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# Real economic activity and state of financial markets

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# REAL ECONOMIC ACTIVITY AND STATE OF FINANCIAL MARKETS

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**Abstract**

This study examines the relation between real economic activity and condition of financial markets in Poland in the framework of Consumption Based Capital Asset Pricing Model (CCAPM). The article analyses the relation between yield spreads calculated for Polish debt securities and real economic activity. Since CCAPM is the framework of presented analysis the value of real retail sale is used as a measure of real economic activity (here level of real consumption). Furthermore, since host of researchers apply in their studies the whole spectrum of measures of real economic activity the study is extended to encompass also the supply side of the economy. The outcomes for Polish economy suggest that there is some evidence that financial markets may facilitate to forecast the real economic activity. The conclusions from models evaluated for supply and demand side of economy are coherent. Although, the research is conducted on monthly time series the results are consistent with quarterly analyses done for other economies.

Key words: CCAPM, economic growth, financial markets, term spreads, expectations.

JEL classification: G12, E43, E44

# 1 INTRODUCTION

The paper focuses on links between real economic activity and the state of financial markets. On the basis of Consumption Based Capital Asset Pricing Model (CCAPM) I prove that the relation between real economic activity and financial market expectations exists for Polish economy. The analysed relation probably rests on agent's expectations and his motivation to smooth the level of his consumption. In order to meet his expectations he is willing to hedge against recessions and to invest his endowment in financial markets. I depict the existence of this causality by regressing annual real seasonally adjusted logarithmic growth of retail sale on a proper nominal expected yield spreads. The empirical results suggest that nominal yield spreads facilitate the explanation of the volatility of one year retail sale growth (real annual seasonally adjusted retail sale growth). The analysis is compiled on monthly data mainly due to the lack of reasonable sample of quarterly time series. The monthly analysis confirms results of quarterly analyses conducted for other countries.

The presented approach is an example of implementation of the Capital Asset Pricing Model (CAPM) in the inverse sense. The origin of CAPM was to estimate the possible return from an asset and the plausible risk of the investment. Nowadays, however, host of researchers implement the CAPM framework to explain apparent relation between financial market expectations and real economic activity. Such attitude is also presented in this work.

Similar approach may be found in papers of Harvey (1997),Ferreira, Martinez, Navarro, and Rubio (2003) or Pena and Rodriguez (2006). Harvey proposed the CCAPM framework with CRRA (Constant Relative Risk Aversion) type utility function to explain the relation between real GDP growth and bond yield spreads for economies of United States and Canada. The paper concerns yield spreads calculated between short-term and long-term interest rates. The annual rate of Treasury bills is used as a short-term interest rate while bond yields of different maturities are used as long-term interest rate.

In the paper of Ferreira, Martinez, Navarro, and Rubio (2003) authors used an innovative approach implementing money market interest rates from seven different European countries and calculated for them interest term spreads. In order to avoid multicolinearity of time series the Principal Components Analysis (PCA) was conducted and eigenvectors were used for further calculations. Moreover, the capital market returns were implemented as additional explanatory variables apart from yield spreads. Authors assume that the last twelve months average returns of Eurostoxx-50 index are reasonable substitution of expected stock market returns. The conclusion is that expected stock market returns have additional explanatory power on expected consumption growth, but this power itself is very small.

An interesting approach to the CCAPM is presented in work of Pena and Rodriguez (2006). Authors derived the expected stock market returns by means of econometric model. On the basis of forecasts generated by econometric model they constructed expected stock market term spreads. The results combined with yield spreads were used to forecast expected consumption growth. The results presented for Canada confirmed the explanatory power of both: expected stock market term spreads and bond yields. The outcomes presented for Unites States were less clear-cut. On the one hand, yield spreads explanatory power in predicting future economic growth is confirmed. On the other hand, however, the significance of stock market term spreads is not stable, due to the possible structural break in stock market data.

The article is organised as follows. Section 2 presents the theoretical framework for the relation of real economic activity and the condition of financial markets. Section 3 presents empirical results and econometric estimations for Polish economy. Section 4 extends the analysis on the supply side of economy and finally section 5 presents ultimate conclusions. A detailed description of the data, all necessary data transformations and additional tables are included in appendix.

# 2 Model

Following Harvey (1997) and Ferreira, Martinez, Navarro, and Rubio (2003) I assume that representative agent has utility function with constant relative risk aversion (CRRA) parameter as presented bellow.

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

The $U(C_t, \gamma)$ stands for agent's intertemporal utility at time $t$, $C_t$ indicates the level of agent's consumption at time $t$. The utility function assumes constant coefficient of relative risk aversion ($\gamma$).

Assuming that $R_{i,t+j}$ denotes gross, real return on an asset held from time $t$ to $t+j$ Harvey (1997) and Ferreira, Martinez, Navarro, and Rubio (2003) showed that optimising (1) with respect to standard budget constraints gives the following Euler equation:

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

for $j = 1, ..., k$,

The equation (2) for many researchers is a starting point for an in-depth analysis of the relation between financial markets and real economic activity. At first, however, some additional assumptions ought to be done. Namely, assuming homoskedasticity and joint lognormality of consumption growth and real return on an asset the equation (2) can be rewritten as follows:

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

Further the relation (3) can be simplified as follows:

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

The lower cases denote log returns ($\Delta c_{t,t+1}=ln\left(\frac{C_{t+j}}{C_t}\right)$). The $r_{i,t+j}$ is the log of one plus interest rate, $\rho$ is consumer's rate of time preference ($ln\left(\beta\right)$), $\Theta=\frac{1}{\gamma}$ is the risk tolerance and $v_{i,t+j}$ is the conditional variance of the log interest rate plus the log consumption rate.

Differencing the equation (4) for $j=1$ and $j=k$ gives the relation between real economic activity and real yield term spread.

$$\Delta c_{t+1:t+k}=\psi+\Theta YS_t+u_{t+k} \quad (5)$$

The relation (5) depicts that future economic growth commencing in one period and ending in $t+k$ periods is linearly related to expected real yield spread ($YS_t=r_{i,t,t+k}-r_{i,t,t+1}$). Following Harvey (1997) the constant $\psi$ captures the conditional variance of consumption-return process, which is assumed to be constant. Since real yield spreads are not observed I follow Ferreira, Martinez, Navarro, and Rubio (2003) and implement nominal values according to the following reasoning. Assuming that:

$$X_{t,t+j}=\beta^j\left(\frac{C_{t+j}}{C_t}\right)^{-\gamma}(1+R_{i,t+j}) \quad (6)$$

the relation (2) can be written as follows:

$$lnE_t\left[X_{t,t+j}\right]=0 \quad (7)$$

Following Ferreira, Martinez, Navarro, and Rubio (2003) and considering Taylor expansion of $ln\left[X_{t,t+j}\right]$ around the $E_t\left[X_{t,t+j}\right]$ the $E_t\,ln\left[X_{t,t+j}\right]$ can be written as follows:

$$E_t\,ln\left[X_{t,t+j}\right]=\sum_{r=1}^{\infty}\frac{(-1)^{r-1}}{r\,!}E_t\,\left[X_{t,t+j}-1\right]^r=\Lambda_j \quad (8)$$

The parameter $\Lambda_j$ is a constant which differs across $j$ assuming that all central moments are constant and do not depend on time. Combining equations (6) and (8) the following relation is derived:

$$E_t\, ln\left[X_{t,t+j}\right] = E_t\, ln\left[\beta^j\left(\frac{C_{t+j}}{C_t}\right)^{-\gamma}(1+R_{i,t+j})\right] =$$
$$E_t\left[jln\beta - \gamma lnC_{t+j} + \gamma lnC_t + ln\left(1+R_{i,t+j}\right)\right] = \Lambda_j \tag{9}$$

Rearranging (9) I get:

$$E_t\left[ln\frac{C_{t+j}}{C_t}\right] = \frac{jln\beta - \Lambda_j}{\gamma} + \frac{1}{\gamma}E_t\left[ln\left(1+R_{i,t+j}\right)\right] \tag{10}$$

Applying some additional symbols (10) can be rewritten as follows:

$$E_t\left[\Delta c_{t,t+j}\right] = \alpha_j + \beta\left(r^n_{i,t+j} - E_t\left[\pi_{t,t+j}\right]\right) \tag{11}$$

where:

$\alpha_j = \frac{jln\beta - \Lambda_j}{\gamma}$
$\beta = \frac{1}{\gamma}$
$r^n_{i,t+j}$ - denotes nominal bond yield for j period instrument
$\pi_{t,t+j}$ - denotes inflation rate in period between t and t+j

Furthermore, I introduce the following symbols denoting by $NYS_{t-p-1,t,t+N}$ nominal yield spread at $t-p-1$ period calculated between nominal yields of debts securities maturing in $t$ and $t+N$ years. I assume that expected consumption growth is explained by real expected yield spread plus noise which is a stationary process. The expected real spreads for bond yields are quantified by average of past realisations of nominal yield spreads implying:

$$E_t\left[\Delta c_{t+1,t+N}\right] = \alpha + \beta\frac{1}{n+1}\sum_{k=0}^{n} NYS_{t-k,t,t+N} + \mu_t \tag{12}$$

The consistency between equation (11) and (12) if $N = j$ implies that:

$$r^n_{i,t+j} - E_t\left[\pi_{t,t+j}\right] = \theta_0 + \theta_1\frac{1}{n+1}\sum_{k=0}^{n} NYS_{t-k,t,t+N} \tag{13}$$

The equation (13) implies that nominal yield spreads are good predictors of real expected interest rates. Due to the close link between real interest rates and business cycle the equation (13) is sufficient to assume that nominal yield spreads are good predictors of real economic activity variables ( for demand side approximated by level of real consumption, for supply side by level of real output).

# 3 Empirical Analysis

In order to verify whether the presented model CCAPM holds for Polish economy it is necessary to find a reasonable substitution of real consumption. As far as this difficulty is concerned, one more matter ought to be considered. Namely, the relatively short history of Polish quarterly time series. Combining these two issues it is suggested to implement monthly time series of retail sale. The monthly analysis has additional advantages because on the one hand it allows to compare higher frequency data results with analysis conducted on lower frequency data. On the other hand, it does not require aggregation of financial time series implying demonstration of more accurate information.

Further analysis is based on the relation (5) where consumption growth is explained by real bond yield spread. As explained in the previous section, the nominal yield spreads are sound replacement of real yield spreads. The detailed description of the construction of both yield spreads and real seasonally adjusted growth of retail sale is situated in appendix (equation (A-1) and (A-3)). In order to keep the following analysis consistent with data construction presented in the appendix it is necessary to transform the relation (5) to the following one:

$$\Delta rrs_{t,t-k} = \alpha + \beta NYS_{t-p-1,t,t+N} + \mu_{t-k} \tag{14}$$

where:
$k = 12$
$p \in \langle k, \infty)$

$\Delta rrs_{t,t-k}$ denotes logarithmic one year increment ($k = 12$) of real seasonally adjusted retail sale, $NYS_{t-p-1,t,t+N}$ denotes nominal yield spread lagged p months and calculated between yields of government debt securities maturing in t and t+N years.

Such an intensive lagging for $p - 1$ is essential to make "expectations" consistent with $\Delta rrs_{t,t-k}$. Nominal yield spreads are calculated between yields of treasury bills and n-year yields of benchmark government bonds. Two yields of treasury bills are concerned:

- yields of 3-month treasury bills,
- yields of 12-month treasury bills.

As far as bond yields are concerned, the Polish benchmark bonds are used with maturities of: 2, 3, 4, 5, 10 years. Constructing yield spreads for Polish economy two issues must be taken into account. Firstly, the liquidity of the debt securities market. The most liquid treasury bills are 12-month treasury bills. The tenders for 12-month treasury bills are regularly organised and continuity of yield quotes is preserved. As the opposite, the tenders for 3-month treasury bills are less regular and in the period of last year not recorded. This is why not only yields of 3-month treasury bills are concerned but also yields of 12-month treasury bills.

Secondly, the situation on Polish interest rate market before European union accession differed from trends observed in developed economies. The reasons for Polish interest rate market distinctness are:

- need to satisfy convergence criteria,
- yield curve inversion.

The above factors cause that time series depicting yield spreads especially calculated between treasury bills and benchmark bonds with longer maturities than 3 years are non-stationary. The following tables prove the non-stationarity of those yield spreads.

Table 1: ADF Test - 10 year yield spread

| Variable: | $NYS_{1,10}$ | | | $NYS_{0.25,10}$ | |
|---|---|---|---|---|---|
| Information Criterion | AIC | SIC | HQ | AIC | SIC,HQ |
| No Lags | 2 | 0 | 1 | 11 | 2 |
| **ADF TEST** | -0.75 | -0.65 | -0.95 | -1.20 | -0.85 |
| 1% level | -3.50 | -3.50 | -3.50 | -3.52 | -3.51 |
| 5% level | -2.89 | -2.89 | -2.89 | -2.90 | -2.89 |
| 10% level | -2.58 | -2.58 | -2.58 | -2.58 | -2.58 |

Table 2: KPSS Test - 10 year yield test

| Variable: | $NYS_{1,10}$ | | $NYS_{0.25,10}$ | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Newey West Parzen kernel | Newey-West Bartlett kernel | Newey West Parzen kernel |
| Bandwidth | 7 | 11 | 6 | 10 |
| **KPSS test** | 0.98 | 0.88 | 1.03 | 0.89 |
| 1% level | 0.73 | 0.73 | 0.73 | 0.73 |
| 5% level | 0.46 | 0.46 | 0.46 | 0.46 |
| 10% level | 0.34 | 0.34 | 0.34 | 0.34 |

This implies that the relation (14) cannot be tested in traditional way as far as long term spreads are concerned and only spreads calculated for bonds with maturity no longer than 3 years could be concerned.[1] The implementation of yield spreads calculated for bonds with maturity no longer than 3 years in the relation (14) stands, however, in no opposition to the theoretical framework of CCAPM. It is because the relations (5) and (14) suggest that the yields of bonds with relatively short maturity should be concerned.[2] However, most of researchers use the yield spread calculated between 10-year government bond and 3-month Treasury Bills. The reason for this practice is probably the conviction that long spreads can reflect the slope of the yield curve.

[1]Further stationarity analyses are presented in appendix.

[2]Compare the construction of $YS_t$ with $\Delta c$ and analyse the subscripts in relations (2), (3) and (4).

As far as stationarity issue is concerned, it is important to draw attention to one more fact. Many researchers (as for example Estrella and Trubin (2006)) emphasise that the level of yield spread, not the rate of change, is only meaningful as far as its forecasting ability is concerned. This implies that differencing the non-stationary time series in this case is not the panacea for unit-root exclusion.

The presented above arguments imply that for further analysis "short" yield spreads [3] are used. To be specific, time series of three yield spreads proved to be stationary according to enclosed in the appendix test results. Namely, the following yield spreads were verified to be level stationary:

- $NYS_{t-p-1,1,2}$ - spread calculated between yields of 2-year Polish government bonds and yields of one-year treasury bills,
- $NYS_{t-p-1,0.25,2}$ -spread calculated between yields of 2-year Polish government bonds and yields of 3-month treasury bills,
- $NYS_{t-p-1,0.25,3}$ -spread calculated between yields of 3-year Polish government bonds and yields of 3-month treasury bills.

The spread calculated between yields of bonds with maturity of 3 years and yields of one year treasury bills $NYS_{t-p-1,1,3}$ seems to be non-stationary as far as presented in appendix results of the tests are concerned. This implies that it is possible to acquire stationary and economically meaningfully explanatory variables of the relation (14). It is however, also very important to have a stationary variable on the left hand side of the relation (14) in order to test the relation. The presented below results of ADF (table 3) and KPSS (table 4) tests confirm that the variable $\Delta rrs_{t,t-k}$ is level stationary ($I(0)$).

Table 3: ADF test - $\Delta rrs_{t,t-k}$

| Variable: | $\Delta rrs_{t,t-k}$ | |
|---|---|---|
| Information Criterion | AIC,HQ | SIC |
| No Lags | 11 | 0 |
| **ADF TEST** | -3.72 | -3.27 |
| 1% level | -3.52 | -3.51 |
| 5% level | -2.90 | -2.89 |
| 10% level | -2.58 | -2.58 |

As the set of stationary and economically meaningful variables is identified the relation (14) can be estimated. However, to the initial model specification two more variables need to be

[3]Here short stands for yield spreads calculated between yields of bonds with 2 or 3 years to maturity and treasury bills ( 3 or 12 month).

Table 4: KPSS test - $\Delta rrs_{t,t-k}$

| Variable: | $\Delta rrs_{t,t-k}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey-West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 11.9 | 10 | 24.4 |
| **KPSS test** | 0.15 | 0.11 | 0.13 | 0.09 |
| 1% level | 0.73 | 0.73 | 0.73 | 0.73 |
| 5% level | 0.46 | 0.46 | 0.46 | 0.46 |
| 10% level | 0.34 | 0.34 | 0.34 | 0.34 |

added. Namely, it is necessary to include early effects of European union accession which are visible in the data. This is the reason for model (14) respecifiaction which is as follows:

$$\Delta rrs_{t,t-k} = \alpha + \beta NYS_{t-p-1,t,t+N} + \gamma_1 D_{2005:04} + \gamma_2 D_{2004:04} + \mu_{t-k} \quad (15)$$

where:

$D_{2004:04}$- denotes an increase in retail sale one year growth one month before EU accession

$D_{2005:04}$- denotes a decrease in retail sale one year growth one year after EU accession

Model (15) implies that yield spreads should be lagged 13 periods for $k = 12$, however, very often researchers omit the proper number of lags assuming 12 periods (or even other) to be the accurate order. [4] In order to make results estimated for Polish economy comparable with outcomes for other countries both cases were considered. Furthermore, the estimates encompass the period 1999:01-2006:10 but since yields are lagged 13 (or 12) periods the sample is respectively shorter. For the estimates where explanatory variable is $NYS_{t-p-1,0.25,2}$ or $NYS_{t-p-1,0.25,3}$ the sample ends in 2006:01 since up to this point it was possible to calculate yields of 3-month treasury bills. After January 2006 tenders for 3 month treasury bills were suspended. In remaining cases the sample ends in 2006:10. The tables 5, 6 and 7 present the results of model (15) estimations. Since in all estimated models the autocorrelation is present the t-Statistics from an ordinary least squares regression will be incorrect.[5] The technique of Newey and West (1987) is used to recalculate the t-Statistics. The bolded lines mean staistical significance at least at the level of 5%.

The preliminary results suggest that the positive relation between real economic activity ( here presented by one year logarithmic growth of real seasonally adjusted retail sale) and nominal yield spreads might exists. Additional test, however, must be conducted. The table

[4]As for example Hamilton and Kim (2000).

[5]The results of autocorrelation tests are not presented in order to save space, however can be presented on demand.

Table 5: The estimates on the sample: 2000:05 2006:01 - Yield Spreads Lagged 12 periods

| Variable | $NYS_{t-12,0.25,2}$ | | $NYS_{t-12,0.25,3}$ | | $NYS_{t-12,1,2}$ | | $NYS_{t-12,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | -0.795 | -0.570 | **1.781** | **2.185** | **3.044** | **1.923** | **3.198** | **3.197** |
| $\gamma_1$ | **-0.193** | **-13.559** | **-0.213** | **-13.524** | **-0.220** | **-12.047** | **-0.234** | **-12.910** |
| $\gamma_2$ | **0.221** | **18.847** | **0.223** | **20.521** | **0.227** | **21.081** | **0.220** | **21.764** |
| $\alpha$ | 0.020 | 1.735 | **0.026** | **2.083** | **0.023** | **2.008** | **0.035** | **2.780** |
| $R^2$ | 0.321 | | 0.358 | | 0.351 | | 0.452 | |

Table 6: The estimates on the sample: 2000:05 2006:01 - Yield Spreads Lagged 13 periods

| Variable | $NYS_{t-13,0.25,2}$ | | $NYS_{t-13,0.25,3}$ | | $NYS_{t-13,1,2}$ | | $NYS_{t-13,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | -1.300 | -0.897 | **1.479** | **1.821** | 2.425 | 1.491 | **3.065** | **3.170** |
| $\gamma_1$ | **-0.191** | **-13.481** | **-0.210** | **-12.927** | **-0.211** | **-12.445** | **-0.227** | **-13.353** |
| $\gamma_2$ | **0.223** | **18.981** | **0.221** | **18.483** | **0.223** | **19.643** | **0.219** | **20.330** |
| $\alpha$ | 0.019 | 1.675 | **0.024** | **1.903** | **0.022** | **1.858** | **0.034** | **2.642** |
| $R^2$ | 0.332 | | 0.346 | | 0.339 | | 0.442 | |

7 presents further estimations of the model (15) for the extended sample only with $NYS_{t-p,1,2}$ and $NYS_{t-p,1,3}$.[6]

Table 7: The estimates on the sample: 2000:05 2006:10 - Yield Spreads Lagged 12 & 13 periods

| Variable | $NYS_{t-12,1,2}$ | | $NYS_{t-12,1,3}$ | | $NYS_{t-13,1,2}$ | | $NYS_{t-13,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | **4.241** | **2.358** | **3.907** | **3.651** | **3.520** | **1.939** | **3.764** | **3.764** |
| $\gamma_1$ | **-0.238** | **-12.023** | **-0.249** | **-13.693** | **-0.226** | **-12.735** | **-0.242** | **-0.242** |
| $\gamma_2$ | **0.221** | **21.284** | **0.213** | **22.402** | **0.214** | **19.296** | **0.210** | **0.210** |
| $\alpha$ | **0.033** | **2.852** | **0.045** | **3.706** | **0.032** | **2.709** | **0.044** | **0.044** |
| $R^2$ | 0.326 | | 0.451 | | 0.308 | | 0.437 | |

General results suggest that there exists the positive relation between real economic activity and yield spread in Poland. The parameters are significant and have the expected sign. Moreover, the credibility of presented in table 7 results is supported by results of residuals distribution diagnostic tests presented in table 8 [7]. Although, estimations seems to support the relation (14) it must be emphasised that the model with $NYS_{t-12,1,3}$ as explanatory variable ought to be treated with caution since unit root test indicated that $NYS_{t-12,1,3}$ might be I(1).

[6]Tenders for 12- month treasury bills (52 weeks) are regularly organised also after January 2006 so yield spreads are possible to calculate.

[7]Tests for normality of residuals for estimates presented in tables 5 and 6 were also conducted and are not presented in order to save space. All residuals passed the normality tests.

Table 8: Residuals Normality Tests CCAPM models

| Model | $NYS_{t-12,1,2}$ | $NYS_{t-12,1,3}$ | $NYS_{t-13,1,2}$ | $NYS_{t-13,1,3}$ |
|---|---|---|---|---|
| Mean | 0 | 0 | 0 | 0 |
| Median | 0 | 0 | 0 | 0 |
| Maximum | 0.146 | 0.142 | 0.148 | 0.138 |
| Minimum | -0.114 | -0.127 | -0.112 | -0.127 |
| Std. Dev. | 0.054 | 0.048 | 0.055 | 0.049 |
| Skewness | 0.275 | 0.275 | 0.234 | 0.202 |
| Kurtosis | 2.548 | 3.084 | 2.531 | 2.987 |
| Jarque-Bera Test | 1.649 | 1.011 | 1.411 | 0.526 |
| Probability | 0.438 | 0.603 | 0.493 | 0.768 |

Although presented results seem to be satisfying some comments need to be done. Firstly, due to the lack of sufficient quarterly data the analysis is done on the monthly data. The level of retail sale is proposed as a measure of the level of consumption. As a result, the proposed variable might be only an approximation of the genuine level of consumption.

Secondly, as far as yield spreads are concerned the problem of unit root exists. The presented in appendix tests suggest that only "shorter" term spreads are level stationary (with one exception ) implying that it is impossible to test the relation between the real economic activity and "longer" yield spreads.

Considering the above drawbacks the following section proposes an alternative approach extending the analysis on production side of the economy. This solves the first drawback of presented above reasoning and give the researcher the option to use different measure of real economic activity than various measures of consumption.

# 4 Further issues - supply side of the economy

This section proposes an alternative approach to the relation between real economic activity and the state of financial markets. The idea of this section is not to derive the theoretical framework of Production Based Capital Asset Pricing Model (PCAPM) but to verify the hypothesis of the possible existence of the relation between the supply side of the economy and the state of financial markets.This section is introduced as the extension of the previous due to the lack of the ideal measure of consumption. Although the theoretical framework of PCAPM is not derived I will use the abbreviation PCAPM further in the paper in order to distinguish between the supply side of the economy (PCAPM) and demand side of the economy (CCAPM).

The argumentation supporting the Production Based Capital Asset Pricing Model may be presented at least in two ways. Firstly, companies striving to hedge their liquidity risk plan to match maturity of their capital projects with maturity of its financing. As a result, companies foreseeing future economic slowdown will not plan long-term capital investments reducing the number of long-term corporate bonds. The decrease in the number of available long-term financial instruments causes its prices to rise and yields to fall declining the slope of the term structure. Additionally, short-term financing can put extra pressure on short-term interest rates and further reduce the slope of the yield curve. Such an attitude toward Production Based Capital Asset pricing model is presented in articles of Cochrane (1991) and Brock (1982).

Secondly, as Balvers and Huang (2005) or Belo (2006) proposed that aggregate output might be proportionate or even equal to aggregate consumption in a competitive economy with complete financial markets. Further, they argue that marginal rate of intertemporal substitution is tied to a stochastic version of the marginal rate of intertemporal transformation.

The above arguments suggest that the a smooth transition between Consumption based Capital Asset Pricing Model and Production based Capital Asset Pricing Model might exist. As a result, the relation (5) in the framework of Production Based Capital Asset Pricing Model can be rewritten as follows:

$$\Delta p_{t+1:t+k} = \psi + \Theta YS_t + u_{t+k} \tag{16}$$

where $\Delta p_{t+1:t+k}$ denotes one year growth of real production. For the purpose of this study time series of industrial production is used as a measure of the value of production recorded in Polish economy. This indicator of economic activity is widely exploited by researchers (Mehl, 2006) mainly since it is available on the monthly basis which is of great importance for economies where history of quarterly time series is relatively short.

The verification of the relation (16) is based on the following econometric model:

$$\begin{aligned} \Delta rsp_{t,t-k} = \alpha + \beta NYS_{t-p-1,t,t+N} + \gamma_1 D_{2005:04} \\ +\gamma_2 D_{2005:03} + \gamma_3 D_{2005:02} + \gamma_4 D_{2004:04} + \gamma_5 D_{2004:03} + \gamma_6 D_{2004:02} + \mu_{t-k} \end{aligned} \tag{17}$$

where:
$k = 12$
$p \in \langle k, \infty)$

$\Delta rsp_{t,t-k}$ denotes logarithmic one year increment of real seasonally adjusted industrial production, $NYS_{t-p-1,t,t+N}$ denotes nominal yield spread lagged p-1 months and calculated between yields of government debt securities maturing in t and t+N years. The detailed construction of the data is presented in appendix (equation (A-1), (A-2) and (A-3)). The construction and selection of yield spreads as explanatory variables are similar to the one proposed in the previous section. Additionally, there are two sets of dummy variables which are initiated due to the EU accession. They can be divided into:

Table 9: ADF test $\Delta rsp_{t,t-k}$

| Variable: | $\Delta rsp_{t,t-k}$ | |
|---|---|---|
| Information Criterion | AIC,HQ | SIC |
| No Lags | 1 | 0 |
| **ADF TEST** | -2.023 | -3.374 |
| 1% level | -3.506 | -3.505 |
| 5% level | -2.894 | -2.894 |
| 10% level | -2.584 | -2.584 |

- pre-accession dummies $D_{2004:02}$, $D_{2004:03}$, $D_{2004:04}$ that denote respectively an increase in industrial production one year growth three, two and one month before EU accession,

- post-accession dummies $D_{2005:02}$, $D_{2005:03}$, $D_{2005:04}$ that denote a decrease in industrial production one year growth one year after EU accession respectively in February, March and April 2005.

Dummy variables are present in the model (17) because the effects of EU accession ought to be eliminated from the time series in order not to blur final results. Before the ultimate estimates are presented the stationarity tests of all variables need to be conducted. Since the explanatory variables are the same as in the previous section only integration level of $rsp$ ought to be tested. Unfortunately, the results presented in tables 9 and 10 are rather ambiguous. Namely, the ADF test with lag number equal 1 cannot rejected the $H_0$ (at any significance level) and also all variants of KPSS test can not reject $H_0$. In this case, it is, however, assumed that ADF test results are blurred by autocorrelation and variable $rsp$ is treated as level stationary for the purpose of this research. Additional tests presented in appendix (table A-1) support the assumption.

Table 10: KPSS test - $\Delta rsp_{t,t-k}$

| Variable: | $\Delta rsp_{t,t-k}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey-West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 12.4 | 10 | 25 |
| **KPSS test** | 0.387 | 0.268 | 0.339 | 0.232 |
| 1% level | 0.739 | 0.739 | 0.739 | 0.739 |
| 5% level | 0.463 | 0.463 | 0.463 | 0.463 |
| 10% level | 0.347 | 0.347 | 0.347 | 0.347 |

Since majority of variables seems to be stationary it is possible to estimate all variants of the model (17) with particularly no risk of spurious regression. The estimation results are presented in the following tables. The estimation procedure is the same as in previous section.

The t-Statistics are recalculated on the basis of Newey and West (1987) methodology. The bolded lines mean significance at least at the level of 5%.

Table 11: Estimates on the sample: 2000:05 2006:01 Yield Spreads lagged 12 periods

| Variable | $NYS_{t-12,0.25,2}$ | | $NYS_{t-12,0.25,3}$ | | $NYS_{t-12,1,2}$ | | $NYS_{t-12,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | -0.173 | -0.104 | **2.086** | **2.913** | **3.138** | **2.153** | **3.136** | **3.453** |
| $\gamma_1$ | **-0.032** | **-2.474** | **-0.053** | **-3.941** | **-0.057** | **-3.703** | **-0.070** | **-5.236** |
| $\gamma_2$ | **-0.073** | **-5.762** | **-0.092** | **-6.979** | **-0.092** | **-6.774** | **-0.105** | **-8.573** |
| $\gamma_3$ | **-0.036** | **-2.716** | **-0.057** | **-4.229** | **-0.057** | **-4.081** | **-0.070** | **-5.627** |
| $\gamma_4$ | **0.1376** | **12.476** | **0.138** | **15.503** | **0.142** | **15.509** | **0.134** | **17.465** |
| $\gamma_5$ | **0.121** | **11.887** | **0.117** | **12.268** | **0.120** | **12.967** | **0.115** | **14.730** |
| $\gamma_6$ | **0.117** | **11.399** | **0.112** | **11.420** | **0.118** | **12.911** | **0.108** | **13.382** |
| $\alpha$ | **0.046** | **4.527** | **0.054** | **5.137** | **0.050** | **5.154** | **0.061** | **6.821** |
| $R^2$ | 0.305 | | 0.392 | | 0.360 | | 0.499 | |

Table 12: Estimates on the sample: 2000:05 2006:01 Yield Spreads lagged 13 periods

| Variable | $NYS_{t-13,0.25,2}$ | | $NYS_{t-13,0.25,3}$ | | $NYS_{t-13,1,2}$ | | $NYS_{t-13,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | -0.728 | -0.419 | **1.752** | **2.098** | 2.422 | 1.453 | **2.986** | **3.228** |
| $\gamma_1$ | **-0.030** | **-2.370** | **-0.049** | **-3.515** | **-0.048** | **-3.243** | **-0.064** | **-4.970** |
| $\gamma_2$ | **-0.069** | **-5.079** | **-0.090** | **-6.251** | **-0.089** | **-5.772** | **-0.105** | **-7.975** |
| $\gamma_3$ | **-0.034** | **-2.695** | **-0.054** | **-3.774** | **-0.049** | **-3.674** | **-0.066** | **-5.321** |
| $\gamma_4$ | **0.138** | **13.362** | **0.135** | **13.439** | **0.137** | **14.189** | **0.132** | **16.150** |
| $\gamma_5$ | **0.120** | **11.493** | **0.116** | **11.318** | **0.122** | **12.727** | **0.112** | **13.193** |
| $\gamma_6$ | **0.115** | **10.389** | **0.114** | **11.519** | **0.118** | **12.382** | **0.107** | **12.349** |
| $\alpha$ | **0.046** | **4.459** | **0.052** | **4.797** | **0.049** | **4.818** | **0.061** | **6.412** |
| $R^2$ | 0.312 | | 0.366 | | 0.339 | | 0.481 | |

The estimates suggest that there is a statistically significant relation between real industrial production one year growth and relatively "short" yield spreads. The positive and stable in time relation is especially apparent for yield spreads lagged 12 periods particularly for $NYS_{t-12,1,2}$. Moreover, the results of estimates for models with $NYS_{t-p-1,1,3}$ as explanatory variable ought to be treated with caution due to possible non-stationarity of $NYS_{t-p-1,1,3}$. In general, however, the estimates of PCAPM confirm the results obtained in the previous section implying that the relation between real economic activity and the slope of yield curve exists also for Polish economy.

Table 13: Estimates on the sample: 2000:05 2006:10 - Yield Lagged 12 & 13 periods

| Variable | $NYS_{t-12,1,2}$ | | $NYS_{t-12,1,3}$ | | $NYS_{t-13,1,2}$ | | $NYS_{t-13,1,3}$ | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat. | Coef. | t-Stat |
| $\beta$ | **4.217** | **2.588** | **3.728** | **3.873** | 3.436 | 1.860 | **3.605** | **3.605** |
| $\gamma_1$ | **-0.073** | **-4.288** | **-0.083** | **-6.033** | **-0.061** | **-3.861** | **-5.718** | **-5.718** |
| $\gamma_2$ | **-0.105** | **-7.203** | **-0.117** | **-9.378** | **-0.103** | **-6.185** | **-8.626** | **-8.626** |
| $\gamma_3$ | **-0.071** | **-4.681** | **-0.082** | **-6.456** | **-0.061** | **-4.317** | **-6.081** | **-6.081** |
| $\gamma_4$ | **0.136** | **15.457** | **0.128** | **17.219** | **0.130** | **13.594** | **15.746** | **15.746** |
| $\gamma_5$ | **0.113** | **12.440** | **0.109** | **14.348** | **0.115** | **12.254** | **12.593** | **12.593** |
| $\gamma_6$ | **0.112** | **12.544** | **0.101** | **12.874** | **0.111** | **11.924** | **11.680** | **11.680** |
| $\alpha$ | **0.058** | **5.993** | **0.070** | **7.853** | **0.058** | **5.632** | **7.347** | **7.347** |
| $R^2$ | 0.328 | | 0.490 | | 0.299 | | 0.470 | |

Table 14: Residuals Normality Test PCAPM models

| Model | $NYS_{t-12,2,52}$ | $NYS_{t-12,3,52}$ | $NYS_{t-13,2,52}$ | $NYS_{t-13,3,52}$ |
|---|---|---|---|---|
| Mean | 0 | 0,00 | 0,00 | 0,00 |
| Median | 0 | 0 | 0 | 0 |
| Maximum | 0.095 | 0.083 | 0.089 | 0.077 |
| Minimum | -0.091 | -0.095 | -0.103 | -0.097 |
| Std. Dev. | 0.043 | 0.037 | 0.044 | 0.038 |
| Skewness | -0.05 | 0.077 | -0.099 | 0.043 |
| Kurtosis | 2.480 | 2.699 | 2.435 | 2.602 |
| Jarque-Bera | 0.909 | 0.371 | 1.15 | 0.53 |
| Probability | 0.634 | 0.830 | 0.562 | 0.767 |

# 5 Final tests and conclusions

The purpose of this section is to compare the results of CCAPM and PCAPM and to draw economically meaningful conclusions on the character and stability of the relation between real economic activity and state of financial markets in Poland. The figures from 1 to 8 present 3 types of Chow stability tests:

- 1-Step Chow test ($\frac{(RSS_t - RSS_{t-1})(t-k-1)}{RSS_{t-1}}$) for $t = M, ..., T$ where $M$ denotes the initial sample,
- N-down Chow test ($\frac{(RSS_T - RSS_{t-1})(t-k-1)}{RSS_{t-1}(T-t+1)}$) for $t = M, ..., T$ where number of forecasts goes from $N = T - M + 1$ to 1 and $M$ denotes the initial sample,
- N-up Chow test ($\frac{(RSS_t - RSS_{M-1})(M-k-1)}{RSS_{M-1}(t-M+1)}$) for $t = M, ..., T$ where number of forecasts goes from M to T and $M$ denotes the initial sample.

All tests presented in the following figures are recursively calculated. The initial sample ($M$) encompasses the 20% of the whole sample and one step is equal to one observation. Test were also conducted for different percentage of initial sample (different $M$) but the conclusions were identical. The values of the statistics are standardized in the way that critial values (critical values are calculated for $\alpha = 1\%$) are constant and equal 1. Tests were conducted for models from previous sections where estimates were statisticaly significant and economically meaningful.

Figure 1: Chow stability test for CCAPM model version with $NYS_{t-12,0.25,3}$ as explanatory variable

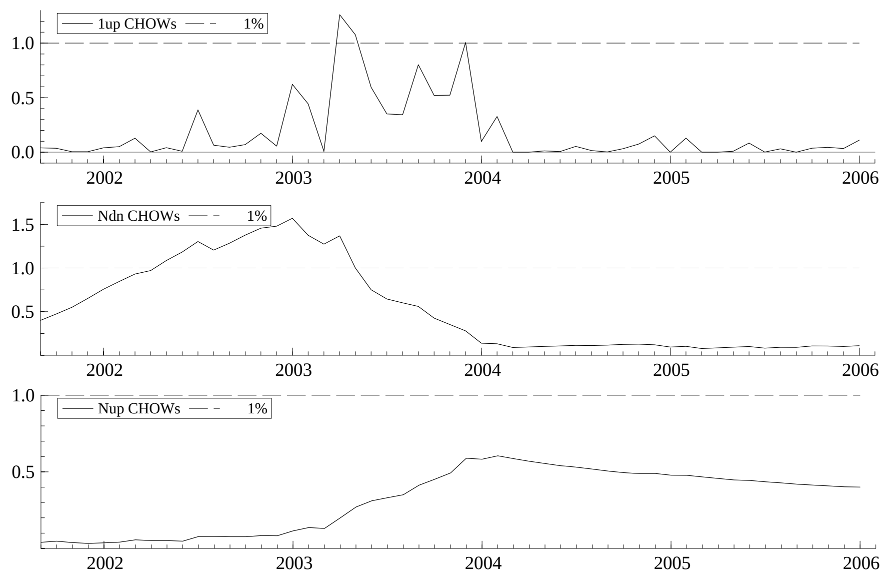


Figure 2: Chow stability test for CCAPM model version with $NYS_{t-12,1,2}$ as explanatory variable

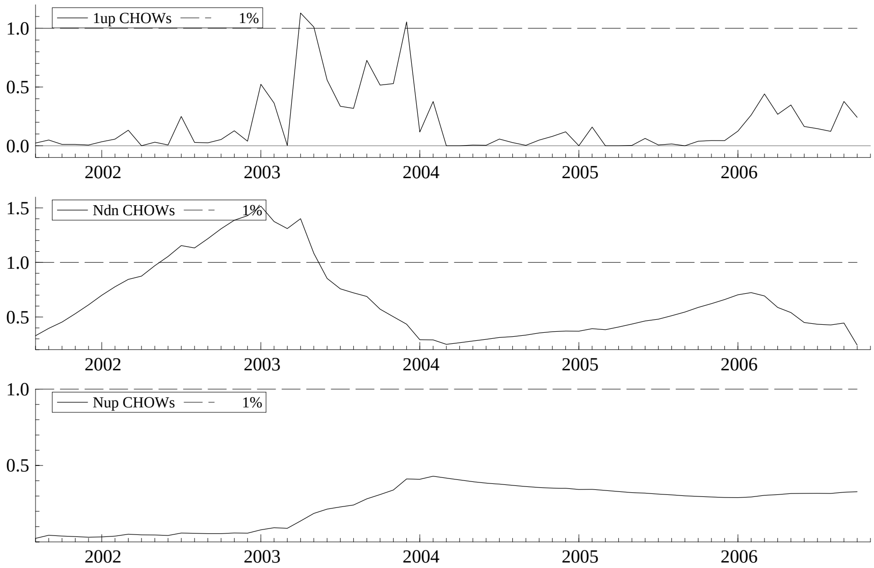



Figure 3: Chow stability test for CCAPM model version with $NYS_{t-13,0.25,3}$ as explanatory variable

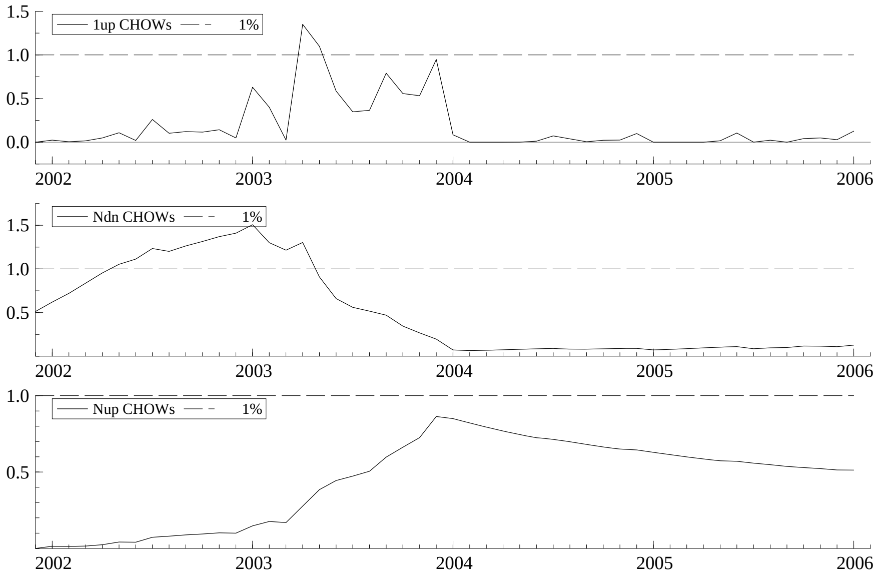


Figure 4: Chow stability test for CCAPM model version with $NYS_{t-13,1,2}$ as explanatory variable

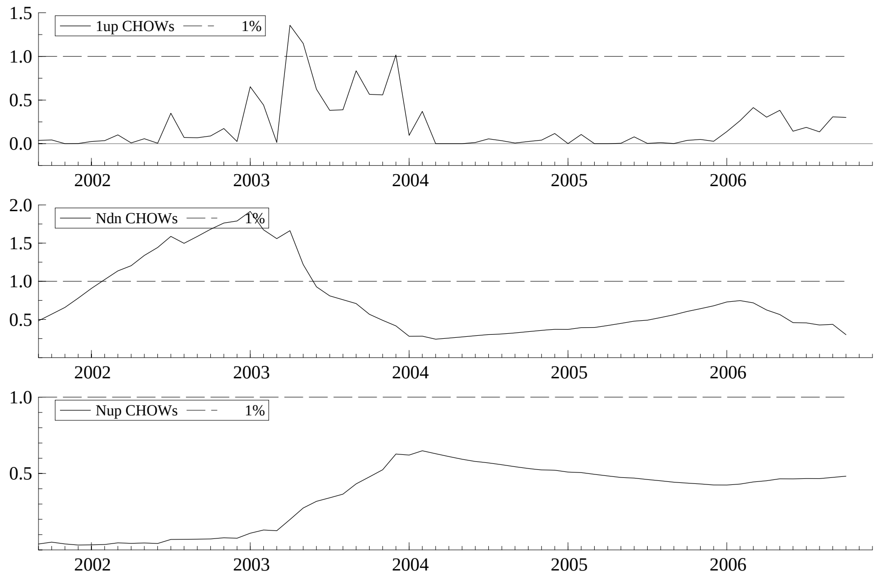



Figure 5: Chow stability test for PCAPM model version with $NYS_{t-12,1,2}$ as explanatory variable

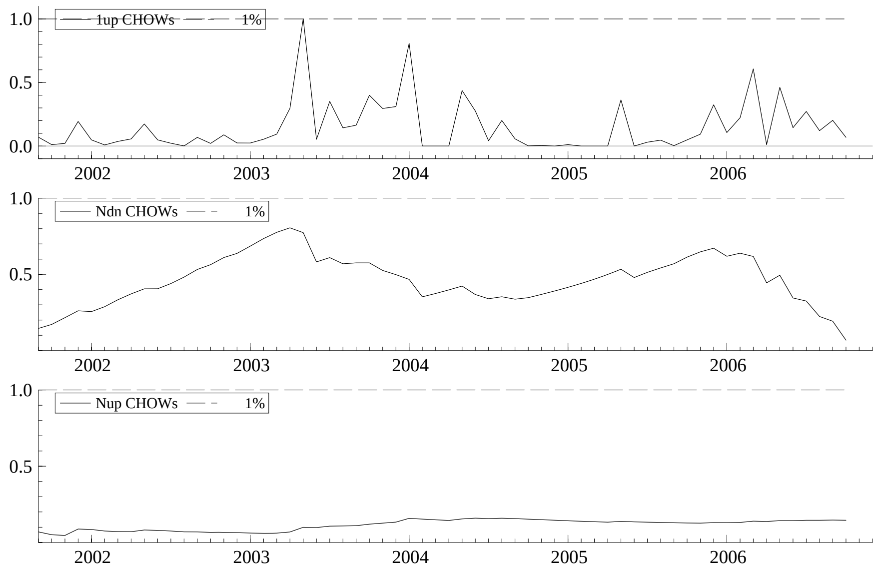


Figure 6: Chow stability test for PCAPM model version with $NYS_{t-12,0.25,3}$ as explanatory variable

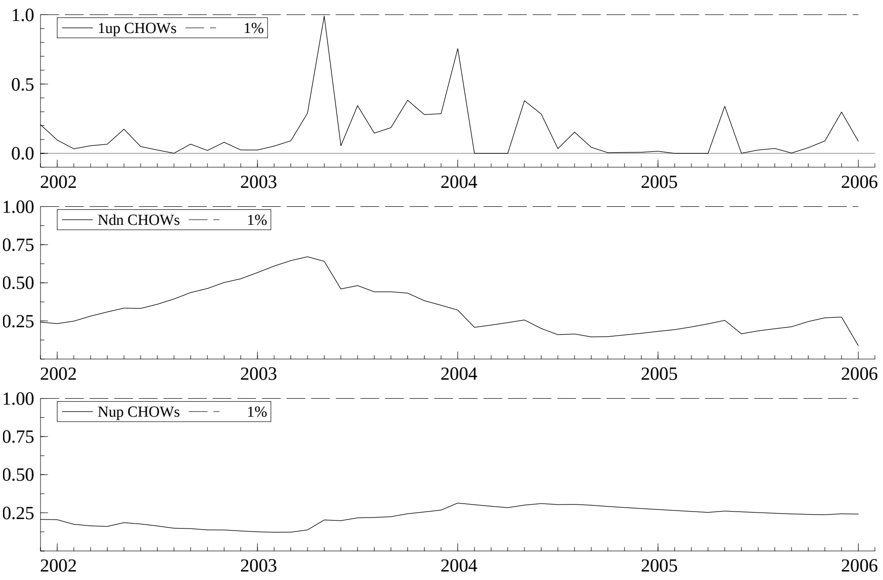



Figure 7: Chow stability test for PCAPM model version with $NYS_{t-13,1,2}$ as explanatory variable

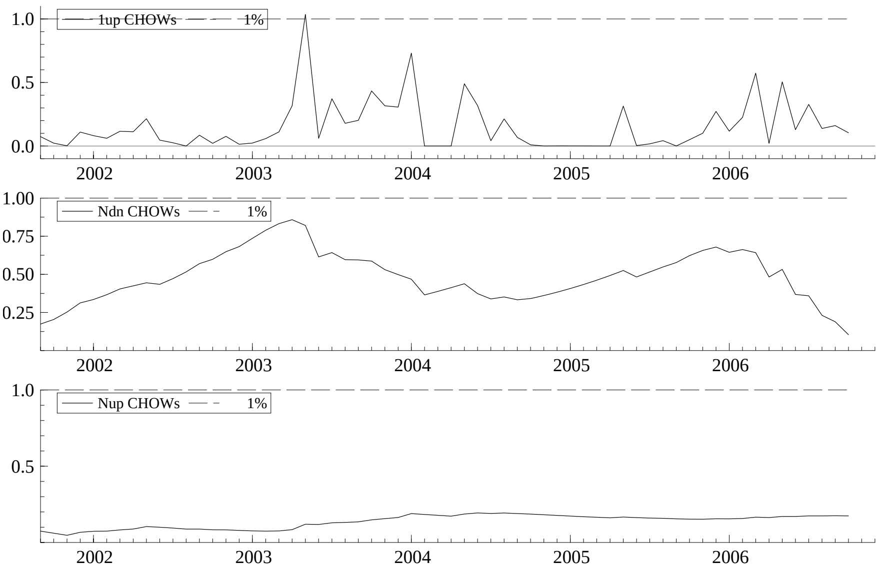
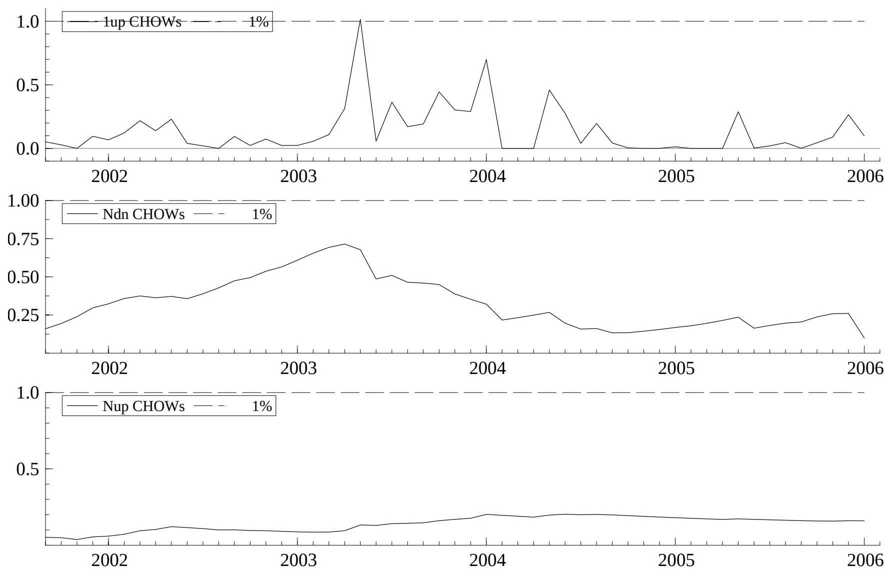


Figure 8: Chow stability test for PCAPM model version with $NYS_{t-13,0.25,3}$ as explanatory variable




The overall conclusion is that models of PCAPM seem to be more stable in time than models of CCAPM. In all variants of test the EU accession effects are apparent. In case of CAPM the effects may even cause the instability of the parameter estimates. The instability of the CCAPM estimates is, however, not affirmed since some evidence of instability are present only for N-down version of CHOW test. The estimates of PCAPM model seems to be stable in time.

The worse CHOW test results for CCAPM than PCAPM might be due to the following reasons. Firstly, as many researchers emphasise, it is extremely difficult to find a reasonable measure of consumption. Host of economists use quarterly consumption of nondurable goods or simply GDP. However, in case of Polish economy the quarterly time series are relatively short implying that the analyses should be conducted on monthly time series. This is the reason why real retail sale is used, although it does not include such effects as demand on rendered services or consumption of leisure time.

Secondly, debt securities investments are not as popular in Poland as it is in developed countries. However, it must be emphasised that recently due to the very low interest rates and ongoing developments of Polish financial markets the units of investment funds have gained on popularity. This is why considerable part of savings may be invested in debt securities by means of investment funds.

Concluding, the presented paper proves that the relation between real economic activity and state of financial markets (depicted by the slope of yield curve) for Poland seems to exist. The research proposes two points of view. On the one hand, the relation between real economic activity and state of financial markets is considered for the demand side of the economy under Consumption based Capital Asset Pricing Model. On the other hand, the results of the demand side of the economy are compared with its supply side. In general both the demand (CCAPM) as well as supply (PCAPM) models relate the real economic activity with value of nominal yield spreads. In this way it is proved that the slope of the yield curve facilitates to forecast future real economic activity in Poland.

The study differs from its counterparts in a way that it applies relatively "short" yield spreads placing in this way emphasis mainly on initial "knot points" of the yield curve. Such a solution steams from specific character of Polish financial markets, however, is fully supported by economic framework. In this way the agreement between econometric requirements (stationarity of time series) and economic common sense ( interpretation of yield spreads) are reached. The results should be treated with caution due to the short sample, stationarity issues and some evidence of possible instability of parameters. Moreover, the results cannot be fully compared with those studies which as an explanatory variable apply "long" yield spreads ( calculated for example between: yields of 10-year bonds and 3-month treasury bills ).

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# APPENDIX

## DATA DESCRIPTION

$$\Delta rss_{t,t-k} = ln\left(\frac{rss_t}{rss_{t-k}}\right) \tag{A-1}$$

$rss_t$ - denotes real seasonally adjusted level of retail sale, monthly data, source Polish Central Statistical Office.

$$\Delta rsp_{t,t-k} = ln\left(\frac{rsp_t}{rsp_{t-k}}\right) \tag{A-2}$$

$rsp_t$ - denotes real seasonally adjusted level of industrial production,monthly data, source Polish Central Statistical Office.

In the presented article one year logarithmic increments of $rss$ and $rsp$ are used ($k = 12$, $\Delta rss_{t,t-12}$ and $\Delta rsp_{t,t-12}$ ).

$$NYS_{t-p-1,t,t+N} = \frac{1 + R^{t+N}}{1 + R^t} \tag{A-3}$$

$NYS_{t-p-1,t,t+N}$ - denotes nominal bond yield spread lagged $p - 1$ months

$R^{t+N}$ - denotes nominal yield of Polish government benchmark bond maturing in N years (long interest rate), monthly data, period average, source Reuters

$R^t$ - denotes yield of Polish treasury bills (short interest rate): 3-month treasury bills or 12-month treasury bills, monthly data, period average,source Polish Ministry of Finance

The seasonally adjusted time series are derived by means of TramoSeats procedure.

## EXAMPLES OF DATA ENCODING

$NYS_{t-12,0.25,3}$ - denotes 12-month lagged nominal yield spread calculated between yield of 3-month (13-week) treasury bills and yield of Polish benchmark bonds maturing in 3 years
$NYS_{t-13,1,2}$ - denotes 13-month lagged nominal yield spread calculated between yield of 1-year (52-week) treasury bills and yield of Polish benchmark bonds maturing in 2 years

## UNIT ROOT TESTS

In the enclosed below unit-root tests the optimal number of lags for ADF test is chosen on the basis of information criteria: Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQ). As far as Philips Perron and KPSS tests are concerned, the bandwidth is chosen on the basis of Newey and West (1995) and Andrews (1991).

Table A-1: Philips Perron test for $rsp$

| Variable: | $rsp$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 2.16 | 9 | 3.49 |
| **Phillips-Perron test** | -3.172 | -2.959 | -3.104 | -2.932 |
| 1% level | -3.505 | -3.505 | -3.505 | -3.505 |
| 5% level | -2.894 | -2.894 | -2.894 | -2.894 |
| 10% level | -2.584 | -2.584 | -2.584 | -2.584 |

Table A-2: Phillips-Perron test for $rrs$

| Variable: | $rrs$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 5 | 2.08 | 8 | 3.42 |
| **Phillips-Perron test** | -3.093 | -2.976 | -3.044 | -2.952 |
| 1% level | -3.514 | -3.514 | -3.514 | -3.514 |
| 5% level | -2.898 | -2.898 | -2.898 | -2.898 |
| 10% level | -2.586 | -2.586 | -2.586 | -2.586 |

Table A-3: ADF test of all $NYS$ variables

| Variable: | $NYS_{1,2}$ | $NYS_{0.25,2}$ | | $NYS_{1,3}$ | $NYS_{0.25,3}$ | |
|---|---|---|---|---|---|---|
| Information Criterion | AIC,SIC,HQ | AIC | SIC,HQ | AIC,SIC,HQ | AIC | SIC,HQ |
| No Lags | 1 | 4 | 1 | 1 | 2 | 1 |
| **ADF TEST** | -3.916 | -3.374 | -4.783 | -2.406 | -2.810 | -3.941 |
| 1% level | -3.515 | -3.509 | -3.506 | -3.506 | -3.516 | -3.515 |
| 5% level | -2.898 | -2.895 | -2.894 | -2.894 | -2.899 | -2.898 |
| 10% level | -2.586 | -2.585 | -2.584 | -2.584 | -2.586 | -2.586 |

Table A-4: Phillips-Perron test of $NYS_{1,2}$

| Variable: | $NYS_{1,2}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 2 | 3.76 | 8 | 6.97 |
| **Phillips-Perron test** | -3.278 | -3.220 | -3.058 | -3.138 |
| 1% level | -3.514 | -3.514 | -3.514 | -3.514 |
| 5% level | -2.898 | -2.898 | -2.898 | -2.898 |
| 10% level | -2.586 | -2.586 | -2.586 | -2.586 |

Table A-5: KPSS test of $NYS_{1,2}$

| Variable: | $NYS_{1,2}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 14.2 | 9 | 30.1 |
| **KPSS test** | 0.687 | 0.495 | 0.726 | 0.371 |
| 1% level | 0.739 | 0.739 | 0.739 | 0.739 |
| 5% level | 0.463 | 0.463 | 0.463 | 0.463 |
| 10% level | 0.347 | 0.347 | 0.347 | 0.347 |

Table A-6: KPSS test of $NYS_{0.25,2}$

| Variable: | $NYS_{0.25,2}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 5 | 10.6 | 8 | 21.4 |
| **KPSS test** | 0.179 | 0.166 | 0.165 | 0.162 |
| 1% level | 0.739 | 0.739 | 0.739 | 0.739 |
| 5% level | 0.463 | 0.463 | 0.463 | 0.463 |
| 10% level | 0.347 | 0.347 | 0.347 | 0.347 |

Table A-7: Phillips-Perron test of $NYS_{0.25,2}$

| Variable: | $NYS_{0.25,2}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 3.37 | 11 | 6.3 |
| **Phillips-Perron test** | -3.531 | -3.681 | -3.420 | -3.680 |
| 1% level | -3.514 | -3.514 | -3.514 | -3.514 |
| 5% level | -2.898 | -2.898 | -2.898 | -2.898 |
| 10% level | -2.586 | -2.586 | -2.586 | -2.586 |

Table A-8: KPSS test of $NYS_{1,3}$

| Variable: | $NYS_{1,3}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 32.9 | 10 | 80.3 |
| **KPSS test** | 1.091 | 0.371 | 0.944 | 0.332 |
| 1% level | 0.739 | 0.739 | 0.739 | 0.739 |
| 5% level | 0.463 | 0.463 | 0.463 | 0.463 |
| 10% level | 0.347 | 0.347 | 0.347 | 0.347 |

Table A-9: Phillips-Perron test of $NYS_{1,3}$

| Variable: | $NYS_{1,3}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 3 | 4.64 | 9 | 8.44 |
| **Phillips-Perron test** | -1.927 | -1.822 | -1.713 | -1.753 |
| 1% level | -3.505 | -3.505 | -3.505 | -3.505 |
| 5% level | -2.894 | -2.894 | -2.894 | -2.894 |
| 10% level | -2.584 | -2.584 | -2.584 | -2.584 |

Table A-10: KPSS test of $NYS_{0.25,3}$

| Variable: | $NYS_{0.25,3}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 14.3 | 9 | 30.4 |
| **KPSS test** | 0.683 | 0.521 | 0.699 | 0.387 |
| 1% level | 0.739 | 0.739 | 0.739 | 0.739 |
| 5% level | 0.463 | 0.463 | 0.463 | 0.463 |
| 10% level | 0.347 | 0.347 | 0.347 | 0.347 |

Table A-11: Phillips-Perron test of $NYS_{0.25,3}$

| Variable: | $NYS_{0.25,3}$ | | | |
|---|---|---|---|---|
| Information Criterion | Newey-West-Bartlett kernel | Andrews Bartlett kernel | Newey West Parzen kernel | Andrews Parzen kernel |
| Bandwidth | 6 | 3.76 | 11 | 6.98 |
| **Phillips-Perron test** | -2.839 | -3 | -2.715 | -2.971 |
| 1% level | -3.514 | -3.514 | -3.514 | -3.514 |
| 5% level | -2.898 | -2.898 | -2.898 | -2.898 |
| 10% level | -2.586 | -2.586 | -2.586 | -2.586 |