PROGNOZIRANJE POSLOVNIH CIKLUSA I CIKLUSA RASTA U HRVATSKOJ

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FORECASTING BUSINESS AND GROWTH CYCLES IN CROATIA

This paper is a report on the development and the performance of the composite leading indicator of the Croatian economy – CROLEI, whose purpose is to forecast classical business and growth cycles. The structure of the paper follows the latest CROLEI revision, based on NBER barometric method. After briefly describing the characteristics of CROLEI and its database, the turning points in the reference series (industrial production) are determined by applying Bry-Boschan algorithm. By combining the graphic analysis, Granger causality and Wald exclusion test on potential leading time series and the reference series, the list of 15 best leading series is compiled. Recursive estimation of Granger test is applied to check whether the time series´ leading properties are stabile over time. Then 14 composite leading indicators are constructed from 15 best leading series. In order to decide which composite indicator yields the best forecasts, Granger causality test is used. New CROLEI indicator is composed of 7 series and leads the reference series by 8 months. Additionally, a diffusion index - an auxiliary tool for forecasting business and growth cycles - is constructed.

Key words: leading indicator, forecasting, non-model based approach, growth cycles

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1. Introduction

Since the publishing of Mitchell and Burns´ seminal papers in 1938 and 1946, leading indicators have been in the focus of interest of both policymakers and academics. While policy makers consider them as a useful tool for predicting future economic developments, economists have developed more ambiguous attitude towards the leading indicators. While some feel that leading indicators provide an excellent insight into future business cycle development, others (starting with Koopmans's (1947) critique) consider them as an exercise in "measurement without theory". The resulting debate has resulted in vast literature dealing with the different aspects of the leading indicators, from the choice and evaluation of the best indicators to the development of more sophisticated methods to relate them to the reference series (Marcellino, 2006).

In this paper we wish to provide an overview of the construction, use and evaluation of leading indicator in a small transition country - Croatia. We feel that transition countries deserve special attention because the development of leading indicators is still in its early stage, constrained by relative shortness of available time series (10 to 15 years) and frequent structural changes taking place since 1990es. As against transition countries, in developed economies leading indicators are a standard tool for forecasting business cycles, recently expended in order to forecast inflation, currency crisis, stock market developments and even government deficits (Banerjee et al, 2005; Kaminsky et al, 1998; Chauvet and Potter, 2000; Perez, 2007).

The Croatian economy faced significant economic and political changes (including the Homeland war) when the NBER leading indicators method (also known as the barometric method) was applied for the first time, in 1994. Since then, the economy has undergone serious structural and political changes like military activities in 1995, the introduction of VAT tax, three banking crisis, Kosovo crisis, political turnaround in early 2000, the signing of Stabilization and Association Agreement, the beginning of EU accession negotiations and so on. So far, the development of the leading indicators relied on the original NBER non-model based method, with the method being somewhat modified to account for the weaknesses in the statistical base (Ahec-Šonje, 1995; Ahec-Šonje, 1997; Bačić and Vizek, 2006).[1] In this paper, we explain the particularities of the method applied in the latest 2007 revision and summarize its main results in terms of new CROLEI indicator and accompanying diffusion index. One must note that the approach assumed in the latest revision is still mostly non-model based, although

[1] More specifically, the Granger causality test was introduced, as a substitute for other methods aimed at measuring *timing* and *conformity to the business cycle* of potential leading time series.

several steps toward model based approach, including the introduction of Wald test and recursive estimates of Granger test, were made.

The rest of the paper is divided in three main sections. The first section briefly discusses main features of CROLEI index, its reference series and database. The second section presents the course and the results of the 2007 CROLEI revision. This section describes the dating of growth cycle turning points, the process of estimating and choosing the potential CROLEI components from the time series available in the database, the calculation of several competing new CROLEI indicators and the choice of the best indicator. Moreover, a diffusion index, an auxiliary forecasting instrument, will be presented. The last section summarizes main findings.

2. About CROLEI indicator

CROLEI (***Cro****atian* ***L****eading* ***E****conomic* ***I****ndicator*) is a leading indicator that has been developed in 1994 and calculated monthly at the Institute of Economics, Zagreb in the cooperation with the Ministry of Finance. Like any other composite leading indicator, CROLEI is an indicator whose purpose is to forecast business cycle turning points (recessions and expansions). The ability of the leading indicator to forecast a change in the business cycle stems from the manner of its composition. Namely, a leading indicator is composed from the time series that tend to shift direction in advance of business cycle i.e. it is composed from the time series that exhibit leading relationship with a reference series at the cyclical turning points. The reference series is an economic variable whose cyclical movements approximate well the business cycle developments in the economy. In cases of the majority of the countries that use leading indicators and in case of CROLEI, the index of industrial production is used as the reference series since industrial production constitutes the more cyclical part of the aggregate economy and the cyclical patterns of the industrial production and GDP have been found to be closely related. Sometimes, instead of the industrial production, researchers use composite coincident indicator that consists of several series whose cyclical behavior is similar to that of the GDP.

Due to the fact that time series composing the leading indicator often change their cyclical and leading patterns and are also sometimes submitted to the methodological changes, it is necessary to revise leading indicator on a frequent basis. The latest CROLEI revision was undertaken in the last quarter of 2007. In the past, CROLEI leading indicator had undergone three other revisions; in 1997, 1999 and in 2004.

The purpose of the latest 2007 revision was to enhance CROLEI indicator constructed in 2004 and used for forecasting since then. Moreover, the revision was undertaken in order to change the main forecasting feature of CROLEI. Namely, CROLEI constructed in 2004 was calibrated to forecast business cycle turning points, whereas new CROLEI indicator was constructed to forecast not only turning points in business cycles, but also turning points in growth or deviation cycles (i.e. moderations and accelerations of growth of the reference series).

Before the 2007 revision CROLEI was composed from 11 time series and had an average lead time of 5.7 months (Bačić and Vizek, 2006). After the revision, CROLEI was downsized to 7 time series composing the index and had the average lead time of 8 months. The 7 series selected for composing a new CROLEI were chosen according to the results of the graphical and statistical analysis applied on altogether 274 time series from the CROLEI database, structured in such a way to represent all relevant economic sectors.[2] By comparison, when first composite leading indicator was developed in 1994, database consisted of 98 series, while during 2004 revision CROLEI database increased to 151 series.

3. 2007 CROLEI revision

3.1. The dating of business cycle turning points

In order to verify which time series tend to shift direction in advance of business or growth cycle i.e. which time series exhibit leading relationship with a reference series at the cyclical turning points, one must first determine the business or growth cycle turning points in the reference series. In 2007 revision, the growth cycle turning points were for the first time determined by applying Bry-Boschan procedure (Bry and Boschan, 1971).[3] According to the results of Bry-Boschan procedure, in the period from January 1995 until August 2007 nine turning points in industrial production series were dated (see Figure 1 and Table 1).

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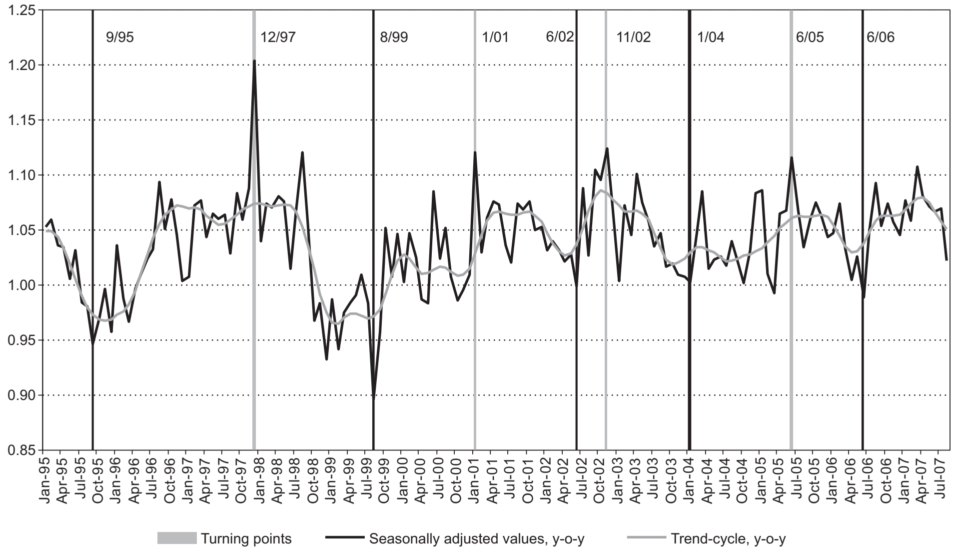
[2] Namely, manufacturing sector is represented by 39 series, labor market by 43 series, construction, trade and tourism sector by 16 series, foreign trade by 22 series, international economic developments by 6 series, monetary sector by 44 series, fiscal sector by 72 series, prices by 29 series, financial market by 2 series and 1 series represents nonfinancial transactions.

[3] In essence, the dating of turning points according to Bry-Boschan procedure begins with determining minimal and maximal values of the reference series in moving averages. Thereafter, it is necessary to eliminate the detected outliers and turning points that are too close to each other (within 5 months). According to Bry-Boschan procedure, the phase of a cycle must last at least 5 months, and the cycle itself 15 months. After the turning points are dated on the smoothed series, one must return to seasonally adjusted reference series where one should identify the same turning points at most 5 months before or after when compared to the smoothed series.

Figure 1.

TURNING POINTS IN GROWTH CYCLE OF THE REFERENCE SERIES (INDUSTRIAL PRODUCTION)



Source: Calculation of the authors.

The first turning point, a bottom of both growth and business cycle was dated in September 1995. Four more bottoms were identified, meaning that during the specified period the economy underwent altogether four growth cycles. The last turning point (a bottom) was identified in June 2006, after which industrial production has started to expand.

Table 1.

TURNING POINTS OF THE REFERENCE SERIES – INDUSTRIAL PRODUCTION

bottom	September 1995
top	December 1997
bottom	August 1999
top	January 2001
bottom	June 2002
top	November 2002
bottom	January 2004
top	June 2005
bottom	June 2006

3.2. Choosing the potential leading indicators

After the turning points in the reference series were dated, we start with the analysis of the 274 time series available from the CROLEI database in order to detect which series exhibit the best leading properties in relation to the reference series. As a first step all series in monthly frequencies were seasonally adjusted. Moreover, some of them were deflated in order to exclude the influence of inflation. There after, we move to the evaluation of the basic requirements for an economic time series to be a useful leading indicator, which can be summarized as (Marcellino, 2006; p.5):

- consistent timing (i.e., to systematically anticipate peaks and troughs in the target variable, possibly with a rather constant lead time);
- conformity to the general business cycle (i.e., have good forecasting properties not only at peaks and troughs);
- economic significance (i.e., being supported by economic theory either as possible causes of business cycles or, perhaps more importantly, as quickly reacting to negative or positive shocks);
- prompt availability without major later revisions (i.e., being timely and regularly available for an early evaluation of the expected economic conditions, without requiring subsequent modifications of the initial statements);
- smooth month to month changes (i.e., being free of major high frequency movements).

First two requirements: consistent timing and conformity to the general business cycle can be determined in a variety of ways, from graphical analysis to other non-model and model based approaches (Marcellino, 2006). We use graphical analysis along with Granger causality test. In the original NBER method graphical analysis was crucial for differentiating leading from coincident and lagging indicators. In 2007 revision we expanded the graphical analysis by applying Hodrick-Prescott filter in order to separate trend from cycle in potential leading indicators and the reference series. In this manner we obtained smoother growth cycles series of potential indicators, which can in turn be more easily compared to the reference series in the graphical representation. Due to space limitations, the graphical analysis is not presented in the paper, but it can be obtained upon the request from the authors.

Granger causality test is used to statistically test the series for consistent timing and conformity to the general business cycle. Granger causality test was also applied in earlier research on CROLEI and CROLEI revisions (Ahec-Šonje, 1996; Ahec-Šonje, 2000, Bačić and Vizek, 2006), but it was also used for developing composite leading indicators in other developing countries (Jagric, 2001; Jagric et al, 2003).[4] The test was applied on altogether 246 series. All series available from the database were tested with the exception of series whose observations start from January 1999. All series were tested in levels and annual growth rates. By testing series in levels we wanted to identify series which lead classical business cycle, while by testing series in annual growth rates we intended to identify series which lead growth cycles. Granger causality tests in levels and first differences have the following forms:

$$IND_t = A_0 + \sum_{j=1}^{k} \alpha_j IND_{t-j} + \sum_{j=1}^{k} \beta_j LI_{t-j} + \varepsilon_j \qquad (1)$$

$$\Delta IND_t = A_0 + \sum_{j=1}^{k} \alpha_j \Delta IND_{t-j} + \sum_{j=1}^{k} \beta_j \Delta LI_{t-j} + \varepsilon_j \qquad (2)$$

where A_0 represents the constant, IND_t is the reference series (industrial production index) and L_t is a potential leading indicator. In order to check whether the series is characterized by leading properties we used Wald exclusion test which tests the working hypothesis that all lags of a potential leading indicator are jointly equal to zero (i.e. $H_0 : \beta_1 = \beta_2 = ... = \beta_k = 0$).

Moreover, in 2007 revision we introduced recursive Granger causality test in order to verify that leading property of the series is stable across time, i.e. that the series exhibit good forecasting properties in relation to reference series along the entire observed period (not just peaks and bottoms). In this manner we further enhanced testing the series for the second requirement - conformity to the general business cycle.[5]

In order to choose from available series, besides graphical analysis and Granger causality test, we also used months for cyclical dominance (MCD) measure. MCD is defined as the shortest span of months for which the ratio of the irregular and trend-cycle component of the series (I/C) is less than unity. I and C are the average month-to-month changes without regard to sign of the irregular and trend-cycle component of the series, respectively. The convention is that the leading

[4] Granger definition of causality is the most widely accepted definition of causality. According to Granger (1969), Y is said to “Granger-cause” X if and only if X is better predicted by using the past values of Y than by not doing so with the past values of X being used in either case. In short, if a Y can help to forecast another X, then we say that Y Granger-causes X. Essentially, since Granger’s definition of causality is framed in terms of predictability, Granger causality test is the perfect method for identifying leading time series.

[5] In the paper we only present the results of recursive estimates of Granger causality test for CROLEI indicator and the reference series. The recursive estimates of particular time series and the reference series can be obtained upon the request from the authors.

Table 2.

GRANGER CAUSALITY TEST RESULTS AND MCD VALUES
FOR 15 BEST LEADING INDICATORS

	RESULTS OF GRANGER CAUSALITY TEST						**MCD value**
	levels			**annual growth rates**			
LEADING INDICATORS	Lag	t-stat. (p-value)	Wald test (p-value)	Lag	t-stat. (p-value)	Wald test (p-value)	
S26 Manufacturing of fabricated metal products	**12**	3.21*** (0.002)	1.81** (0.05)	**12**	3.56*** (0.001)	2.05** (0.026)	**5**
S43 Average net wage	**9**	2.24** (0.027)	2.9 (0.0002)	**5**	1.85** (0.067)	2.67*** (0.0036)	**2**
S51 The users of unemployment benefit	**11**	-2.18** (0.03)	1.70* (0.08)	**11**	-3.73*** (0.00)	2.83*** (0.002)	**1**
S54 Tourist stays	**9**	2.84*** (0.005)	2.25** (0.013)	**9**	2.23** (0.028)	2.23** (0.015)	**4**
S58 Retail trade turnover	**6**	1.09 (0.28)	0.79 (0.66)	**5**	1.45 (0.15)	1.10 (0.37)	**3**
S55 Tourist arrivals	**9**	1.89* (0.061)	1.72* (0.07)	**9**	2.22** (0.028)	2.52*** (0.006)	**4**
S81 Total import of goods	**3**	1.69* (0.093)	1.12 (0.34)	**10**	2.64** (0.01)	1.69* (0.078)	**5**
S95 Unconsolidated revenues of central government, county and municipal budgets	**5**	2.71*** (0.008)	1.64* (0.09)	**5**	2.15** (0.034)	1.43 (0.16)	**7**
S109 Narrow money	**11**	-2.36** (0.02)	1.61* (0.097)	**8**	1.70* (0.09)	1.79* (0.058)	**2**
S119 Credits to households	**12**	3.63*** (0.00)	3.3*** (0.0004)	**12**	3.09*** (0.003)	4.05*** (0.00)	**1**
S132 Interest rate to credits in HRK, without the currency clause	**4**	-.88* (0.06)	1.61* (0.09)	**4**	-1.62 (0.11)	1.47 (0.15)	**3**
S59 Producer price index - EU-25	**17**	2.04** (0.04)	1.83** (0.031)	**18**	2.04** (0.045)	2.10** (0.012)	**2**
S60 Producer price index - Eurozone-13	**17**	2.16** (0.033)	2.07** (0.012)	**18**	2.04** (0.045)	2.10** (0.012)	**2**
S61 Producer price index - Germany	**17**	1.80* (0.075)	1.68* (0.06)	**17**	1.63 (0.106)	1.77** (0.04)	**2**
S62 Producer price index - Italy	**17**	2.38** (0.019)	2.14*** (0.009)	**18**	2.5** (0.016)	2.41*** (0.004)	**2**

Note: *** - significant at 1%, ** - significant at 5%, * - significant at 10%.

Source: calculation of the authors.

indicators should be characterized by low value of MCD (preferably 1), while the maximum value of MCD should be 6 (OECD, 2001). Hence, this measure detects series that have smooth month-to-month changes (which is the fifth requirement for an economic time series to be a useful leading indicator), as against series characterized by high irregular movement.

By comparing and combining the graphical analysis, Granger causality test and MCD measure, we narrowed down the choice from 246 to 15 best leading indicators. In Table 2 we present the results of Granger test in levels and first differences and MCD value for those 15 indicators.[6] One must note that out of 15 chosen leading indicators, 7 of them were also short listed in 2004 revision (average net wage, users of unemployment benefit, tourist stays, retail trade turnover, total import of goods, tourist arrivals, narrow money, unconsolidated revenues of the central government, county and municipal budgets). This result not only implies that some leading indicators exhibit stable properties over time, bit it also confirms the choice of CROLEI indicator in 2004 revision.

3.3. The calculation of competing composite leading indicators

As one can conclude from analyzing Table 2, all 15 listed leading indicators satisfy requirements for an economic time series to be a useful leading indicator. Hence, all series systematically anticipate peaks and troughs in the target variable with a constant and long enough lead time (4 months or more), they are able to forecast the reference series in all phases of a cycle, not just at peaks and troughs and they are supported by economic theory either as possible causes of business cycles or, perhaps more importantly, as quickly reacting to negative or positive shocks. Moreover, all 15 indicators are released in timely manner and are not submitted to revisions and exhibit smooth month-to-month changes.[7]

The next step is to calculate composite leading indicators. Since we had 15 high quality leading indicators at our disposal, we constructed 14 CROLEI composite indicators. Thereby, we made sure that CROLEI is not composed out of

[6] For space considerations we do not present graphical analysis of 15 indicators, however, the figures can be obtained upon the request from the authors.

[7] The only exception for fulfilling the fifth requirement is the series Unconsolidated revenues of central government, county and municipal budgets which MCD value is 7, which is considered to be too high. However, we will include this series in the calculation of the composite leading indicators (with and without its irregular component) because this series had been a component of CROLEI since 1997, hence indicating that its leading properties are not diminished by higher irregular component.

two series that represent the same economic activity, but at the different level of the aggregation (like producer price index in EU-25 and producer price index in Germany).

The NBER method involves five methodological steps for calculating the final composite indicator (USDC/BEA, 1977; Zarnowitz and Boschan, 1975; Gapinski, 1982; Shiskin, 1961, Bačić and Vizek, 2006):

- computing symmetric percentage changes of the individual components;
- standardizing the symmetric changes;
- weighting and summing the individual standardized changes;
- standardizing the weighted sum of changes;
- turning the changes into the leading indicator.

For more details on the methodological steps, the interested reader is referred to Appendix.

Following the methodological instructions, we obtained fourteen competing CROLEI composite indicators. These indicators are composed from different series (components) and also have different number of components.[8] The composition of the indicators is shown in Table 3. In order to decide which composite indicator predicts with the most success the reference series, we again used Granger causality test. This time composite indicator was the independent variable, while reference series was the dependent variable. As with choosing the best leading time series, here we also test Granger causality test in levels and annual growth rates in order to obtain an indicator that is able to forecast both, business and growth cycle. Granger test also enabled us to obtain a lead time.[9] The results are also presented in Table 3.

The results of the test suggest that there are significant differences in the forecasting performance of 14 composite indicators. T-statistics, corresponding p-values and Wald test statistics imply that indicators composed of 7 series (CROLEI 3 to CROLEI 3j) lead industrial production much better when compared to indicators composed of 9 series (CROLEI 2 to CROLEI 2i). As with the procedure for choosing the best leading time series, we also conducted recursively estimated Granger test in order to detect which composite indicators are characterized by stabile leading properties over time.

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[8] We must note that 14 competing CROLEI indicators present only a part of composite indicators that were initially calculated. The selected 14 indicators were chosen because they had the best leading properties.

[9] A lead time of a composite leading indicator is obtained by comparing t-values of individual lags of independent variable (i.e. composite indicator) in Granger causality test. The lag that has the highest t-value (and consequently the lowest p-value) represent the lead time of composite indicator (given the condition that t-value has to be positive).

Table 3. TESTING THE COMPETING CROLEI INDICATORS

Potential components	CROLEI 3	CROLEI 3a	CROLEI 3b	CROLEI 3c	CROLEI 3d	CROLEI 3h	CROLEI 3j	CROLEI 2	CROLEI 2c	CROLEI 2d	CROLEI 2e	CROLEI 2f	CROLEI 2g	CROLEI 2i
S26 S51 S54 S55 S58 S59 S60 S62 S81 S95 S95* S109 S119 S132	S51 S58 S62 S95 S109 S119 S132	S51 S58 S62 S95* S109 S119 S132	S51 S58 S59 S95 S109 S119 S132	S51 S58 S60 S95 S109 S119 S132	S51 S58 S62 S81 S95 S109 S119	S51 S58 S59 S81 S95 S109 S119	S51 S55 S58 S62 S95 S109 S119	S26 S51 S55 S58 S62 S95 S109 S119 S132	S51 S55 S58 S62 S81 S95 S109 S119 S132	S26 S51 S55 S58 S59 S95 S109 S119 S132	S51 S54 S58 S62 S81 S95 S109 S119 S132	S26 S51 S54 S58 S62 S95 S109 S119 S132	S51 S55 S58 S59 S81 S95 S109 S119 S132	S26 S51 S55 S58 S62 S95* S109 S119 S132
Number of components	7	7	7	7	7	7	7	9	9	9	9	9	9	9
Granger causality test - levels														
t-statistics & p-value	2.69*** (0.008)	2.19** (0.031)	2.80*** (0.006)	2.67*** (0.009)	1.97* (0.052)	2.10** (0.038)	1.69* (0.094)	1.26 (0.210)	1.26 (0.210)	1.26 (0.211)	1.03 (0.304)	1.03 (0.304)	1.26 (0.21)	0.95 (0.35)
Wald test	3.7315*** (0.0001)	3.41*** (0.0003)	3.40*** (0.0003)	3.38*** (0.0003)	3.38*** (0.0003)	3.25*** (0.0005)	2.73*** (0.0027)	1.34 (0.207)	1.34 (0.207)	1.21 (0.29)	1.20 (0.291)	1.20 (0.291)	1.21 (0.29)	1.58 (0.11)
Lead time	8	8	8	8	8	8	2	8	8	8	8	8	8	8
Granger causality test – annual growth rates														
t-statistics & p-value	2.67*** (0.009)	2.03** (0.04)	2.77*** (0.007)	2.68*** (0.009)	2.07** (0.041)	2.20** (0.03)	1.15 (0.25)	1.34 (0.18)	1.34 (0.189	1.44 (0.15)	1.30 (0.19)	1.30 (0.19)	1.44 (0.15)	0.92 (0.36)
Wald test	3.91*** (0.0001)	3.69*** (0.0001)	3.57*** (0.0002)	3.61*** (0.0002)	3.77*** (0.0001)	3.56*** (0.0002)	3.47*** (0.0003)	1.75** (0.07)	1.74** (0.07)	1.55 (0.12)	1.30 (0.19)	1.56 (0.11)	1.55 (0.12)	1.91 (0.042)
Lead time	8	8	8	8	8	8	8	8	8	8	4	8	8	9

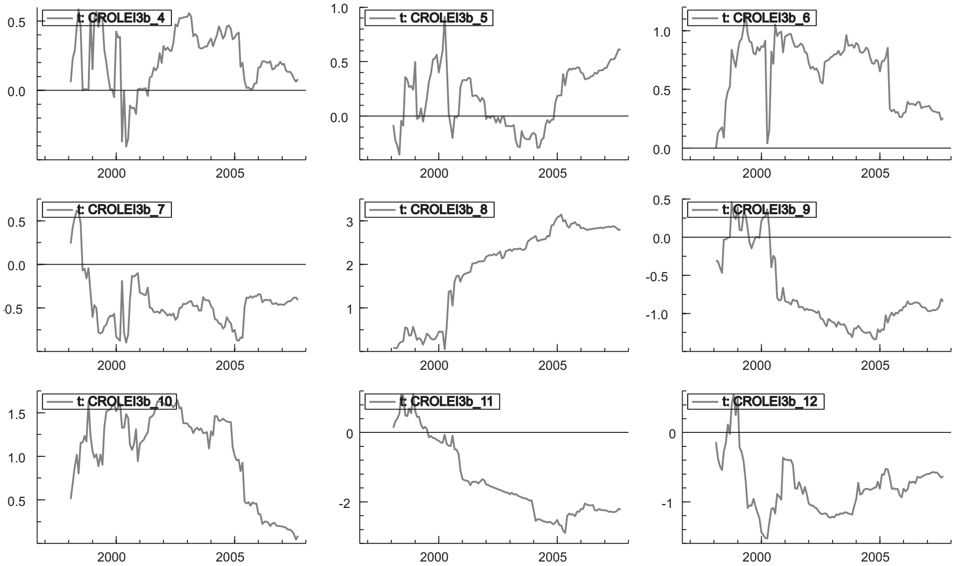
Note: *** - significant at 1%, ** - significant at 5%, * - significant at 10%.

Source: calculation of the authors.

In order to choose which of the CROLEI indicators with markings 3, 3a, 3b, 3c, 3d, 3h and 3j is the best one, we adopted the highest t-statistics of Granger test in levels and annual growth rates criterion. Since composite indicator CROLEI 3b has the highest t-statistics in both tests, it was chosen for a new CROLEI leading indicator.

Figure 2.

RECURSIVE ESTIMATES OF GRANGER CAUSALITY TEST FOR CROLEI 3B AND INDUSTRIAL PRODUCTION; IN LEVELS

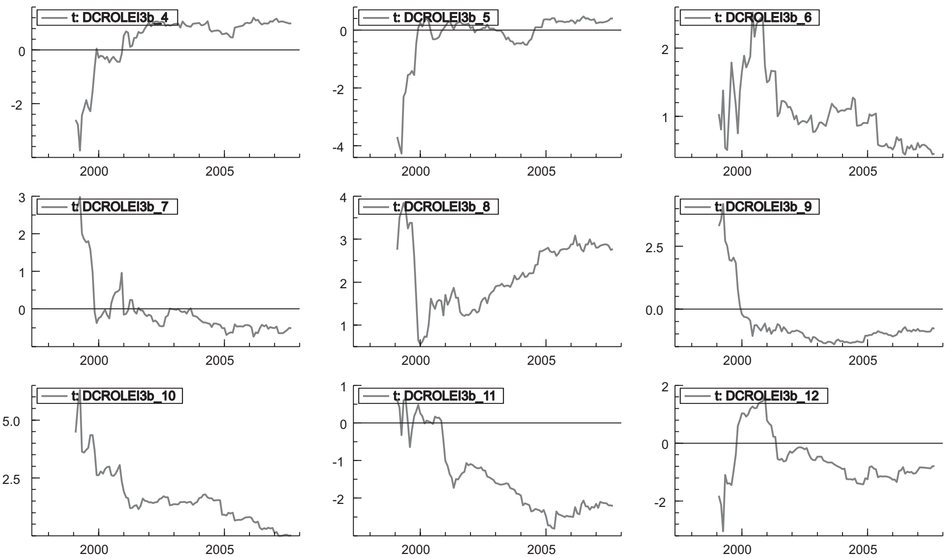


Note: CROLEI3b_4 is recursively estimated t-value of the fourth lag of independent variable CROLEI3b in levels in Granger causality test, CROLEI3b_5 is recursively estimated t-value of the fifth lag of independent variable and so on.

Source: calculation of the authors.

Figure 3.

RECURSIVE ESTIMATES OF GRANGER CAUSALITY TEST FOR CROLEI 3B AND INDUSTRIAL PRODUCTION; IN ANNUAL GROWTH RATES



Note: CROLEI3b_4 is recursively estimated t-value of the fourth lag of independent variable CROLEI3b in first differences in Granger causality test, CROLEI3b_5 is recursively estimated t-value of the fifth lag of independent variable and so on.

Source: calculation of the authors.

New CROLEI indicator (i.e. CROLEI 3b) is composed from the following time series: users of unemployment benefit, real retail trade, unconsolidated revenues of central government, county and municipal budgets, producer price index for EU– 25, narrow money, credits to households and interest rate on kuna loans without currency clause.

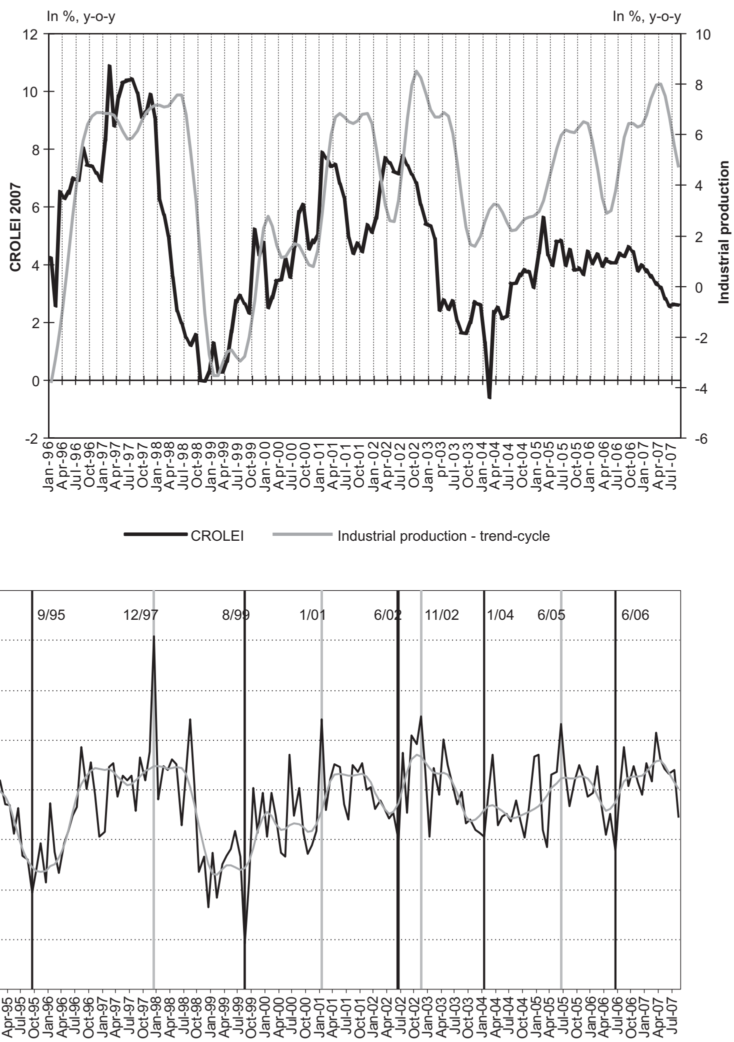
Moreover, both tests indicated the same lead time – 8 months, which means that this indicator is equally successful in forecasting business and growth cycles. A recursive estimate of Granger tests also pointed to CROLEI 3b, as the composite indicator with lead time of 8 months, the most consistent timing and conformity to business and growth cycle patterns. Figure 2 and 3 present the recursive estimates of Granger test in levels and annual growth rates of CROLEI 3b and industrial production.

3.4. The performance of new CROLEI indicator

Once we selected a new CROLEI indicator, it is useful to present it on a graph together with a reference series and its turning points. After observing the

Figure 4.

CROLEI, REFERENCE SERIES AND TURNING POINTS



Source: calculation of the authors.

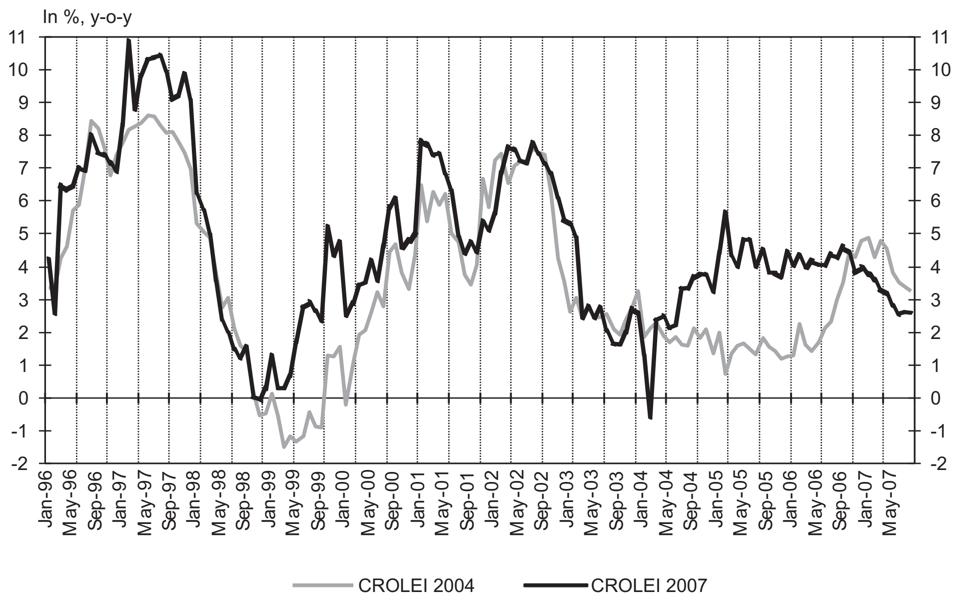
Figure 4, we can conclude that new CROLEI indicator has successfully predicted all nine turning points in growth cycle of industrial production. Three consecutive increases/decreases in annual growth rates of CROLEI took place from 12 to 5 months before the turning points (specified in Table 1). Moreover, decreases in CROLEI annual growth rate were followed by a slowdown (and consequently a mild recession) in late 1998 and a slower real economic activity in early 2004. On the other hand, increases in CROLEI growth rates were followed by increasing pace of economic activity in second half of 1996, early 2001 and in first half of 2006. This means that new CROLEI conforms well to the general growth cycle (i.e., has good forecasting properties not only at peaks and troughs, but across the entire cycle).

In order to check whether 2007 revision has improved leading properties of CROLEI indicator, we compare CROLEI constructed in 2004 revision (CROLEI 2004) with CROLEI constructed in 2007 revision (CROLEI 2007).

First of all, we must note CROLEI 2004 is composed of 11 time series and has an average lead time of 5.7 months. CROLEI 2007 is downsized to 7 time se-

Figure 5.

CROLEI 2004 AND CROLEI 2007



Source: calculation of the authors.

ries composing the index and has the average lead time of 8 months. However, the two composite indicators have three time series in common; i.e. both indicators are composed of the following series: retail trade turnover, unconsolidated revenues of central government, county and municipal budgets and narrow money.

The forecasting properties of two CROLEI indicators can be compared graphically and statistically. Figure 5 displays annual growth rates of CROLEI 2004 and CROLEI 2007. From the figure it is evident that two indicators had tracked each other quite well until the last quarter of 2004. From then onwards, the path of two indicators deviated considerably. In that period, CROLEI 2004 did not signal the turning points in January 2004 and June 2005, while CROLEI 2007 did.

As far as the statistical analysis is concerned, leading properties of the two indicators can be measured with cross-correlation coefficient and Granger causality test (where composite indicator is an independent variable and reference series is a dependant variable). Both approaches point to the conclusion that CROLEI 2007 exhibits considerable improvement in leading properties when compared to CROLEI 2004. As one can see from the Table 4, according to Granger causality test, CROLEI 2004 does not lead the business cycle approximated by the reference series in levels and is only marginally successful at leading the growth cycle approximated by reference series in annual growth rates. On the other hand, CROLEI 2007 is very successful at leading both business and growth cycles of the industrial production.

The same conclusion is reached upon observing the Table 5. CROLEI 2007 has higher cross-correlation coefficients with the reference series, both in levels and in annual growth rates. Moreover, the highest value of cross-correlation coefficient for series in annual growth rates is recorded at lag 8 of CROLEI 2008, hence confirming the composite indicators´ lead time of 8 months.

Table 4.

GRANGER CAUSALITY TEST FOR CROLEI INDICATOR AND THE REFERENCE SERIES

	levels		annual growth rates	
	t-statistics & p-value	Wald test	t-statistics & p-value	Wald test
CROLEI 2004	1.52 (0.13)	1.64* (0.087)	1.74* (0.085)	1.51 (0.13)
CROLEI 2007	2.80*** (0.006)	3.40*** (0.0003)	2.77*** (0.007)	3.57*** (0.0002)

Note: *** - significant at 1%, ** - significant at 5%, * - significant at 10%.

Source: calculation of the authors.

Table 5.

CROSS-CORRELATION COEFFICIENT OF CROLEI INDICATOR AND THE REFERENCE SERIES

	levels				annual growth rates			
Lag of CROLEI	6	7	8	9	6	7	8	9
CROLEI 2004	0.965	0.964	0.963	0.961	0.414	0.406	0.408	0.359
CROLEI 2007	0.976	0.976	0.975	0.973	0.492	0.490	0.505	0.432

Note: cross-correlation coefficient is tested for 6^{th} lag of CROLEI and contemporaneous value of the reference series, then for 7^{th} lag of CROLEI and contemporaneous value of the reference series and so on.

Source: calculation of the authors.

3.5. A note on the diffusion index

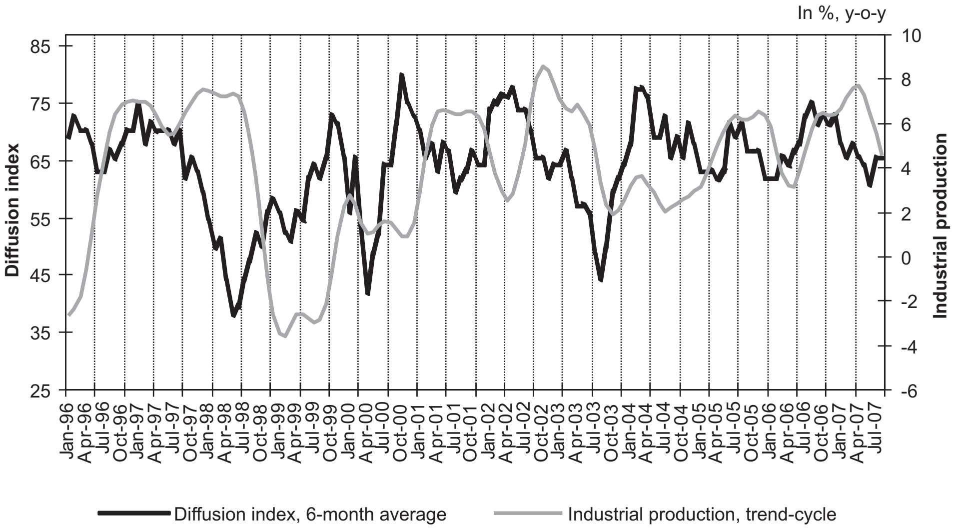
Besides constructing new CROLEI indicator, in 2007 revision we constructed for the first time a complete diffusion index series. Diffusion index measures the number of components of a composite leading indicator that are increasing in any given month. When all components of a leading indicator increase, the value of the diffusion index is 100. When all components are decreasing the value of the diffusion index is 0.

According to Conference Board (Conference Board, 2001), diffusion index provides another source of useful, but often neglected, information about the business cycle. They tell us how *widespread* a particular business cycle movement (expansion or contraction) has become, and measure the breadth of that movement. Diffusion indices are not redundant even though they are based on the same set of data as the composite indexes. On occasion, they even move in different directions than a composite indicator. A composite indicator differentiates between small and large overall movements in the component series, while a diffusion index measures the prevalence of those general movements. The difference is often very useful when attempting to either confirm or predict cyclical turning points.

Diffusion index and the reference series are displayed on Figure 6. After analyzing the figure, it is evident that diffusion index also leads the reference series very successfully. Since the changes of its 6-month average are somewhat more pronounced when compared to the CROLEI indicator, it not only reinforces the forecasts based on CROLEI indicator, but also it facilitates forecasting the turning points with more certainty.

Figure 6.

DIFFUSION INDEX AND THE REFERENCE SERIES



Source: calculation of the authors.

4. Concluding remarks

The aim of this paper was to report the results of 2007 CROLEI revision. In other words, the paper presented the process of choosing the best leading time series, the construction and the performance a composite leading indicator of the Croatian economy – CROLEI. New CROLEI indicator is composed from the following seven time series: users of unemployment benefit, real retail trade turnover, unconsolidated revenues of central government, county and municipal budgets, producer price index for EU – 25 countries, narrow money, credits to households and interest rate on kuna loans without currency clause, and has a lead time of 8 months. When compared to CROLEI indicator used before the revision, new composite indicator has better leading properties and longer lead time. Moreover, new indicator forecasts both classical business cycles as well as growth cycles, while the old indicator was calibrated to forecast only classical business cycles. 2007 revision also produced a diffusion index series. This index is another source of information for forecasting which indicates how widespread a particular business or growth cycle movement (expansion or contraction) has become.

Many challenges regarding composite leading indicator – CROLEI - still remain to be tackled. Namely, so far CROLEI was mostly based on non-model based approach to leading indicators. This was mostly due to the fact that most time series in Croatia start either from 1995 or 1997. Since at the time when the last revision was undertaken 13 years long series were available, the logical next step is to move to model based approach, where the dating of turning points, the choice of the best indicator components and the interpretation of the indicator is based on statistical models. Hopefully, this approach will not only offer new insights, but also it will confirm the results of the research on leading indicators in Croatia undertaken in the past 14 years.

APPENDIX

The NBER method involves five methodological steps for calculating the final composite indicator (USDC/BEA, 1977; Zarnowitz and Boschan, 1975; Gapinski, 1982; Shiskin, 1961):

- computing symmetric percentage changes of the individual components;
- standardizing the symmetric changes;
- weighting and summing the individual standardized changes;
- standardizing the weighted sum of changes;
- turning the changes into the leading indicator.

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:

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

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:

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

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:

$$s_{it} = c_{it} / A_i \tag{3}$$

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 was in previous revisions based on best leading indicators scores, whereby their significance weights, reflecting behavior of the series in regard to reference series, are calculated:

$$W_i = S_i / (\sum_{i=1}^{k} (S_i / k) \tag{4}$$

Weight is the ratio of the score of a certain component (S_i) and the average score of all components (k = number of composite index components). In 2007 revision we did not conduct scoring, but instead we chose to give an equal weight to all components in line with Conference Board practice and Marcellino (2006) recommendations. Weights serve for weighting of the standardized monthly percentage changes of indicators s_{it}:

$$R_t = (\sum_{i=1}^{k} s_{it} W_i) / (\sum_{i=1}^{k} W_i) \tag{5}$$

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

$$F = ((\sum_{t=2}^{n} |R_t|) / (N-1)) / ((\sum_{t=2}^{n} |P_t|) / (N-1)) \tag{6}$$

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:

$$r_t = R_t / F \tag{7}$$

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

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

$$I_{t\,=}\,I_{t-1}\,((200 + r_t)/(200 - r_t)\qquad (8)$$

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.

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PROGNOZIRANJE POSLOVNIH CIKLUSA I CIKLUSA RASTA U HRVATSKOJ

Sažetak

Ovaj članak opisuje razvoj i prognostička svojstva kompozitnog prethodećeg pokazatelja hrvatskog gospodarstva - CROLEI, svrha kojeg je da prognozira poslovne cikluse i cikluse rasta. Struktura članka slijedi tijek zadnje revizije CROLEI pokazatelja, zasnovane na NBER barometarskoj metodi. Nakon što se ukratko opisuju osnovne karakteristike CROLEI pokazatelja i njegove baze podataka, prelazi se na određivanje točaka zaokreta u referentnoj seriji (indeks volumena industrijske proizvodnje) pomoću Bry-Boschan algoritma. Kombinirajući grafičku analizu, test Grangerove uzročnosti i Waldov test isključenja, dolazi se do liste od 15 vremenskih serija s najboljim prethodećim svojstvima. Rekurzivna ocjena Grangerovog testa se primjenjuje da bi se utvrdilo jesu li prethodeća svojstva vremenskih serija stabilna tijekom promatranog razdoblja. Zatim se od 15 najboljih serija konstruira 14 kompozitnih prethodećih pokazatelja. Grangerov test se pritom primjenjuje da bi se odlučilo koji od 14 pokazatelja ima najbolja prognostička svojstva. Novi CROLEI pokazatelj je sastavljen od 7 vremenskih serija i prethodi referentnoj seriji 8 mjeseci. Osim novog CROLEI pokazatelja, izračunat je i indeks rasipanja, koji je pomoćna mjera za predviđanje poslovnih ciklusa i ciklusa rasta.

Ključne riječi: prethodeći pokazatelj, prognostika, nemodelski pristup, ciklusi rasta.