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ARE LEADING INDICATORS A USEFUL TOOL FOR PREDICTING BUSINESS CYCLES? THE POLISH EXPERIENCE

Abstract. From the moment when economists realized that business cycles are important patterns of aggregate economic activity, their main efforts were concentrated on finding of conjugate indicators of periods of boom and recession. Variables with fluctuations that systematically predate the movements in a general economic activity are called leading variables (LV) or leading indicators (LI). Combining a number of these leading variables into a single indicator provides a representation of cyclical fluctuations. The aims of this paper are to present and briefly discuss theoretical and practical problems of business cycle forecasting based on results of leading indicator analysis, as well as to review the empirical evidence on forecasting performance of leading indicators in Poland.

Keywords: leading indicators, business cycle, reference cycle, forecasting of business cycles, spectral analysis, causality test.
JEL Classification: E32, C12, C22.

1. INTRODUCTION

Business cycles are significant forms of aggregate economic activity. Thus, it is important to recognize indicators of booms and recessions, the phase of business cycles. A good example of such indicators for the US-economy, till 1930, is the number of loaded wagons released by rail companies (cf. Kowalewski 2000, p. 36).

Although single economic variables exhibit an oscillating pattern, related to business cycle, more popular now are composite indices of economic variables. In Poland, such indices were initially constructed by Kudrycka and Nilsson (1993) and later, from 1994 by the group of researchers from the Institute of Economic Development in Warsaw School of Economics.

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In what follows, by leading variables (LV) or leading indicaters (LI) we will understand variables (in the form of time series) that systemastically predate moverments in a geveral economic activity. It is easily seen that a composition of LV (or LI) in the form of syntetic variable or indicator is a useful determinant of business cycle models.

According to Klein and Moore (1982, p. 1–2), the leading indicators are, for the most part, measures of anticipations or new commitments. They have a "look ahead" quality and are highly sensitive to changes in the economic climate as perceived by market participants.

In this paper we discuss usefulness of leading indicators analysis in business cycle forecasting in the case of Polish economy.

Among leading indicators of BC[1] we distinguish:

- economic variables empirically observed;
- economic variables theoretically defined though empirically measured;
- economic parameters empirically estimated.

In all cases, we shall treat LI as explanatory factors (determinants) of BC-phases dates. Acceptation of LI as these factors follows from confirming either high correlation $corr(LI, GR)$ of LI and growth rate GR or high correlation in the absolute value $corr(T^n_{LI}, T^n_{GR})$ of expansion (or recession) phase time of LI and GR, while $n \equiv b, r$, (b – period of boom, r – period of recession).

We consider here the growth cycle as a trend-adjusted business cycle. The expansion phase is a period when the short-run growth rate of aggregate economic activity is greater than the long-run rate, whereas in the contraction phase the short-run growth rate is less than the long-run rate (cf. Klein and Moore 1982, p. 11).

In Section 2 we present main economic theories, from which we can conclude about possible leading variables of business cycles.

In Section 3 we construct time series of the Polish reference cycle as the representation of the business cycle as well as we test empirically relations between Polish economic indicators and the reference cycle. In Section 4 we present the results of forecasts made by using selected leading indicators from Section 3.

[1] More definitions of business cycles can be found in Milo (2000).

2. LEADING INDICATORS (LI) AND ECONOMIC THEORY

P. A. Klein and M. P. Niemira propose some useful rules for screening cyclical movements by the use of leading indicators. They advise searching them on the base of a casual relationship and looking for data with the highest frequency and the longest history (cf. Niemira and Klein 1994, p. 170).

F. De Leeuw, for example, mentions the most important rationales that underlie an indicator choice and justify research on leading indicators. These are (cf. De Leeuw 1991):

- production time (time between ordering and production);
- ease of adaptation (some aggregates are affected by short-term fluctuations earlier and/or stronger than others);
- market expectations (some series reflect or react to anticipations of future economic activity);
- prime movers (economic fluctuations are driven by measurable economic forces such as monetary policy).

Moreover, indicators are often chosen for their resistance against revisions, as well as early availability (Fritsche and Marklein 2001). In the process of searching for casual relationships between leading variables and reference cycle, the macroeconomic theory should be taken into account. It may guarantee better reliability of forecasts of forthcoming reference cycle.

From the explanations of business cycles in history, we can make conclusions about possible causes of fluctuations as well as about a chain mechanism which pre-dates fluctuations of the aggregate economic activity. Studies on economic theory could bring some hints on which variables should be tested as leading indicators.

Below, we present a few economic variables, which from the point of view of business cycle theories can be regarded as leading information about future cycles.[2]

2.1. Agricultural Crops

According to relatively simple unicausal theories of business cycles, agricultural crops played a role of either a trigger of BC (W. S. Jevons, H. S. Jevons, H. L. Moore, A. C. Pigou, D. Robertson), or a result of fluctuations of a different origin (A. Hansen, J. M. Clark). In those days, agriculture production shared a much larger percentage of GNP, so its impact on the economy was stronger. Today, no one would attribute modern

[2] More information can be found in available literature on BC.

business fluctuation to this cause. In Poland, the relation of agriculture production to GDP is at 6%, and by itself, does not influence Polish BC changes in a significant way.

2.2. Inventory

According to L. Metzler's theory of inventory cycles, entrepreneurs have a fixed notion of their desired *inventory/sales ratio*. During expansion, their demands rise and they find their inventories reduced. They enlarge their production. It raises employment and income. During contraction, the entrepreneurs try to reduce their inventory levels and their sales fall.

2.3. Consumption

Among the oldest explanations for cyclical instability are *underconsumption* theories. They date back to the nineteenth century, to theories of T. R. Malthus. In these theories, the cause of the upper turning point in BC is the decreasing ability of the economy to continue consuming what it produces during expansion. In our research for Poland, consumption is considered as an index of retail sale.

2.4. Investment/Savings Ratio

Non-monetary theories, which explain fluctuations in modern market economies by the *shortage of capital* (M. Tugan-Baranowski, A. Spiethoff, G. Cassel) argue that the cause of upper turning point in BC is that the rate of investment during expansion has exhausted the resources available for investment: that is, the rate of investment has outrun savings.

2.5. Monetary Factors

Modern economists would criticize Hawtrey's purely monetary theory, which overemphasizes the role of *domestic credit* and *interest rates* as leading indicators of a forthcoming business cycle. However, W. C. Mitchell stresses the importance of such monetary factors as *credit crunches* and their possible cyclical changes. F. von Hayek and L. von Mises developed monetary overinvestment theory which underlines the impact of a monetary system (*expansion of bank credit*) on investment process and economic fluctuations.

Modern Keynesians and modern monetarists both agree that changes in the *money supply* affect aggregate economic activity. For Keynesians, the relationship is indirect and depends on the responsiveness of the entrepreneurs to changes in the interest rate.

Interest rates in general are classified differently: sometimes as leading and sometimes as lagging indicators. It depends on a country. The US Department of Commerce/NBER method classifies most interest rates as lagging indicators. However, the United Kingdom's Central Statistical Office uses the rate of interest on three-month prime bank bills (inverted) as a leading indicator (cf. Niemira and Klein 1994, p. 169).

2.6. Profit Margins

W. C. Mitchell explained fluctuations in aggregate economic activity as a result of rising *profit expectations* (during expansion) and *cost-cutting* (during recessions). According to his theory, the expansion is dominated by growth in business demand based on rising profits expectations. This inevitably leads eventually to shortages and rising prices, which squeeze profit margins. Therefore, the business activity will diminish, ultimately resulting in recession. Then cost-cutting (during recession) will improve productivity and increase profit margins. The improved outlook for profits sparks recovery.

2.7. Investment

For J. M. Keynes, business cycles were largely the result of instability in private investment.

Moreover, he emphasized that investment could be affected by changing profit expectations and by changes in interest rate. Therefore, from this point of view, correlation between time series of aggregate economic activity and LI-variables should be checked, i.e.:

- investment;
- entrepreneurs' profit expectations;
- interest rate.

2.8. Stock Prices and Volume of Stocks

Index of stock prices and volume of sales at the stock market includes information about expected companies' profits. They also reflect domestic and foreign investors' forecasts of the economy as a whole.

3. LEADING INDICATORS IN POLISH EMPIRICAL STUDIES

3.1. Reference cycle

In order to test the predictive relevance of particular variables as leading indicators, one needs to construct a reference cycle. The most frequently used reference cycle economic variable is gross domestic product (GDP). Unfortunately, in Poland, it is available only yearly and quarterly.

Z. Matkowski have proposed the construction methodology of the general coincident indicator (GCI) for Poland (Matkowski 1996) based on the methodology of OECD (adjusted for local conditions and available data). Matkowski's GCI is the weighted average of production volume indices in five main sectors of economy: industry, construction, agriculture, transport and retail trade. In our research, we continue the general methodology suggested by Matkowski, but in a few details, we apply our ideas. Our coincident indicator (GCI03) is a monthly time series dating from January 1992 to December 2003.[3]

The process of construction of GCI03, based on Matkowski's methodology is presented in Figure 1.

Let a time series y_t be viewed as the sum of a growth (trend) component g_t and a cyclical component c_t:

$$y_t = g_t + c_t$$

for

$$t = 1,\ 2,\ \ldots,\ T.$$

In order to obtain a cyclical component from GCI03 time series, we used the Hodrick-Prescott filter with λ (smoothing parameter) equal 14 400 (advised for monthly data). V. Zarnowitz and A. Ozyildirim confirm that the Hodrick-Prescott approach is flexible. For very high λ it produces growth cycles quite similar to PAT method (phase average trend), used frequently by CSO in many countries (cf. Zarnowitz and Ozyildrim 2001).

Figure 2 presents the shape of the reference cycle computed on GCI03 basis.

[3] Matkowski analyzed also earlier periods (from 1975), but we focus only on the period, when Polish economy was becoming market-oriented and statistical data were more reliable.

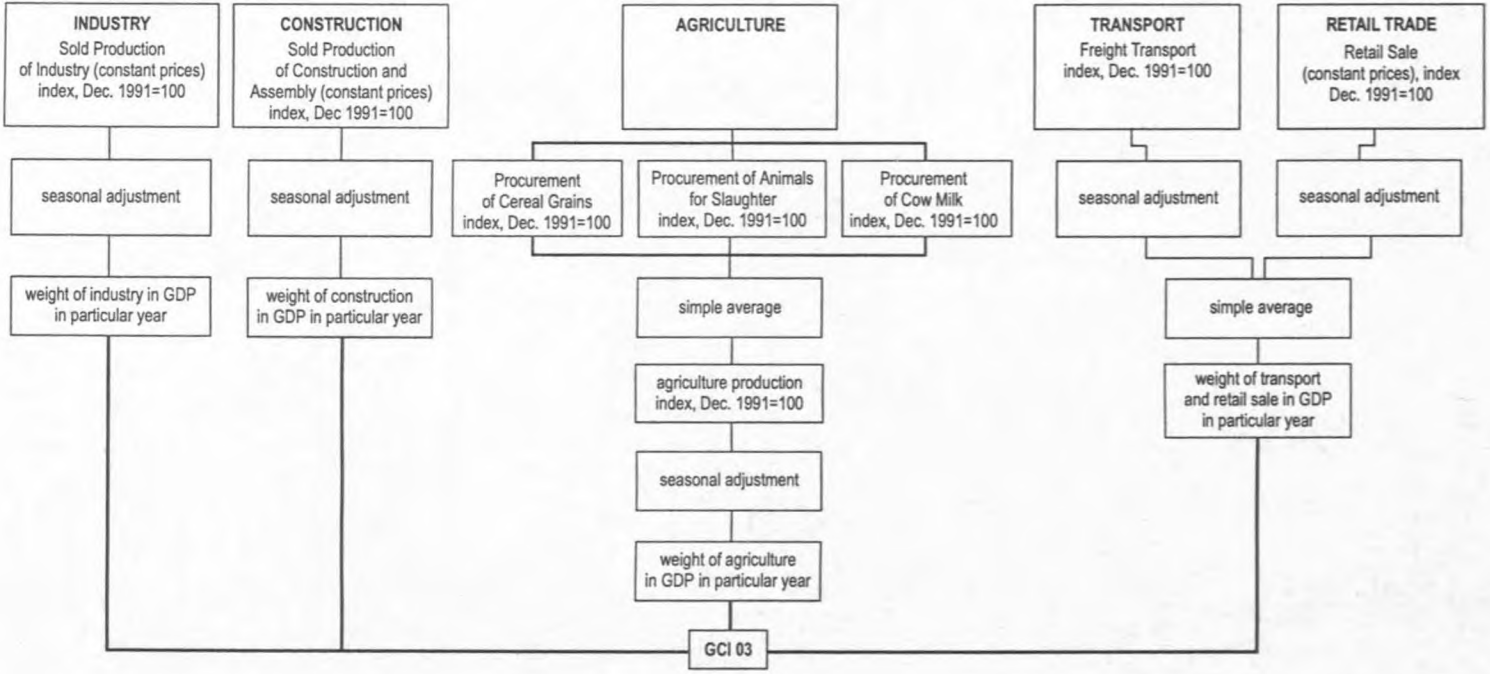

Fig. 1. Methodology of GC103

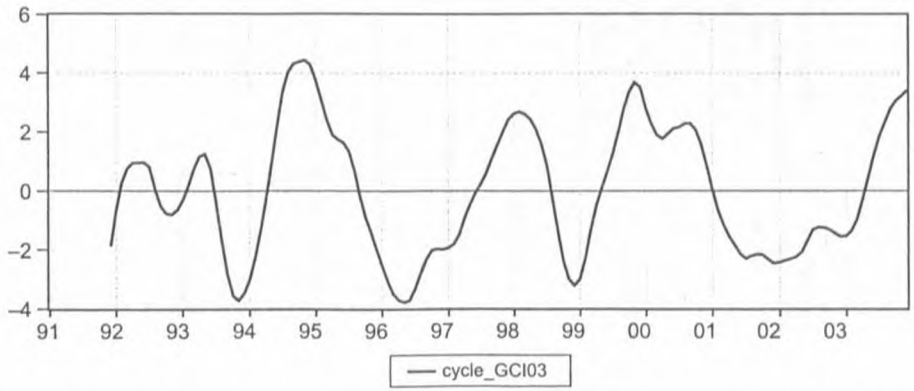

Fig. 2. Reference cycle of aggregate economic activity for Poland, computed on GCI03 basis (from January 1992 to December 2003)

After detrending, irregular component was eliminated using the Hodrick-Precott filter ($\lambda = 10$). To identify characteristics of the obtained time series, the stationarity was checked and spectral analysis was done. We found zero degree of integration ($I(0)$). In the next step, we applied spectral analysis to search for fixed-length cycles by transforming the process into an amplitude frequency-domain versus the typical amplitude time domain. A spectral representation describes the cycle in terms of frequency and amplitude. The frequency is defined as an inverse of the cycle length, whereas amplitude is the range between peak and through values. We found that dominating cycle length was three-year.[4]

There is a question whether this cycle could be interpreted as 3–3.5 years long empirical inventory cycle estimated by economists.

3.2. Cross-Spectral Analysis

Cross-spectral analysis is the two-series counterpart of spectral analysis. This method assesses the strength of wave-length relationship between pairs of economic indicators (in our case, between reference cycle based on GCI03 and particular economic indicator).

To apply cross-spectral analysis, it is desirable to have at least 100 observations and the economic indicators must be weakly stationary, that is, the mean and variance must be constant over time.

In the process of searching economic variables, which could act as leading indicators for the Polish economy, we used four criteria:

[4] More detailed description of spectral analysis can be found in Priestley (1981), Zieliński and Talaga (1986), Milo (1990) and some applications in Kozera (2004).

- relevance to economic theory;
- early availability;
- high frequency (monthly data);
- high number of observations available.

As we checked, GCI03-cycle process is stationary. In the next step, a degree of integration of variables tested as LI-s is verified. As before, unit root test – ADF (augmented Dickey-Fuller) was used. The results are shown in Table 1 (cf. Dickey and Fuller 1981).

To determine the lead or lag between pairs of economic indicators, two cross-spectral statistics are used: coherence and phase.

The coherence measure can take a value between 0 and 1; the concept is similar to the well known R^2 in a traditional regression analysis. But no casual relationship between the two variables has to be assumed, as it is implicitly the case in regression analysis. This is a measure of the stochastic relationship between different components of two processes at specific frequencies.

Phase measures the time difference between the leading and the coincident indicator (reference cycle) and is measured in radians. *Phase* can be estimated using the following formula (cf. Zieliński and Talaga 1986 or Priestley 1981):

$$\hat{\varphi}(\omega_j) = \operatorname{arctg}\left(-\frac{\hat{q}(\omega_j)}{\hat{c}(\omega_j)}\right), \tag{1}$$

where:

$j = 0, 1, \ldots, m$,

ω_j – frequency at number j, $\omega_j = \frac{\pi j}{m}$;

$\hat{c}(\omega)$ – cospectrum, the real part of the cross-spectrum could be estimated from:

$$\hat{c}(\omega_j) = \frac{1}{2\pi}\lambda_0[C_{xy}(0) + C_{yx}(0)] + \frac{1}{\pi}\sum_{\tau=1}^{m}\lambda_\tau[C_{xy}(\tau) + C_{yx}(\tau)]\cos\omega_j\tau, \tag{2}$$

where:

m – number of harmonics;

C_{xy} – covariance between time series x and y;

λ_τ – filter's weights (e.g. Parzen or Tukey-Hanning);

τ – time difference;

and

$\hat{q}(\omega_j)$ – quadrature, the imaginary part of cross-spectrum estimated from:

$$\hat{q}(\omega_j) = \frac{1}{\pi}\sum_{\tau=1}^{m}\lambda_\tau[C_{xy}(\tau) - C_{yx}(\tau)]\sin\omega_j\tau. \tag{3}$$

Table 1. The results of unit root testing – ADF for selected economic indicators

Indicators (monthly data)	Levels (x)		First differences (dx)		Second differences (d^2x)		Degree of integration
	t-value	specification	t-value	specification	t-value	specification	
1	2	3	4	5	6	7	8
Consumer price index	–2.696 (–4.02)	C, t, $x(-1)$, dx: (–1)	–0.94 (–2.58)	dx: (–1), d^2x: (–1)–(–9)	–7.85 (–2.57)	d^2x: (–1), d^3x: (–1)–(–8)	$I(2)$
Price of sold production of industry, index	–3.52 (–3.48)	C, $x(-1)$, dx: (–1)–(–3)					$I(0)$
Oil price index	–2.12 (–4.02)	C, t, $x(-1)$, dx: (–1)–(–3)	–5.05 (–3.48)	C, dx: (–1), d^2x: (–1)–(–2)			$I(1)$
Sold production of construction and assembly, index	–0.78 (–2.58)	$x(-1)$, dx: (–1)–(–2)	–12.15 (–2.58)	dx: (–1), d^2x: (–1)			$I(1)$
Sold production of industry, index	–2.67 (–4.02)	C, t, $x(-1)$, dx: (–1)–(–3)	–17.47 (–3.48)	C, dx: (–1), d^2x: (–1)			$I(1)$
Retail sale index	–2.61 (–3.47)	C, $x(-1)$, dx: (–1)–(–4)	–8.87 (–4.02)	C, t, dx: (–1), d^2x: (–1)–(–3)			$I(1)$
Index of the overall economic climate of sold production (surveys)	–2.42 (–2.58)	$x(-1)$, dx: (–1)–(–4)	–9.69 (–2.58)	dx: (–1), d^2x: (–1)–(–3)			$I(1)$
Index of stocks of finished products (surveys)	–1.23 (–2.58)	$x(-1)$, dx: (–1)–(–2)	–12.21 (–2.58)	dx: (–1), d^2x: (–1)			$I(1)$
Index of domestic and foreign orders (surveys)	–2.21 (–2.58)	$x(-1)$, dx: (–1)–(–2)	–11.44 (–2.58)	dx: (–1), d^2x: (–1)			$I(1)$

Index of domestic orders for construction and assembly production/services (surveys)	–3.34 (–4.03)	C, t, $x(-1)$,	–6.80 (–2.58)	dx: (–1), d^2x: (–1)–(–3)			$I(1)$
Prices of export, index	–2.44 (–3.47)	C, $x(-1)$, dx: (–1)–(–4)	–9.63 (–4.02)	C, t, dx: (–1), d^2x: (–1)–(–3)			$I(1)$
Prices of import, index	–1.37 (–3.47)	C, $x(-1)$, dx: (–1)	–10.20 (–3.47)	C, dx: (–1), d^2x: (–1)			$I(1)$
Trade balance, index	–2.17 (–3.48)	C, $x(-1)$, dx: (–1)–(–2)	–13.66 (–4.03)	C, t, dx: (–1), d^2x: (–1)			$I(1)$
Exchange rate (PLN/USD)	–2.06 (–3.47)	C, $x(-1)$, dx: (–1)–(–2)	–9.77 (–4.02)	C, t, dx: (–1), d^2x: (–1)			$I(1)$
Interest rate of bill rediscount	–1.8 (–4.03)	C, t, $x(-1)$, dx: (–1)	–7.68 (–3.48)	C, dx: (–1), d^2x: (–1)			$I(1)$
WIBOR1M	–3.05 (–4.03)	C, t, $x(-1)$, dx: (–1)	–4.76 (–3.48)	dx: (–1), d^2x: (–1)–(–2)			$I(1)$
WIBOR3M	–2.34 (–4.03)	C, t, $x(-1)$, dx: (–1)	–6.44 (–3.48)	C, dx: (–1), d^2x: (–1)			$I(1)$
Due from non financial sector in the banking system	–2.50 (–4.02)	C, $x(-1)$, dx: (–1)	–0.51 (–2.58)	dx: (–1), d^2x: (–1)–(–9)	–7.45 (–2.58)	d^2x: (–1), d^3x: (–1)–(–8)	I(2)
Due from households in the banking system	–1.66 (–4.02)	C, t, $x(-1)$, dx: (–1)–(–2)	–11.52 (–4.02)	C, t, dx: (–1), d^2x: (–1)			I(1)
Nonfinancial sector zloty deposits	–2.12 (–4.03)	C, t, $x(-1)$, dx: (–1)–(–5)	–2.84 (–3.48)	C, dx: (–1), d^2x: (–1)–(–4)	–11.73 (–2.6)	d^2x: (–1), d^3x: (–1)–(–3)	$I(2)$

Table 1 (continued)

1	2	3	4	5	6	7	8
Money supply (M0)	–2.23 (–3.48)	*C*, *x*(–1), *dx*: (–1)	–11.61 (–2.58)	*dx*: (–1), d²x: (–1)			*I*(1)
Money supply (M1)	–1.49 (–3.49)	*C*, *x*(–1), *dx*: (–1)	–8.88 (–2.58)	*dx*: (–1), *d*²*x*: (–1)			*I*(1)
Money supply (M2)	–1.04 (–4.03)	*C*, *t*, *x*(–1), *dx*: (–1)	–13.44 (–3.48)	*C*, *dx*: (–1)			*I*(1)
Money supply (M3)	–2.46 (–3.51)	*C*, *x*(–1), *dx*: (–1)	–6.82 (–4.07)	*C*, *t*, *dx*: (–1), *d*²*x*: (–1)			*I*(1)
Index of stock prices –WIG	–2.28 (–4.02)	*C*, *t*, *x*(–1), *dx*: (–1)–(–3)	–8.19 (–3.47)	*C*, *dx*: (–1)–(–2), *d*²*x*: (–1)			*I*(1)
Government expenditures	–5.16 (–4.02)	*C*, *t*, *x*(–1), *dx*: (–1)–(–2)					*I*(0)
Average monthly gross wages and salaries in real terms	–0.75 (–3.49)	*C*, *x*(–1), *dx*: (–1)	–8.06 (–3.49)	*C*, *dx*: (–1), *d*²*x*: (–1)			*I*(1)
Average monthly gross wages and salaries in nominal terms	–1.25 (–3.48)	*C*, *x*(–1), *dx*: (–1)–(–2)	–7.02 (–3.48)	*C*, *dx*: (–1), *d*²*x*: (–1)			*I*(1)
Employed persons in enterprise sector	–3.57 (–2.58)	*x*(–1)					*I*(0)
Rate of unemployment	–1.21 (–3.48)	*C*, *x*(–1), *dx*: (–1)–(–2)	–3.5 (–2.58)	*dx*: (–1), *d*²*x*: (–1)			*I*(1)

Unemployment – inflow	–5.42 (–4.03)	*C*, *t*, *x*(–1), dx: (–1)					*I*(0)
Unemployment – outflow	–2.51 (–3.48)	*C*, *x*(–1), *dx*: (–1)–(–2)	–8.14 (–3.48)	*C*, *dx*: (–1), *d*²*x*: (–1)–(–3)			*I*(1)
Procurement of cereal grains	–7.92 (–4.02)	*C*, *t*, *x*(–1), *dx*: (–1)	–10.98 (–2.57)	*dx*: (–1), *d*²*x*: (–1)–(–3)			*I*(1)
Procurement of animals for slaughter	–2.49 (–4.02)	*C*, *t*, *x*(–1), *dx*: (–1)–(–3)	–7.04 (–4.02)	*C*, *t*, *dx*: (–1), *d*²*x*: (–1)–(–2)			*I*(1)
Procurement of cow milk	–3.29 (–4.02)	*C*, *t*, *x*(–1)	–9.76 (–4.02)	*C*, *t*, *dx*: (–1), *d*²*x*: (–1)			*I*(1)
Freight transport	–3.63 (–4.02)	*C*, *t*, *x*(–1), *dx*: (–1)–(–2)	–14.96 (–3.47)	*C*, *dx*: (–1), *d*²*x*: (–1)			*I*(1)

Note: In *t*–value columns (brackets), McKinnon critical values are given (1% significance level). *C* – constant, *t* – trend, *dx* – first difference, d^2x – second difference. All indices are compared to the base equal 100 in December 1991. All variables excluding prices, interest rates, exchange rate, unemployment, procurements and series from surveys are in real terms. Variables with seasonality were seasonally adjusted.

Coherence could be calculated using the formula:

$$\hat{R}(\omega_j) = \left[\frac{\hat{c}(\omega_j) + \hat{q}(\omega_j)}{\hat{f}_x(\omega_j)\hat{f}_y(\omega_j)}\right]^{\frac{1}{2}}, \tag{4}$$

where $\hat{f}_x(\omega_j)$ and $\hat{f}_y(\omega_j)$ are the individual spectra calculated using the given formulas:

$$\hat{f}(\omega_j) = \frac{C_0}{2\pi} + \frac{1}{\pi}\sum_{\tau=1}^{m} \lambda_\tau C_\tau \cos \omega_j \tau, \tag{5}$$

where C_τ – covariance function, $j = 0, 1, \ldots, m$.

The results of the estimation of coherence and phase for the business cycle reference series and the indicators are shown in Table 2.

Table 2. The results of computation of coherence and phase for the reference cycle and economic indicators (Hamming's window)

Time series under investigation (monthly data)	Frequency	Period (months)	Coherence	Phase (months)
1	2	3	4	5
Consumer price index	0.845	11.8	**0.651**	–3.9
Price of sold production of industry, index	0.037	26.8	0.275	+6
Oil price index	0.030	33	0.361	–3
Index of the overall economic climate of sold production (surveys)	0.317	31.5	**0.748**	+2.1
Index of stocks of finished products (surveys)	0.026	37.3	**0.817**	–3.3
Index of domestic and foreign orders (surveys)	0.027	37.3	**0.757**	+0.3
Index of domestic orders for construction and assembly production/services (surveys)	0.036	28	**0.634**	–1.6
Prices of export, index	0.035	28.8	0.493	–4
Prices of import, index	0.035	28.8	**0.630**	–2.7
Trade balance, index	0.015	66	0.383	–9.4
Exchange rate (PLN/USD)	0.034	28.8	0.442	–1.5
Interest rate of bill rediscount	0.030	33	**0.628**	–6.6
WIBOR1M	0.030	33	0.267	–4.1

Table 2. (cont.)

1	2	3	4	5
WIBOR3M	0.030	33	**0.726**	–5.6
Due from non financial sector in the banking system	0.833	12	**0.548**	+13.8
Due from households in the banking system	0.303	33	0.475	–1.3
Nonfinancial sector zloty deposits	0.030	33	**0.582**	–10
Money supply (M0)	0.017	60	**0.647**	+11
Money supply (M1)	0.028	36	0.467	+7.2
Money supply (M2)	0.083	12	**0.736**	+8.9
Index of stock prices – WIG	0.286	35	**0.615**	+4.7
Government expenditures	0.014	67	0.010	+13.2
Average monthly gross wages and salaries in real terms	0.028	36	0.357	+4.9
Average monthly gross wages and salaries in nominal terms	0.185	54	0.081	–3.5
Employed persons in enterprise sector	0.037	26.8	0.262	–12.1
Rate of unemployment	0.030	33	**0.611**	+9.3
Unemployment – inflow	0.024	40.7	0.155	+15.4
Unemployment – outflow	0.017	60	0.127	–6.5

Note: Minus before phase length means a lead and plus means a lag of the indicator. Due to short length of M3 time series, it was impossible to perform spectral analysis.

In Table 2, bold numbers of coherence indicate a situation, where the stochastic relationship between different components of two processes (indicator and reference series) at specific frequencies is the strongest. Only in cases of high level of coherence, we can conclude about possible lead or lag (phase shift) of an indicator in relation to reference series.

3.3. Cross-correlation

For those indicators, that passed the spectral analysis criterion (coherence), cross correlation can be calculated to compare results with obtained phase-shifts.

The cross correlations between the two series x and y are given by:

$$r_{xy}(\ell) = \frac{C_{xy}(\ell)}{\sqrt{C_{xx}(0)}\sqrt{C_{yy}(0)}} \quad \ell = 0, \pm 1, \pm 2, \ldots, \tag{6}$$

where:

$$C_{xy}(\ell) = \begin{cases} \sum_{t=1}^{n-\ell} (x_t - \overline{x})(y_{t+\ell} - \overline{y})/n & \ell = 0, 1, 2, \ldots \\ \sum_{i=1}^{n+\ell} (y_t - \overline{y})(x_{t-\ell} - \overline{x})/n & \ell = 0, -1, -2, \ldots \end{cases} \tag{7}$$

We have found that the strongest cross correlation have indicators, which are presented in Table 3.

Table 3. Economic indicators which have the strongest cross-correlation with the reference cycle (GCI03)

Indicator (monthly data)	Transformation	The strongest correlation	Lead (–) or Lag (+) in months
Index of the overall economic climate of sold production (surveys)	Level 1st differences	0.365 –0.046	0 1
Index of stocks of finished products (surveys)	Level 1st differences	–0.497 0.141	–14 –3
Index of domestic and foreign orders (surveys)	Level 1st differences	–0.555 –0.117	–18 0
Interest rate of bill rediscount	Level 1st differences	0.239 0.250	3 3
WIBOR1M	Level 1st differences	–0.201 0.202	–18 0
WIBOR3M	Level 1st differences	0.227 0.142	2 0
Money supply (M1)	Level 1st differences	0.380 –0.121	0 2
Money supply (M3)	Level 1st differences	–0.424 0.194	0 11
Average monthly gross wages and salaries in real terms	Level 1st differences	–0.208 0.209	4 –11
Rate of unemployment	Level 1st differences	–0.212 0.400	3 12
Unemployment – outflow	Level 1st differences	–0.362 –0.015	–15 0

As before, the results that could be noted as the best (the strongest correlation with the reference cycle) can be attributed to indicators obtained from surveys. Their leads or lags are similar to those obtained from cross-spectral analysis (in case of first differences). The rest of specified correlation is very low with the exception of money supply aggregates, outflow (in levels) and rate of unemployment (first differences).

3.3. Causality Test

In order to identify reliable indicators, it should be empirically determined whether movements in the indicator series "lead" movements in the reference series. Granger-causality tests were developed to answer such questions. The test for Granger-causality attempts to determine whether changes in the indicator series precede changes in the reference series or vice versa. A regression of the stationary reference series is extended on its own lagged variables by including past values of a stationary indicator series. However, it should be remembered that the fit of equation does not mean that "true" causality between time series exists.

For each economic indicator and reference series, we estimated a VAR-equation and identified the best model specified by the minimum of the Hannan-Quinn criterion. Selected lag-length was used to specifys Granger test. The results are summarized in Table 4.

The application of Granger test for the assessment of leading indicator suitability is difficult. Fritsche and Marklein (2001) give a common example of the relation between the sales of Christmas cards and the occurrence of Christmas. A Granger test would find that the sales of Christmas cards are causal for the occurrence of Christmas. However, as we know, Christmas occurs even without Christmas card sales.

Another problem is the significant feedback relationship, which shows interdependence between the indicator and the reference series. In this case indicators could reflect a correct anticipation of business cycle by the economic agents, whereas business cycle itself reflects the economic sentiment. As an example, the result of Granger test for the index of the overall economic climate of sold production as well as index of domestic and foreign orders presented in Table 4 could be mentioned. However, we must reject feedback relationship if we believe that only unanticipated shocks can cause changes in the business cycle (according to some theories of BC).

The results presented in Table 4 concerning lengths of leads and lags are surprisingly different from those obtained earlier using cross-spectral analysis and cross-correlations. It can be caused by the fact, that the equations used for causality testing contain variables, which need not be statistically significant, so that the results may be biased.

Table 4. Results and conclusions from an application of Granger-causality test to the reference cycle (RC) and economic indicators (Only those, which give the proof of possible "causal" relations between indicators and RC are included)

Indicator (monthy data)	Transformation	VAR lag-length	H_0: Indicator not Granger causal	H_0: Reference cycle not Granger causal	Result
Index of the overal economic climate of sold production (surveys)	Level 1st differences	3 3	3.19(0.02) 6.02(0.00)	2.72(0.03) 2.36(0.06)	feedback indicator → RC
Index of stocks of finished products (surveys)	Level 1st differences	3 3	1.18(0.32) 1.26(0.29)	3.48(0.02) 3.36(0.03)	RC → indicator RC → indicator
Index of domestic and foreign orders (surveys)	Level 1st differences	6 6	3.92(0.00) 4.65(0.00)	2.90(0.01) 3.21(0.01)	feedback feedback
Trade balance, index	Level 1st differences	3 3	4.81(0.00) 5.21(0.00)	1.23(0.30) 1.25(0.29)	indicator → RC indicator → RC
Exchange rate (PLN/USD)	Level 1st differences	3 3	1.32(0.27) 3.28(0.02)	1.28(0.28) 1.00(0.40)	 indicator → RC
Interest rate of bill rediscount	Level 1st differences	4 4	6.57(0.00) 6.52(0.00)	2.69(0.03) 2.61(0.04)	indicator → RC indicator → RC
Money supply (M1)	Level 1st differences	3 3	3.32(0.02) 3.25(0.02)	1.65(0.18) 1.62(0.19)	indicator → RC indicator → RC
Money supply (M2)	Level 1st differences	3 3	3.07(0.03) 3.04(0.03)	2.01(0.12) 1.94(0.13)	indicator → RC indicator → RC
Money supply (M3)	Level 1st differences	3 3	2.61(0.06) 2.30(0.08)	3.73 0.01) 3.70(0.01)	feedback RC → indicator
Average monthly gross wages and salaries in real terms	Level 1st differences	4 4	2.81(0.03) 2.27(0.07)	1.60(0.18) 1.58(0.18)	indicator → RC –
Unemployment – outflow	Level 1st differences	4 4	2.67(0.03) 3.10(0.02)	0.92(0.45) 0.85(0.50)	indicator → RC indicator → RC

4. FORECASTS

In the next step we included specified leading indicators in regressions as explanatory variables in order to assess how they forecast future movements of reference cycle (GCI03). We have found that indicators predict most accurately with the following leads:

- index of the overall economic climate of sold production (–1, –3);
- index of stocks of finished products (–1, –7);
- index of domestic orders for construction and assembly production/services (–2);
- unemployment-outflow (–15);
- rate of unemployment (–1);
- money supply (M1) (–3);
- WIBOR3M (–5).

The results of this selection in 62% confirm the selections of leading variables and their lags done with the previous methods (cross-spectral analysis, cross-correlations, Granger-causality test).

As we concluded earlier, we estimate the length of the reference cycle (GCI03) at 3 years (36 months). In one of the specifications, we included lagged GCI03 variable with the length of the lag of 18 months (half of the cycle) as an explanatory variable. Obtained values of *t*-statistics are very high. As expected, estimated parameter shows inverse relation. Mentioned above economic variables predict in their best specification 68% of the variability of the reference cycle. The best forecast is presented in Figure 3.

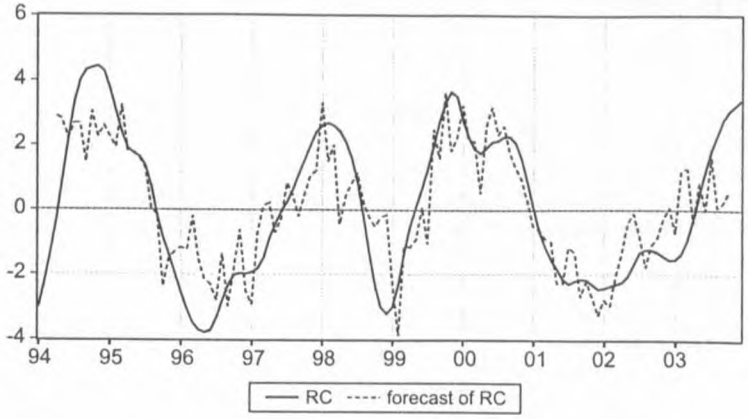

Fig. 3. Forecast of reference cycle (RC) using following indicators as explanatory variables: index of the overall economic climate of sold production (–1, –3), index of stocks of finished products (–1, –7), index of domestic orders for construction and assembly production/services (–2), unemployment-outflow (–15), rate of unemployment (–1), money supply (M1) (–3).

5. CONCLUSION

We presented and briefly discussed theoretical and practical problems of business cycle forecasting based on the results of leading indicator analysis, as well as the review of the empirical evidence on forecasting performance of leading indicators in Poland.

Among selected economic variables, the most reliable as leading indicators of reference cycle (GCI03) are variables obtained from surveys.[5] It is worth mentioning, that not all survey data on economic climate were included in our research. There are a few variables released by Polish Central Statistical Office (CSO), which might be better LI (for example, economic forecast from enterprise surveys), but for this moment, time series are too short to compare them with variability of reference cycle.

Another important group of economic variables that can be used in a role of leading indicators according to results of our research, are monetary variables – supply of money (especially M2) and interest rates (WIBOR3M). These results confirm the point of view of modern Keynesians and modern Monetarists. For Monetarists a relationship between supply of money and business cycle is direct, and for Keynesians, it is indirect and depends on the responsiveness of the entrepreneurs to changes in interest rates.

To sum up results of our forecasts, it was found that the predictive effectiveness of selected leading indicators, as tools in forecasting Polish business cycles is not high. Very similar conclusions made by other authors in case of Euroland could bring into question, whether business cycles could be sufficiently predictable in modern economies.

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[5] Similar conclusions are made by Fritsche and Marklein (2001) in case of leading indicators of Euroland.

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CZY WSKAŹNIKI WIODĄCE KONIUNKTURY SĄ UŻYTECZNYM NARZĘDZIEM PRZEWIDYWANIA CYKLI KONIUNKTURALNYCH? DOŚWIADCZENIA POLSKI

(Streszczenie)

Od momentu, kiedy ekonomiści zdali sobie spawę, że cykle koniunkturalne są nieodłączną charakterystyką zmienności zagregowanej aktywności ekonomicznej, ich główne wysiłki skoncentrowały się na znalezieniu wskaźników odzwierciedlających okresy rozkwitu i recesji gospodarki.

Zmienne, których fluktuacje systematycznie wyprzedzają zmiany ogólnogospodarczej koniunktury, są nazywane zmiennymi wiodącymi (*leading variables*) lub wskaźnikami wiodącymi (*leading indicators*).

Celem artykułu jest krótka prezentacja teoretycznych i praktycznych problemów dotyczących prognozowania cykli koniunkturalnych, opartego na analizie wskaźniów wiodących, jak również omówienie empirycznych wyników dotyczących jakości prognozowania z użyciem wskaźników wiodących na przykładzie cyklu koniunkturalnego Polski.