Leading indicators of aggregate activity of Slovenia" [online]. Prague: Center for Economic Research and Graduate Education and the Economics Institute. Available from: [http://www.cerge-ei.cz/].

Kaminsky, G., Lizondo, S. and Reinhart, C., 1997. "Leading Indicators of Currency Crises". *Policy Research Working Paper*, No. 1852. Washington D.C.: The World Bank.

Moore, G. H. and Shiskin, J., 1967. "Indicators of Business Expansions and Contractions". *Economica*, *New Series,* 35 (139), 335-336.

Nierhaus, W., 2000. *Currency Crises Indicators - The Signal Approach*. Mimeo. Munich: IFO Institute for Economic Research.

Reijer, den A. H. J., 2006. "The Dutch Business Cycle: Which Indicators Should We Monitor?". *DNB Working Papers*, No. 100. Amsterdam: Netherlands Central Bank.

Rousseau, P. D. and Vuthipadorn, 2005. "Finance, Investment and Growth: Time Series Evidence from 10 Asian Economies". *Journal of Macroeconomics*, 27 (1), 87-106.

Sander, H. and Kleimeier, S., 2003. "Contagion and Causality: an Empirical Investigation of Four Asian Crisis Episodes". Journal of International Financial Markets, Institutions and Money, 13 (2), 171-186.

Shiskin, J., 1961. *Signals of Recession and Recovery: An Experiment with Monthly Reporting.* New York: NBER.

USDC and BEA, 1977. *Handbook of Cyclical Indicators*. Washington, D.C.: Department of Commerce : Bureau of Economic Analysis.

Zarnowitz, V. and Boschan, C., 1975. "Cyclical Indicators: An Evaluation and New Leading Indexes" in: *Handbook of Cyclical Indicators*. Washington: U.S. Department of Commerce, BEA.

Zarnowitz, V., 1992. *Business Cycles: Theory, History, Indicators, and Forecasting.* Chicago: The University of Chicago Press.