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The Financial Indicators Leading Real Economic Activity – the Case of Poland

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Abstract

In many research studies it is argued that it is possible to extract useful information about future real economic activity from the performance of financial markets. However, this study goes further and shows that it is not only possible to use expectations derived from financial markets to forecast future economic activity, but that data about the financial system can be used for this purpose as well. This paper sheds light on the ability to forecast real economic activity, based on additional and different financial variables than what have been presented so far.

The research is conducted for the Polish emerging economy on the basis of monthly data. The results suggest that, based purely on the data from the financial system, it is possible to construct reasonable measures that can, even for an emerging economy, effectively forecast future real economic activity. The outcomes are proved by two different econometric methods, namely, by a time series analysis and by a probit model. All presented models are tested in-sample and out-of-sample.

Keywords: forecasting, rational expectations, financial system, term spreads, real economic activity

JEL Classification: G12, E43, E44.

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1 Introduction

The purpose of this paper is to extend the list of financial leading indicators with two new measures and verify whether including additional information from financial system might improve the prediction accuracy of real economic activity. Based on the results of the empirical studies it is proved that the traditional leading indicators of real economic activity can be extended to other financial data variables. It is proposed to extend the list of potential predictors to a measure of financial stability and to stock market expectations towards the banking sector.

Economists often include stock market expectations in leading indicators. However, the list seems not to be limited. In this paper, the author proves that a measure of financial stability as well as stock market expectations toward the banking sector can be utilised to improve performance of the leading indicators of economic activity.

In the most common approaches, leading indicators of real economic activity are based on the real variables such as number of housing permits, average weekly hours, average initial claims for unemployment insurance, etc. Recently, the list of potential variables has been extended to financial variables. For example in the USA, the New Jersey Index comprises of yield spreads which are used to forecast nine-month economic growth in New Jersey and in the New York State; see Orr, Rich, Rosen (2001).

As the financial markets evolved in the last three decades the interest of the economists in financial variables as predictors of real economic activity increased. In 1997 Harvey drew economists attention to variability of a yield curve and variability of real economic activity once again. In a framework of the CCAPM (the Consumption Based Capital Asset Pricing Model) he managed to explain why the shape of a yield curve can explain future real economic activity. Subsequently, many publications on this topic from various countries appeared; see Hamilton and Kim (2000), Bandholz and Funke (2003), Ferreira, Martinez, Navarro, Rubio (2003), Hassapis (2003), Favero, Kaminska, Soderstrom (2005), Moneta (2005), Estrella and Trubin (2006), Mehl (2006), Panopoulou (2006), Pena and Rodriguez (2006).

The hypothesis that the real economic activity can be forecasted on the basis of the shape of a yield curve was positively verified for many countries. Apart from Harvey (1997) also Estrella and Trubin (2006) showed that yield spread facilitates forecasting real economic activity in the United States. Harvey also proved the same for Canada. Further, in the paper of Favero, Kaminska, Soderstrom (2005) the predictive properties of the yield curve are proved for eurozone countries. The study that examines the relation between yield spread and real economic activity in emerging economies is presented in the paper of Mehl (2006). In 2008 Grabowski (2008) tested the possibility of forecasting real economic activity on the basis of the shape of a yield curve for the Polish economy. In this paper different fragments of the Polish yield curve are examined in details including unit-root tests, statistical significance and stability of the relation in time.

The host of empirical evidence on possibilities to forecast real economic activity on the basis of a yield curve inspired economists to find a reasonable explanation of this

phenomenon. Harvey (1997) derived from the classic assumptions a model in which future consumption is explained by the difference in yields of sovereign debt instruments with different maturities. In Brock (1982) one might find theoretical model in which changes in future production are explained by yield spread.
Later economists attempting to explain the predictive power of yield spread propose to decompose the yield spread into expectation and term premium components. Such a decomposition is presented in publications of Hamilton and Kim (2000) and Favero (2005). In both papers the conclusion was that both effects have the predictive power and none of them prevails. Moreover, as Hamilton and Kim (2000) showed, the relation between the shape of a yield curve and future economic growth appears robust to the inclusion of other variables. They considered the following variables: a) federal funds rate, narrow (M1) and broad monetary aggregates (M2) (in order to include the stance of the monetary policy), and b) prices of oil (in order to include changes in prices of row materials).
In all analysed cases the yield spread remained statistically significant. Some publications like for example Bernanke (1990) verify other yield spreads. Namely, Bernanke analysed the forecasting power of the yield spread calculated between commercial papers and treasury bills. He stressed that this spread is informative not so much because it is a measure of the default risk but because it is an indicator of the stance of the monetary policy.
The article is different from its counterparts, since it presents research conducted for an emerging economy. A standard time series analysis is extended with a probit model specification. The author tests the forecasting ability of the proposed models in-sample and out-of-sample.
The article is organised as follows. Section 2 presents the theoretical framework for the relation between real economic activity and the condition of the financial system. Section 3.1 presents an empirical time series analysis of theoretical relations presented in section 2 for the Polish economy. Section 3.2 extends the analysis within the probit framework. Section 4 presents final conclusions.

2 Economic rationale

In the 2 section the economic rationale is presented that discusses grounds of predictive power of selected financial variables which can serve as leading indicators.

2.1 Established leading indicators

Originally, leading indicators were introduced to forecast real economic activity. The first types of leading indicators were mainly based on the idea that some segments of the economy might react faster to changes in the business cycle. For example it is assumed that an increase in average initial claims for unemployment insurance might lead economic contraction (Klein (2001), Hamilton and Perez-Quiros (1996)). Later

economists started to include information coming from the financial system. Very often agents' expectations were included by adding variables such as returns on stock market or yield spreads calculated for instruments of a different maturity or different credit risk profile. The well recognised relation between the shape of a yield curve and future real economic growth followed by three decades of research on this topic allow to classify the shape of a yield curve to the established leading indicators (Wheelock and Wohar (2009)).
In the host of studies on predictive power of a yield spread only some of them present any explanation for the existence of this power. The article of Harvey (1997) proposes the CCAPM framework to explain future economic activity.
Following Harvey (1997) it is assumed that the consumer has the intertemporal utility function $U(C_t, \gamma)$ with constant risk aversion parameter γ (*constant relative risk aversion*; CRRA). The utility function is given by the relation (1):

$$U(C_t, \gamma) = \begin{cases} \frac{C_t^{1-\gamma}-1}{1-\gamma} & \text{if } \gamma > 0, \gamma \neq 1 \\ \ln(C_t) & \text{if } \gamma = 1 \end{cases} \tag{1}$$

Assuming that $R_{i,t+j}$ is the return on i-th financial asset earned between t and $t+j$, Harvey (1997) and Ferreira, Martinez, Navarro, Rubio (2003) showed that, by solving the problem of utility maximisation with standard budget constraints the Euler equation given by the following relation can be derived:

$$E_t \left\{ \beta^j \left(\frac{C_{t+j}}{C_t} \right)^{-\gamma} (1 + R_{i,t+j}) \right\} = 1 \tag{2}$$

for $j = 1, ..., k$.
Assuming further that the growth of the consumption and real return on the financial asset are realisations drawn from multidimensional lognormal homoscedastic stochastic process the equation (2) can be written as:

$$\begin{aligned} E_t \left\{ ln \left[\beta^j \left(\frac{C_t}{C_{t+j}} \right)^{\gamma} (1 + R_{i,t+j}) \right] \right\} + \\ + \frac{1}{2} Var_t \left\{ ln \left[\beta^j \left(\frac{C_t}{C_{t+j}} \right)^{\gamma} (1 + R_{i,t+j}) \right] \right\} = 0 \end{aligned} \tag{3}$$

Small letters in equation (3) represent logarithmic rate of return ($\Delta c_{t,t+j} = ln \left(\frac{C_{t+j}}{C_t} \right)$). Further, the equation (3) using the presented notation can be simplified to (4).

$$E_t \Delta c_{t:t+j} = E_t \Theta r_{i,t+j} + j\Theta\rho - \frac{1}{2}\Theta v_{i,t+j} \tag{4}$$

The equation (4) written for $j = 1$ (the yield of debt instruments with short maturity date) and $j = k$ (the yield of debt instrument with long maturity date) is as follows:

$$E_t \Delta c_{t:t+1} = E_t \Theta r_{i,t+1} + \Theta\rho - \frac{1}{2}\Theta v_{i,t+1} \tag{5}$$

$$E_t \Delta c_{t:t+k} = E_t \Theta r_{i,t+k} + k\Theta\rho - \frac{1}{2}\Theta v_{i,t+k} \tag{6}$$

Differencing (6) and (5) the following could be derived:

$$E_t(\Delta c_{t+1:t+k}) = \Theta E_t NYS_t + \psi \tag{7}$$

In order to derive Harvey's model the following notations were accepted: $U(C_t, \gamma)$ – intertemporal utility function of the consumer, C_t – the consumption level in t, γ – the risk aversion parameter (*constant relative risk aversion*; CRRA), β^j – value of the discount factor in moment j, $R_{i,t+j}$ – the return on the i-th financial asset measured between time t and $t+j$, $r_{i,t+j}$ – logarithm of one plus risk free rate, ρ – consumer's rate of time preference $ln\,(\beta)$, $\Theta = \frac{1}{\gamma}$ – the risk tolerance parameter, $v_{i,t+j}$ – conditional variance between logarithm of interest rate and logarithm of consumption, $\Delta c_{t,t+j}$ – an increase of consumption between time t and $t + j$, NYS_t – nominal yield spread. The equation (7) describes the relation between real economic activity (measured by changes in consumption) and the yield spread. It can be transformed into econometric model.

$$\Delta c_{t+1:t+k} = \psi + \Theta NYS_t + u_{t+k}, \tag{8}$$

where: $NYS_t = r_{i,t+k} - r_{i,t+1}$, $\psi = \Theta((k-1)\rho - \frac{1}{2}(v_{i,t+k} - v_{i,t+1}))$, u_{t+k} – residuals. Since the time series of an expected growth of consumption is not available in empirical research ex-post growth of proxy variable is used. Moreover, the yield spread that is supposed to explain the increase of consumption should be lagged accordingly in order to meet the ex-post growth of consumption with expectations formatted some time ago.
This applies to the equation (8) and after transformation from ex-ante to ex-post it presents as follows:

$$\Delta c_{t,t-k} = \alpha + \beta NYS_{t-p-1,t,t+N} + u_{t+k} \tag{9}$$

where: $k = 12$, $p \in \langle k, \infty)$, $\Delta c_{t,t-k}$ in empirical research is proxied by $\Delta rrs_{t,t-k}$ that is logarithmic one year increase ($k = 12$) of real seasonally adjusted retail sales,
$NYS_{t-p-1,t,t+N}$ – is the nominal yield spread lagged p months calculated between yields of debt securities maturing correspondingly in t and in $t + N$ months.
In the empirical research conducted for Poland the NYS is represented by nominal yield spread calculated between yields of two-year Polish government bonds and one-year treasury bills. As presented in Grabowski (2008) this is the only yield spread that is stationary and do not disagree with the economic framework presented in Harvey (1997).

In the relation (8) the changes of consumption are explained by yield spread. In empirical research the consumption is proxied by retail sales. A similar economic rationale to that presented by Harvey (1997), but for the supply side of the economy, was presented in Brock (1982). In empirical research verifying the predictive power of the yield spread from the prospect of the supply side of the economy the time series of industrial production are usually used.

2.2 Newly proposed leading indicators

The thorough analysis of the relation between real economic activity and the shape of a yield curve in Poland, including analysis of stability of this relation in time, was presented in the paper of Grabowski (2008). However, the yield spread as a financial leading indicator does not exhaust fully the list of possible variables with predictive power. In the paper of Hamilton (2000) the basic relation (8) is extended with additional variables that are supposed to explain the future real economic activity. Hamilton (2000) extend the relation (8) on the empirical basis, but there are examples in the literature of more theoretical approaches. In the paper of Pena and Rodriguez (2006) the extension of basic relation (8) is proposed. The model of Pena and Rodriguez (2006) is the general case of Harvey (1997) which additionally incorporates stock market.

2.2.1 Stock market expectations – the banking sector

There is a vast literature that presents the usefulness of stock market indicators in predicting real economic activity; see Henry, Olekalns, Thong (2004), Siliverstovs and Duong (2006), Bordo (2007). This study also refers to this stream of the literature. The stock market investors' expectations are incorporated in the basic relation (8) following Pena and Rodriguez (2006). Assuming that stock market investors have the rational expectations Pena and Rodriguez (2006) derived the general case of Harvey (1997) model. They solved the standard consumer utility maximisation problem assuming that the consumer has the Kreps-Porteus generalised isoelastic preferences (Kreps and Porteus (1978)). Following Epstain and Zin (1989, 1991) they extended the relation (8) with stock market spread (MK_t). The equation (10) simplifies to the Harvey (1997) case when the $\gamma = \rho$ ($\omega = 1$).

$$\Delta c_{t+1:t+k} = \psi + \frac{1}{\rho\omega} NYS_t + \frac{\omega - 1}{\rho\omega} MK_t + u_{t+k} \tag{10}$$

where: $NYS_t = r_{i,t+k} - r_{i,t+1}$ (see eq. 9), $MK_t = rm_{i,t+k} - rm_{i,t+1}$, $rm_{i,t+k}$ – stock market k-period stock return, $rm_{i,t+1}$ – stock market 1-period stock return, $\frac{1}{\rho}$ - constant elasticity of substitution, $\omega = \frac{1-\gamma}{1-\rho}$ – the measure of the departure of the investor's preferences from the time-additive isoelastic expected utility framework, γ – constant coefficient of relative risk aversion, u_{t+k} – residuals.

The approach presented in this paper is however different from Pena and Rodriguez (2006). Instead of using excess stock market returns, the relative stock market returns are used. Here the stock market spread (MK_t) depicts expectations toward the banking sector in relation to general stock market returns (11).

$$ex\_bank_t = ln(\frac{WIG\_banki_t}{WIG\_banki_{t-12}}) - ln(\frac{WIG_t}{WIG_{t-12}}) \tag{11}$$

where: WIG is the Warsaw Stock Exchange Index, WIG_banks is the Warsaw Stock Exchange Index of banks listed on the stock market.

Similar approach can be found in Cole, Moshirian, Wu (2007), in which authors concluded that the positive relation between real economic activity and excess stock market returns earned on banks' equities exists in all examined countries. Moreover, a positive relation between the banking sector and real economic activity is presented in a wide spectrum of research; see Levine (2004), Klingebiel, Kroszner, Laeven (2004). The study concentrates on investors' expectations toward banking sector since Polish financial system is dominated by the banking sector. In 2007 the Polish banking sector assets accounted for 65% of all assets of the Polish financial system; see Financial system development (2008). Consequently, the banking sector plays the most important role in financing of operations in the real sector. The predictability of stock market expectations toward the banking sector might be closely connected with the credit channel. To this end Wrobel, Łyziak, Przystupa (2008) prove that the credit channel exists in Poland.

Future performance of the banking sector might be useful in predicting real economic activity due to the structure of profits of the Polish banking sector. The majority of banks' profits constitute of an interest profit which is reliant on credit growth. In 2007 more than 50% of profits of the Polish banking sector comprised of interest income. Credits are granted to the real sector as mortgages, consumer credits or investment credits, which in turn, as presented in Bernanke, Gertler, Gilchrist (1998), accelerate the consumption and investments, and in this way increase the real economic activity.

Moreover, the financial result of the banking sector is changing with the business cycle. The income of the banking sector in Poland relies on the interest income and provision income that is higher during the economic growth. As the economy slows down the banking sector faces higher costs because of higher level of defaults in both household and corporate sectors. In order to lead changes of financial results of the banking sector stock market rational expectations toward banking sector are incorporated in the empirical research.

The considered stock market expectations are rational and are based on the available set of information. If it is assumed that the information set is complete than the stock market bubbles do not occur. However, if the information set on which investors form their expectations is incomplete the stock market bubble are probable. In such environment investors form their expectations on the basis of fragmented information and though their expectations are rational their assets appraisal might be biased.

The proposed approach is resistant to the general stock market bubbles. General stock market bubble hits all stock market segments with the same strength. In this case the information set incompleteness is equal in all segments of the stock market. This implies that the probability of stock market bubble is equal in all stock market segments and the occurrence of a stock market bubble does not distort the expectations of relatively better performance of the particular sector of the economy in the future.
Relation (11) measures how the banking sector is perceived by investors in relation to the whole market. If stock market returns concerning the banking sector are higher than returns earned on the remaining sectors, investors assessment of future performance of the banks is better. The approach is not, however, resistant to the specific sector stock market bubble. So it is not resistant to the case in which information set in some stock market segments are inherently more incomplete than in others. Due to this information asymmetry stock market bubbles are more probable in less transparent stock market segments.

2.2.2 Financial Stability

Not only agents' expectations are important in forecasting real economic activity. As the *subprime* crisis has shown, the financial shocks might as well translate into an economic slowdown. Consequently, the stability of the financial system is the key factor underlying sustained economic growth. Looking at the structure of the Polish financial system, it is clear that the banking sector plays the most prominent role in the whole system. The development of the financial system in Poland has been changing the structure of the financial system. Gradually, financial markets are becoming more crucial for stable economic growth in Poland. However, from the beginning of the nineties the banking sector has played the most important role in the financing of the real economy. The value of assets of Polish financial institutions increased by 150% between 2002-2007. As a result financial system assets as a percentage of GDP in Poland grew from 74.8% in 2002 to 103.2% in 2007; see Financial system development (2008).
Polish financial system is still bank-oriented. In 2007 the assets of Polish banking sector accounted for 65% of all assets of the Polish financial system; see Financial system development (2008). Consequently, the banking sector plays the most important role in financing of operations in the real sector.
As far as the banking sector and forecasting real economic activity are concerned, it is robustness of banks (due to the banking oriented type of financial system) that seems to have an important impact on the real economy in Poland. Due to the fact that banks are a key intermediary, redistributing financial sources in the Polish economy, it is very important to monitor the risk contained in the banking sector. As the *subprime* financial crises showed, the banking system's instability easily transforms into a credit crunch that slows down the real economy. As a result, access to financial sources needed, for investments and reconstructions of companies is constrained.

Usually an increasing risk in the banking sector could be visible in increasing risk premium. It is the result of banks' reluctance to lend financial sources to institutions perceived as more risky. In such cases, financial institutions are willing to lend but they require higher margins.
Moreover, if a risky institution is important for the whole system (important from the systemic point of view) all banks will increase margins, rising risk premium in the banking system as a whole in this way. As a result, financing becomes more expensive and constrains credits granted to the non-financial sector of the economy.
The costs of lending among banks might be well measured by the money market interest rates. Monitoring a spread between short term money market interest rates and the reference rate of the Central Bank indicates the level of credit risk of financial institutions. Consequently, in the empirical part of the article the risk premium observed on the interbank market is depicted by the following variable:

$$Risk_t = ln\left(\frac{1 + R\_Market_t}{1 + R\_BC_t}\right) \tag{12}$$

where: R_BC is the reference rate of Central Bank, R_Market is the monthly average of (1M)Wibor (Warsaw Interbank Offer Rate).
For data with higher frequencies the difference between Overnight Indexed Swaps (OIS) and proper interbank rate is usually used to acquire the credit risk premium present in the market. For the purpose of the monthly data analysis the difference between proposed measure and OIS based measure is negligible. Moreover, the proposed measure has the advantage over the OIS based because it offers much longer time series.

3 Empirical analysis

3.1 Time series analysis

The basic economic framework for the empirical analysis of this section is presented in, Harvey (1997), Ferreira, Martinez, Navarro, Rubio (2003), Pena and Rodriguez (2006). The shortened economic rationale is also discussed in the section 2. A special focus on Poland is proposed in Grabowski (2008). The basic CCAPM and PCAPM specifications are extended to a proxy of risk of a financial system and stock market expectations concerning the banking sector. To test robustness of the results, the relation is tested for the supply and demand side of the economy. As in Grabowski (2008) measures of real economic activity are real retail sales $\Delta rrs_{t,t-k}$ (demand) and real industrial production $\Delta rsp_{t,t-k}$ (supply).
The basic economic framework is the CCAPM proposed by Harvey (1997) and PCAPM proposed by Brock (1982) in which yield spreads are lagged at least 12 periods. To keep the whole analysis in line with CCAPM and PCAPM all remaining explanatory variables are also lagged at least 12 periods. The variable $Risk$,

describing distress in a financial system, is lagged 12 periods because it is assumed that some shocks transmit to the real economy with a lag, but not necessarily longer than one year. Only NYS is lagged 13 periods which is in line with theoretical models: CCAPM and PCAPM. The variable NYS is the spread between yields of two-year Polish government bonds and yields of one-year treasury bills. As presented in Grabowski (2008) this is the only yield spread that is stationary and do not disagree with the economic framework presented in Harvey (1997).
As far as equity market expectations are concerned, it is believed that the stock market prices contain information on future performance of the company. In every point in time investors present their n-period rational expectations toward performance of the particular company. In this way the relation (11) is the difference between n-period investors' rational (given the set of information at time t) expectations of the banking sector versus their rational expectations of the remaining sectors of the economy listed on a stock market. Assuming that the horizon of these expectations is at least 12 periods the variable ex_bank ought to be lagged at least 12 periods. In this way the varying relative rational expectations will match with ex-post one year economic activity.
Due to the lack of a perfect measure of real economic activity, the robustness of outcomes is tested for the supply (PCAPM) and demand sides of the economy (CCAPM). The measures of real economic activity: changes in consumption and changes in production are suggested by the theoretical models discussed in section 2. The equations for the demand side (13) and supply side (14) of the economy are presented below:

$$\begin{aligned} \Delta rrs_{t,t-k} &= \alpha + \beta_1 NYS_{t-p-1,1,2} + \beta_2 Risk_{t-p} + \beta_3 ex\_bank_{t-p} \\ &+ \gamma_1 D_{2005:04} + \gamma_2 D_{2004:04} + \mu_{t-k} \end{aligned} \tag{13}$$

$$\begin{aligned} \Delta rsp_{t,t-k} &= \alpha + \beta_1 NYS_{t-p-1,1,2} + \beta_2 Risk_{t-p} + \beta_3 ex\_bank_{t-p} \\ &+ \gamma_1 D_{2005:04} + \gamma_2 D_{2004:04} + \gamma_3 D_{2005:02} \\ &+ \gamma_4 D_{2005:03} + \gamma_5 D_{2004:03} + \gamma_6 D_{2004:02} + \mu_{t-k} \end{aligned} \tag{14}$$

Both specifications include dummy variables because the effects of EU accession ought to be captured from the time series in order not to blur the final results. The model specification explaining the supply side of the economy involves more dummy variables since it is assumed that production side of the economy need more time to adjust to the institutional changes than the demand side of the economy.
All time series are tested for unit-root. The results for dependent variables are given in the table 1. In order to save space only results of ADF test for unit root are presented. For the same reason only results for dependent variables are quoted. However, the remaining results of ADF, KPSS and Philips Perron tests for all analysed time series might be delivered on demand. The results of unit root tests suggest that all variables are stationary in mean and parameters in equations (13) and (14) may be estimated by means of OLS without a thread of spurious regression. Due

Table 1: ADF test for $\Delta rsp_{t,t-k}$ and $\Delta rrs_{t,t-k}$

Variable:	$\Delta rsp_{t,t-k}$		$\Delta rrs_{t,t-k}$	
Information Criterion	AIC,HQ	SIC	AIC,HQ	SIC
No. of lags	1	0	11	0
ADF TEST	-2.782	-4.559	-4.033	-3.343
1% level	-3.495	-3.495	-3.505	-3.497
5% level	-2.890	-2.889	-2.894	-2.89
10% level	-2.582	-2.581	-2.584	-2.582

to overlapping observations in the left-hand side of the equations (13) and (14) the residuals are generated by moving average process. In case of overlapping observations some researches suggest to use Hodrick (1991) procedure to compute standard errors. However, the Hodrick procedure requires loss of observations in the beginning of the sample. If k parameter in equations (13) and (14) is relatively big (here k equals 12) it lowers significantly number of degrees of freedom and more importantly removes from the available sample the observations just before the first economic slowdown (1999-2002). The 1999 is very important for the results of the research and should not be omitted because the analysed time series is relatively short and only one more period of economic slowdown (2004-2005) is available in the sample. The sample starts in 1999 since the reasonable data on yields spreads for Poland are available starting from that date. These drawbacks make Hodrick (1991) procedure impossible to implement. However, as the Monte Carlo simulations conducted by Britten-Jones, Neuberger, Nolte (2010) showed the bias of standard errors computed by means of Newey and West (1987) procedure in case of overlapping observations is relatively low and should not distort the statistical inference.

Being conscious of the overlapping observations problem the Newey and West (1987) procedure is used to compute heteroscedasticity and autocorrelation consistent (HAC) standard errors. Two models passed the tests for collineraity and the Jarque-Bera test for normal distribution of residuals. The results of autocorrelation tests are not presented to save space, however they can be presented on demand. The figures in bold mean statistical significance at least at the level of 5%. The results are in-line with the economic rationale presented in section 2 and have the same interpretation in both models. The decreasing value of the NYS (positive parameter β_1) implies that the yield curve inverts. An inverted yield curve might, *inter alia*, suggest that a level of a long-term savings in debt instruments increases and consumption decreases. A reduction in the consumption level constrains the internal demand and slows the economy.

For the production side of the economy the rationale is as follows. Companies expecting economic slowdown verify their investment plans reducing long run investment projects. Long-run investment projects are usually financed with long-term debt which maturity is approximately equal to the period of investment. Reduced supply of long term commercial papers drives prices of long-term debt instruments up and

Table 2: The structural parameters estimates, sample: 2000:05 - 2007:07

Variable	$\Delta rrs_{t,t-k}$		$\Delta rsp_{t,t-k}$	
	Coef.	t-Stat.	Coef.	t-Stat.
β_1 (NYS)	7.657	3.461	4.590	2.220
β_2 (Risk)	-8.718	-3.190	-7.425	-3.459
β_3 (ex_bank)	0.206	3.497	0.096	2.084
γ_1	-0.231	-16.428	-0.063	-4.635
γ_2	0.225	15.994	0.138	9.694
γ_3			-0.093	-6.776
γ_4			-0.057	-4.544
γ_5			0.143	11.959
γ_6			0.101	9.045
α	0.0595	5.548	0.073	7.879
R^2	0.549		0.516	

lowers their yields. At the same time in the short end of the yield curve exactly the opposite phenomenon takes place. Increase demand for the short-term financing of the corporates lowers the prices of the debt instruments and dives yields up. As a result of those phenomena the expectations of producers might invert the yield curve.

The third group of agents that has the influence on the yield curve are the institutional investors. Even in period of excessive liquidity in the banking sector those financial institutions might prefer to buy and hold debt instruments than grant new credits to the real sector. This scenario might materialise especially when banking sector expects higher loan loss provisions in the near future due to lurking economic slowdown. In this scenario banks would invest in long-term debt securities which would result in increase of debt securities prices and lower yields. In this way banks might contribute to the inverting yield curve.

The negative value of β_2 also accords with economic theory. The increasing spread between the reference rate and money market rate implies growing credit risk concealed in the banking sector. As a result, banks are reluctant to lend money to each other and will probably constrain the number of granted credits to the real sector. The serious financing problems present in the banking sector very often lead to a credit crunch. Assuming that the effective credit channel is present in the economy the constrained lending should slow the economy.

In very extreme cases, the tensions present in the financial system lead to financial crises. In this sense the financial disturbances can be very expensive for the whole economy. A detailed costs analyses of banking crises are presented in Klingebiel (2004).

The last structural parameter β_3 presents how investors perceive the profitability of the banking sector. The parameter β_3 is positive contrary to findings of Pena and Rodriguez (2006). This is due to slight difference in the understanding of the explanatory variable resulting from different type of financial system that is analysed. In Pena and Rodriguez (2006) the financial systems of the United States and Canada

Table 3: Models' forecast performance comparison

Models with extensions vs. basic model (yield spreads)				
	RSP		RRS	
Horizon	HLN Stat.	p-value	HLN Stat.	p-value
1	-1.585	0.062	-2.260	0.016
2	-1.531	0.066	-2.027	0.024
3	-1.621	0.055	-2.023	0.023
4	-1.687	0.047	-2.113	0.018
5	-1.811	0.036	-2.173	0.015

are considered. Typically market oriented financial system are considered. In the research presented in the paper the Polish financial system is investigated, which is bank oriented financial systems. For this reason the variable ex_bank describes only rational stock market investors' expectations of the profitability of Polish banking sector, whereas in Pena and Rodriguez (2006) variable MK_t describes rational stock market investors' expectations of the profitability of all sectors of the economy. Different definition of explanatory variable in both researches must have influenced the discrepancy in the sign of the parameter β_3 existing in between the publications.
In a banking-based financial system the positive value of the β_3 might be a proxy for an increase in future credit. It is the interest income that is the most important and stable part of banks' income. In Poland more than 50% of the banks' profit comprise of interest income. Investors that expect better performance of the banking sector might indirectly forecast future credit expansion.
In banking oriented economies, banks supply the economy with the essential sources for investments and for the financing of current operations. The positive sign in both equations (13) and (14) means that investors expect that banks will perform better than other sectors of the economy, implying indirectly credit expansion which will probably accelerate the economy.
Moreover, the financial result of the banking sector changes with business economic cycle. During economic boom banks grant new credit and increase their net interest margin while during the economic slow down banks face higher loan loss provisions which lower their net income. This implies that measure that leads changes of the financial results of the banking sector leads indirectly the business cycle. The positive and statistically significant parameter proves that the proposed stock market measure indeed facilitates forecasting real economic activity in Poland.
In-sample performance of the model is acknowledged by the out-of-sample statistics. The table 3 and 4 present the version of Diebold-Mariano statistic for small sample as presented in Harvey, Leybourne, Newbold (1997).

Table 3 presents how forecasts of the model with a proxy of financial stability and rational stock market expectations toward the banking sector differ from forecasts of the model based only on the CCAPM (PCAPM) rationale (basic model have only yield spread as an explanatory variable). The figures in the table 4 compare the forecasts accuracy of models (13) and (14) with AR(1) models. The number of lags in

Table 4: Models' forecast performance comparison

Model with extensions vs. AR(1)				
	RSP		RRS	
Horizon	HLN Stat.	p-value	HLN Stat.	p-value
1	0.031	0.487	-0.181	0.428
2	-0.051	0.479	0.001	0.499
3	-0.030	0.488	0.202	0.420
4	-0.033	0.486	0.271	0.393
5	-0.050	0.479	0.315	0.376

AR model was selected on the basis of BIC information criterion. The tests were also conducted for lags of 3 as selected by AIC information criterion but the conclusions were the same.
The presented test results are calculated starting from the sample size of 50 observations. The models are recursively estimated and forecasts of the horizon of 1, 2, 3, 4, 5 periods are generated. Next, the errors of forecasts are calculated for every horizon of forecast and Diebold-Mariano statistic is calculated. The presented results take the adjustment of the DM statistic into account for the small samples as presented in Harvey, Leybourne, Newbold (1997). The robustness of the results was also tested by modifying of the starting point. The conclusions were always the same as presented in the article. Due to the lack of space the results are not presented but are available with the program written in GAUSS at: http://sites.google.com/site/szymontomaszgrabowski.
The results of the out-of-sample tests show that the zero hypothesis assuming that the accuracy of the forecast of basic and extended models are comparable should be rejected for almost all forecast horizon. This implies that including stock market expectations toward banking sector and risk premium on the interbank market improves the accuracy of the future real economic activity. Moreover, models (13) and (14) forecast real economic activity not worse than AR models.
In the paper of Clark and McCracken (2001) the authors suggest that if forecasting models are nested many of the usual test statistics fail to converge to the standard normal distribution. This implies that the results presented in the table 3 might be misleading. However, using statistics proposed in Clark and McCracken (2001) gives the same conclusions (see table 5). All statistics presented in Clark and McCracken (2001) suggest that the zero hypothesis assuming that the accuracy of the forecast of basic and extended models are comparable should be rejected, which implies that extended models forecast real economic activity more accurately than constrained ones.

3.2 Probit model

This section refers to the publication of Estrella and Trubin (2006) in which the probit model is used to forecast periods of recession in the United States. It is another way

Table 5: Models' forecast performance comparison (1-step horizon)

	Δrsp		Δrrs	
Model extension 1 vs. basic model (only spreads)				
Statistic	value	5% C.V.	value	5% C.V.
MSE- F	11.436	1.595	6.377	1.607
MSE-t	3.987	0.668	4.378	0.683
ENC-F	6.879	1.977	3.660	1.924
ENC-t	4.591	1.332	4.962	1.342
Model extension 2 vs. model extension 1				
MSE- F	0.697	1.492	9.661	1.508
MSE-t	0.148	0.590	1.789	0.602
ENC-F	1.604	2.143	7.045	2.108
ENC-t	0.698	1.323	2.717	1.323
Model extension 2 vs. basic model (only spreads)				
MSE- F	11.233	1.617	16.036	1.670
MSE-t	2.965	0.450	3.817	0.467
ENC-F	7.965	2.970	10.455	2.921
ENC-t	3.841	1.436	4.713	1.440

of testing the usefulness of the financial variables in forecasting real economic activity. It might be interpreted as a complimentary approach due to the fact that a different econometric method is implemented.

A standard probit model specification presented in Estrella and Trubin (2006) is extended with additional explanatory variables. It also offers construction of a probability model for a emerging market.

The construction of probability models for emerging markets is a challenging task. The first obstacle that occurs is the lack of the reference variable. Unfortunately there is no equivalent of the National Bureau of Economic Research that specifies exact and unambiguous dates of recessions and economic expansions in Poland.

The author finds the values of the reference variable by referring to different publications concerning business cycles in Poland and by estimating $MS - AR$ (markov switching autoregressive model) on time series of real retail sales (rrs) and real sold production (rsp) in the industry. The dates suggested by $MS - AR$ are compared with dates from economic publications and appropriate adjustments are made; see Białowolski, Drozdowicz-Bieć, Lada, Zwiernik (2007). The methodology of extracting the reference variable of an economic slowdown is complex enough to be described in a separate paper and will thus not be presented here (Kośko (2008)).

It is sufficient that the model forecasts an economic slowdown and not necessarily a more severe scenario – a recession. This is why the reference variable is equal to 1 in periods of economic slowdown and is equal to 0 in periods of economic expansion. Obviously the reference variable is also equal to 1 in the periods of recession as those periods might be interpreted as the more severe case of an economic slowdown. The table below presents the reference variable. As far as the period between 2004:04 – 2005:05 is concerned, there is some ambiguity in the economic literature as this is

Table 6: The reference variable – period classification

Date	Period classification
1999:03 1999:07	Expansion
1999:08 2002:02	Slowdown
2002:03 2004:03	Expansion
2004:04 2005:05	Slowdown
2005:06 2007:12	Expansion

the period after Poland joined the EU. It is very often interpreted as the *rebound effect* of the pre-accession economic growth; see Białowolski, Drozdowicz-Bieć, Lada, Zwiernik (2007). The interpretation of the source of this slowdown does not change the fact that it was indeed the economic slowdown which was thought difficult to forecast ex-ante. Nevertheless, the probability model based on the financial indicators could forecast even such extreme cases.
Model specification is quite similar to (13) or (14). The difference is that there is no dummy variables in periods concerning pre-accession and after accession periods. As the model is a probability model of economic slowdown, fitted values ought to vary between 0 and 1. This is guaranteed by the probit model specification:

$$Z_t = \alpha + \beta_1 NYS_{t-p-1,1,2} + \beta_2 Risk_{t-p} + \beta_3 ex\_bank_{t-p} + \epsilon_t \tag{15}$$

Assuming as in Estrella and Trubin (2006) that the ϵ_t follows the normal distribution the probit model can be written as:

$$P(y_t = 1) = F(Z_t) = \int_{\infty}^{Z_t} \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} dt \tag{16}$$

The variable Z_t in (16) is latent, not observable, variable depicting the probability of the Polish economy to fall into economic slowdown. The Z_t is defined as in (17) and is the "observable" binary variable discriminating between periods of economic expansion and economic slowdown:

$$y_t = \begin{cases} 1 & if\ Z_t > 0 \\ 0 & otherwise \end{cases} \tag{17}$$

Model is estimated by ML method and the results are as presented in the table 7.

Since the reference variable is defined to equal 1 in periods of economic slowdown the parameters from β_1 to β_3 have the opposite signs as in (13) and (14). Consequently, the probability of an economic slowdown decreases as the value of the yield spread increases and the probability of an economic slowdown decreases as the excess return on equities of the banking sector increases. The increasing value of the banking sector risk indicator increases the probability of the slowdown.
The in-sample performance of the model seems to be satisfied, however how well the model forecasts can be tested in out-of-sample tests. Figure 1 shows how well

Table 7: The probit model parameters estimates, sample: 2000:05 - 2007:07

Variable	Y_t	
	Coef.	Z-Stat.
β_1 (NYS)	-1045.630	-2.137
β_2 (Risk)	1594.647	1.948
β_3 (ex_bank)	-80.488	-2.067
α	-6.735	-1.932
$McFaddenR^2$	0.895	

the model identifies the periods of economic slowdown in Poland. The model discriminates properly between periods of economic expansion and economic slowdown in 96.43%.

Table 8: The forecast performance tests

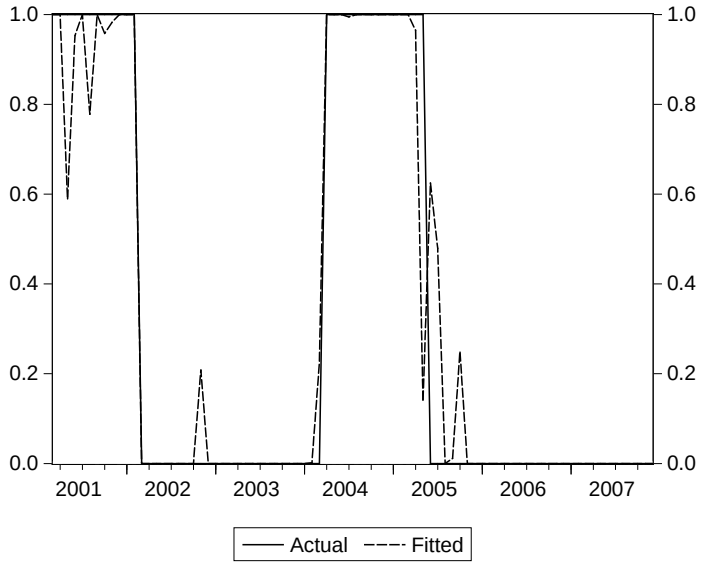
Correlation	AUROC	Brier score
0.948	0.963	0.0222

Moreover, the good performance of the model is acknowledged by its ability to forecast future values of dependent variables (see table 8). The model was estimated on the sample between 1999:03 and 2004:03. The initial sample ended just before the second economic slowdown. Subsequently, one period recursive forecasts of economic slowdown probability were produced and the statistics presented in table 8 were calculated. The high AUROC value as well as the low Brier score value confirm that the model might be a good forecasting tool for projecting the probability of an economic slowdown in one year.

4 Conclusions

The overall conclusion is that it is possible to build leading indicators on the basis of financial variables. Grabowski (2008) and Mehl (2006) show that the forecasting ability of an inverting yield curve can be applied also to an emerging market economy. This study goes further and presents that an extension of the models, based on the CCAPM or PCAPM rationale with other reasonable *"financial"* variables, gives the possibility to forecast real economic activity in Poland.
The explanatory variables are selected on the basis of economic rationale. The first one depicts how investors perceive the profitability of the banking sector in relation to other sectors of the economy listed on the stock market. Since more than 50% of the income of the Polish banking sector comes from the interest income it might be possible that investors indirectly forecast credit expansion.
Moreover, the financial results of the banking sector change with a business cycle.

Figure 1: Fitted versus actual values



In economic boom banks usually grant more credits and earn higher interest margin whereas during the economic downturn they face higher loan loss provisions resulting from increasing number of households and corporates defaults. In this way stock market investors' expectations towards the banking sector might indirectly forecast changes in real economic activity.

The second explanatory variable is a proxy of risk premium observed on the interbank market. The course of the financial crises shows that turmoil in the financial system usually results in a credit crunch and an economic slowdown. In other words a robust financial system is needed for sustained economic growth and effective monetary policy.

Robustness of the results is confirmed by different econometric procedures. The in-sample time series analysis suggest the same conclusions as in-sample probit model approach. Moreover, the satisfactory in-sample results are confirmed by out-of-sample tests.

The research differs from its counterparts due to the fact that it is done for an emerging economy. The research concentrates on Polish data since the Polish financial system starting from 2000 has been developing very rapidly. These developments

allow to consider data derived from Polish financial system as potential leading indicators. For this data, to the best author's knowledge, such detailed analysis has not been presented yet.

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