20th Annual ICMAIF Conference

# Forecasting turning points of the business cycle: dynamic logit models for panel data

Anna Pestova

Senior expert, CMASF
Research fellow, National Research University
Higher School of Economics, Institute for Economic Forecasting

Rethymno
26.05.2016

# The research question

- How to classify the states of the business cycle into the recessionary and expansionary episodes in advance?
  - More importantly, how to predict recessions?
- Useful for macroeconomic forecasting
  - Linear forecasting models tend to perform poorly at the outbreaks of recessions
  - Nonlinear models may improve the forecasting accuracy at the turning points of the cycle
- Panel data approach is helpful for the countries with short comparable macroeconomic data series
  - European economies due to introduction of the Euro, post-communist economies, ..

# Literature review

## Recession prediction with discrete dependent variable models

### Estrella and Mishkin (1998); Kauppi and Saikkonen (2008); Nyberg (2010); Ng (2012), Christiansen at al. (2014)

- Dynamic models with «classical recession predictors» (term spread, short-term interest rate, stock market index), macroeconomic leading indicators, Ng (2012) and sentiment variables, Christiansen at al. (2014)
- Single country approach, mainly for the US
- Ex-ante fixed threshold (value that splits the predicted values of the binary dependent variable into the recessionary states and "normal" states)

## The determinants of duration of expansions and recessions

### Castro (2010)

- Panel data of 13 developed countries
- Additional explanatory variables: OECD leading indicators (calculated for the member countries in the unified methodology), the dynamics of private investment and the US business cycle phase

# Literature review

## Evaluating the classification of business cycle phases

### Berge and Jorda (2011)

- Single-indicator analysis. Different indicators of economic activity, different recession definitions
- Receiver operating characteristic (ROC) analysis. Rank models on the entire space of classification «trade-offs»

## «Optimal» threshold for binary models

### Lo Duca and Peltonen (2013)

- Predict systemic financial crises
- Policymaker loss function, trade-off between false alarms and missed crises

## Dynamic discrete dependent variable models in a panel framework

### Candelon et al. (2014)

- Currency crisis early warning systems (EWS)
- 16 emerging countries, dynamic fixed effects panel model

# Contribution

- Dynamic *panel* data models are used for the first time for recession prediction
  - The same methodology as in dynamic panel EWS for financial crises
- Longer forecasting horizon (up to 1 year vs several months in existing studies)
  - Enlarge the list of potential predictors in comparison to the literature
- "Optimal" threshold for the recession models are used based on the minimization of regulator loss function arising from different types of wrong business cycle phases classification
  - In line with the literature on financial crises (e.g. Bussiere and Fratzscher, 2002; Lo Duca and Peltonen, 2013)

# Methodology and data

- **Panel quarterly dataset** on OECD countries (initially ~40, finally - 22 due to data availability) over the period 1980 – 2013*.
- Dependent variable – state of the economy / business cycle phase (binary)

$$y_{it} = \begin{cases} 1, if\ the\ economy\ i\ is\ in\ a\ recessionary\ state\ at\ time\ t \\ 0, if\ the\ economy\ i\ is\ in\ a\ expansionary\ state\ at\ time\ t \end{cases}$$

- Methodology: *dynamic panel fixed effects logit model*

$$Pr\{y_{it} = 1 | \alpha_i, x_{it-k}, y_{it-k}\} = F(y_{it-k}\,\gamma + x'_{it-k}\beta + \alpha_i)$$

*Pr(.)* is a conditional probability of recession

*F(.)* is a logistic distribution function

$x_{it\text{-}k}$ is a set of explanatory variables for country *i* at quarter *(t-k)*

$\beta$ is a vector of parameters at *x*

$\gamma$ is a state dependence parameter (inertia)

$\alpha_i$ is a country-specific unobservable heterogeneity component

$k$ is the quarter lag: 1, 2 and 4 quarters ahead models



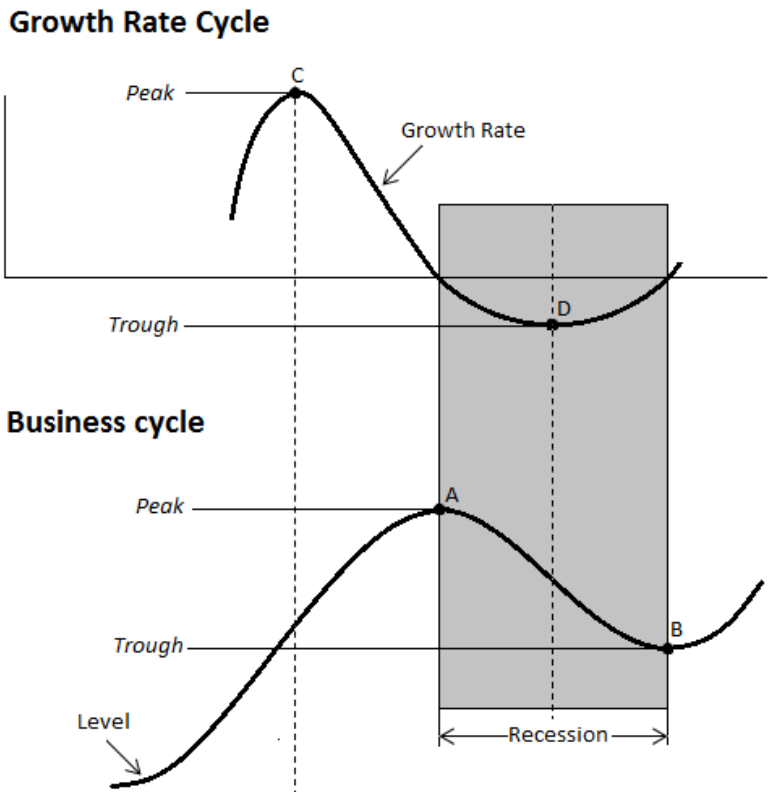
* GDP contraction during transitional period in post socialist countries was removed from the sample

# Dating business cycle phases

## 3 approaches

*Growth rate cycle* - this paper

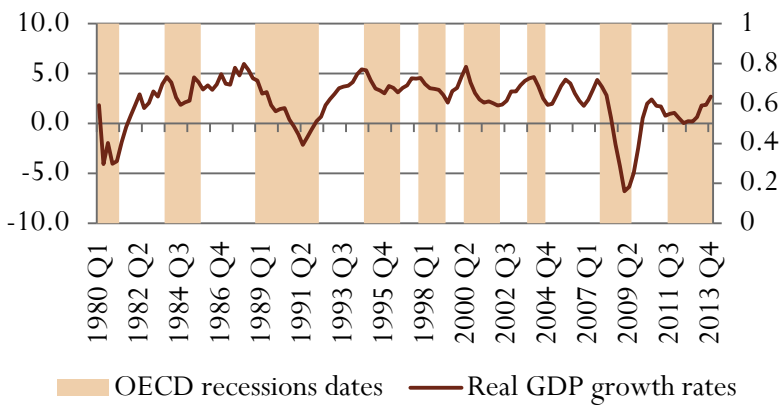
- simple methodology: negative/positive GDP growth rates periods (excluding 1-quarter recessions and expansions)

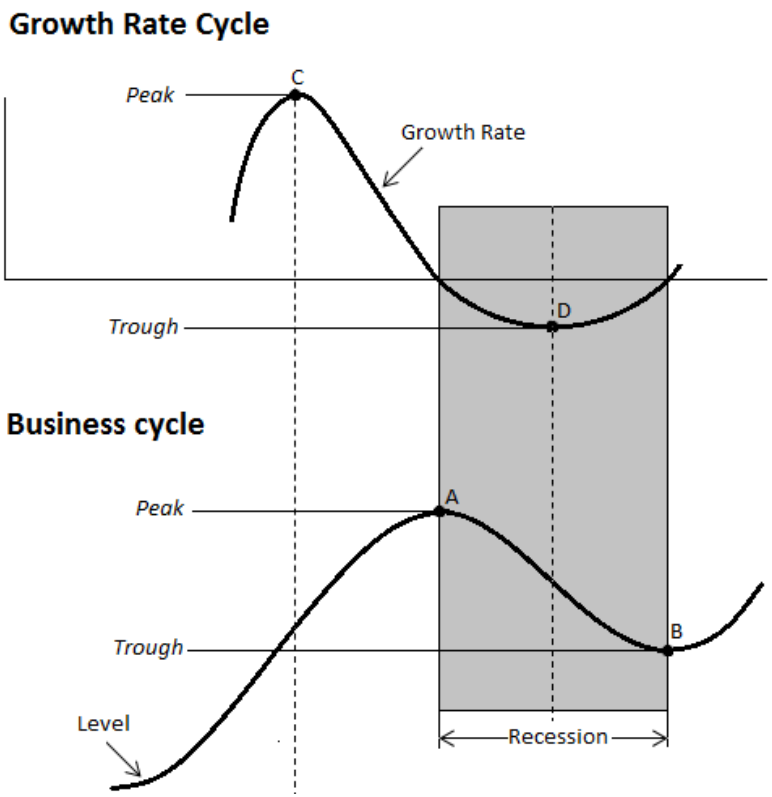


# Dating business cycle phases

## 3 approaches

- *Growth rate cycle* - this paper
  - simple methodology: negative/positive GDP growth rates periods (excluding 1-quarter recessions and expansions)
- Classical (business) cycle - NBER
  - ECRI – 9 European countries
- Deviation (growth) cycle – OECD
  - large number of "false" recessions



# Estimation strategy

- Different explanatory variables
  1. Only country OECD leading indicator (OECD CLI)
  2. Only real sector variables (REAL): country GDP growth, investment growth, consumer and business expectations, US GDP leading indicator, current account to GDP ratio, REER index
  3. Real and financial sector variables (REAL+FIN): real sector variables + stock market growth, interest rates spreads, bank credit to GDP ratio

# Estimation strategy

- Different explanatory variables
  1. Only country OECD leading indicator (OECD CLI)
  2. Only real sector variables (REAL): country GDP growth, investment growth, consumer and business expectations, US GDP leading indicator, current account to GDP ratio, REER index
  3. Real and financial sector variables (REAL+FIN): real sector variables + stock market growth, interest rates spreads, bank credit to GDP ratio
- Different types of model
  1. Static (without state dependence)
  2. Dynamic (inertia in business cycle phases is accounted for)

# Estimation strategy

- Different explanatory variables
  1. Only country OECD leading indicator (OECD CLI)
  2. Only real sector variables (REAL): country GDP growth, investment growth, consumer and business expectations, US GDP leading indicator, current account to GDP ratio, REER index
  3. Real and financial sector variables (REAL+FIN): real sector variables + stock market growth, interest rates spreads, bank credit to GDP ratio
- Different types of model
  1. Static (without state dependence)
  2. Dynamic (inertia in business cycle phases is accounted for)
- Different lags
  - One, two, four quarter ahead models (k – fixed for all explanatory variables)
  - «Best-lag» model (k – mixed)

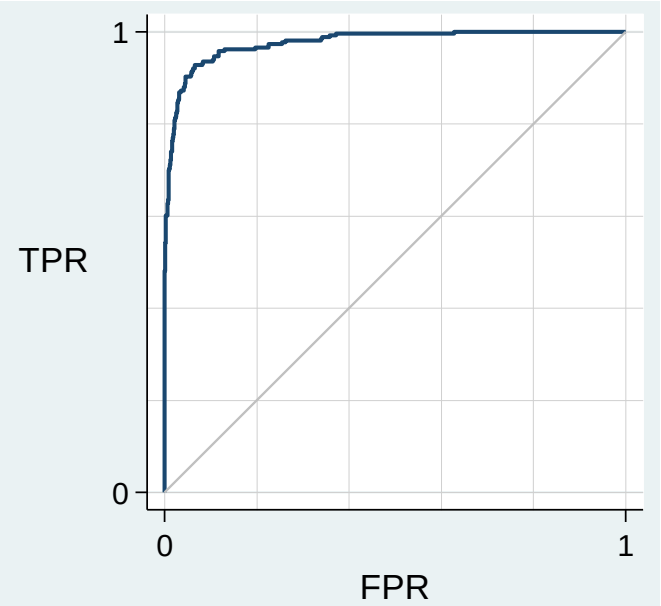
# Evaluating the classification of business cycle phases

| | True state of the economy | |
|---|---|---|
| | $S = 1$ Recession | $S = 0$ Expansion |
| $Y_t \geq c$ Recession prediction | True positive rate TPR(c) | False positive rate FPR(c) |
| $Y_t < c$ Expansion prediction | $1 - \text{TPR}$ | $1 - \text{FPR}$ |

$$ROC(r) = TPR(c)$$

$$r = FPR(c)$$

$$AUROC = \int_0^1 ROC(r)dr$$



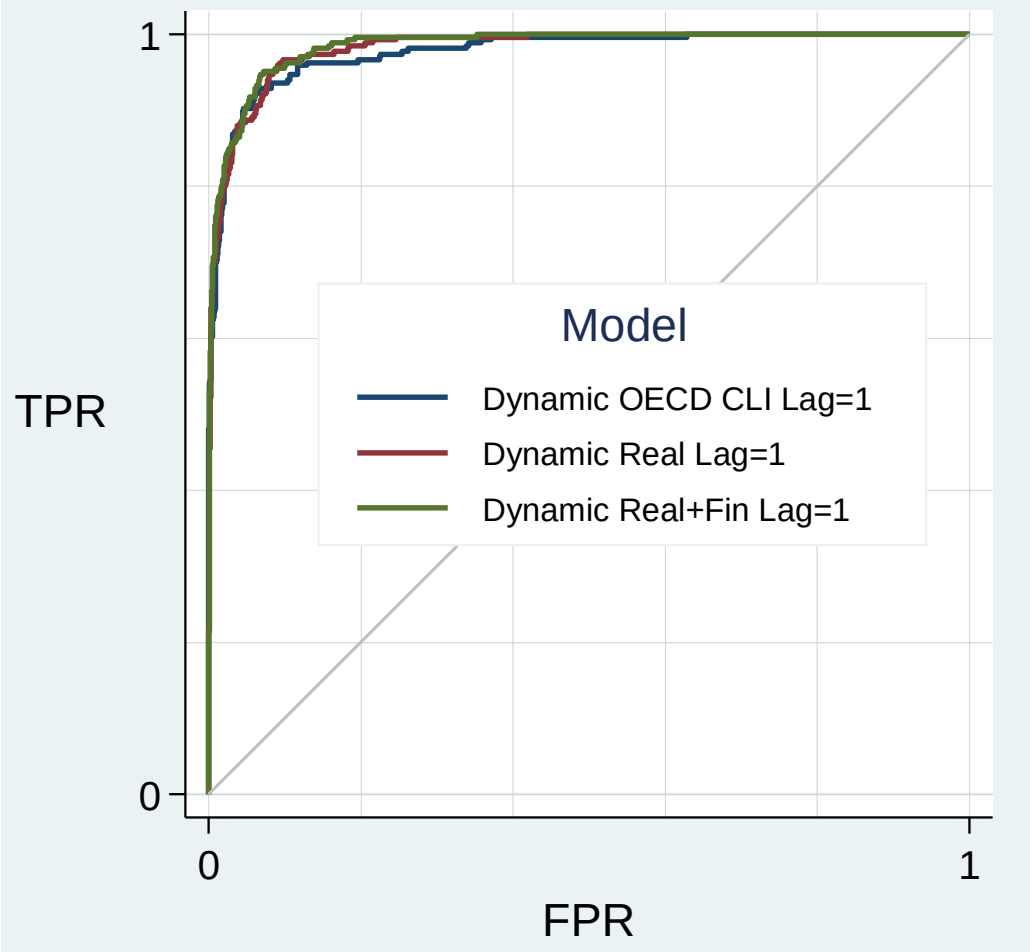
# Different explanatory variables

| | AUROC |
|---|---|
| *OECD CLI* | 0.977 |
| *REAL* | 0.982 |
| *REAL + FIN* | 0.984 |

Prob (Areas are equal) = 0.002

Note:
*OECD CLI* = country OECD leading indicator
*REAL* = real sector variables
*REAL+FIN* = real and financial sector variables

Lag = 1 quarter



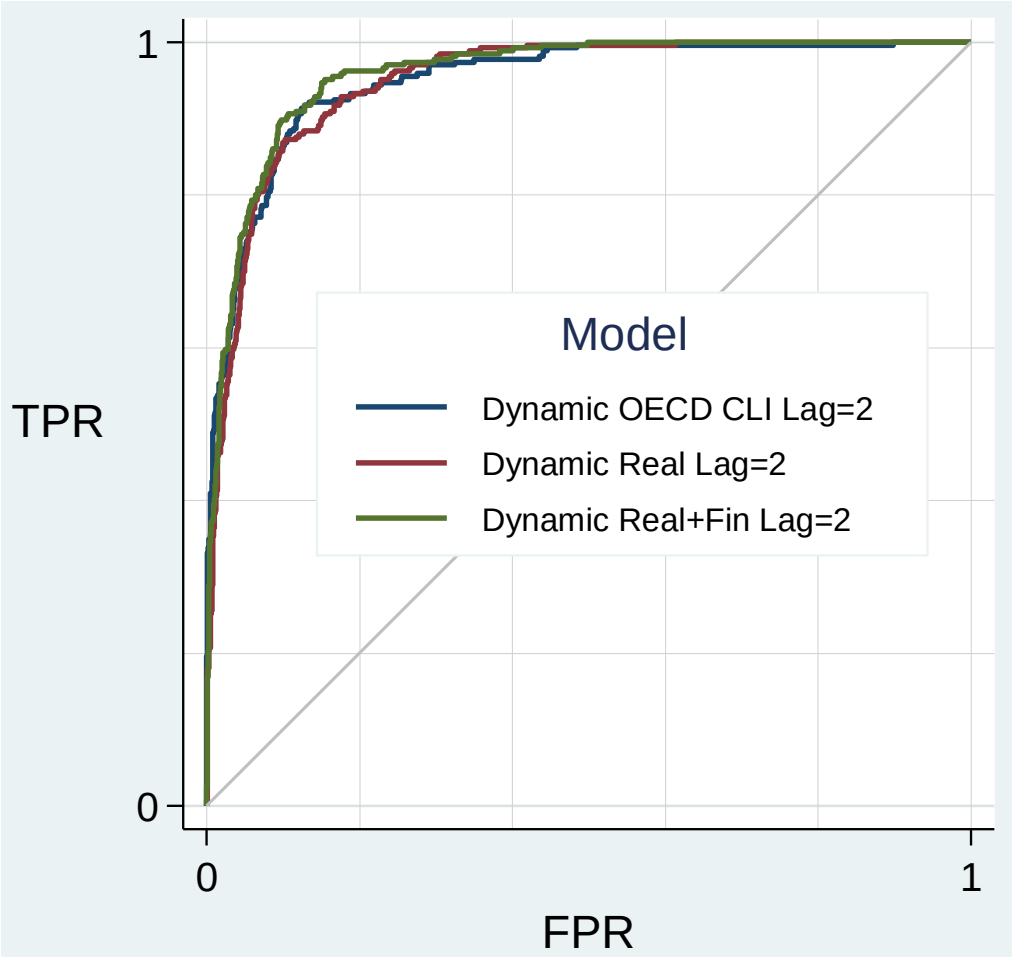
# Different explanatory variables

| | AUROC |
|---|---|
| *OECD CLI* | 0.949 |
| *REAL* | 0.948 |
| *REAL + FIN* | 0.957 |

Prob (Areas are equal) = 0.018

Note:
*OECD CLI* = country OECD leading indicator
*REAL* = real sector variables
*REAL+FIN* = real and financial sector variables

Lag = 2 quarters



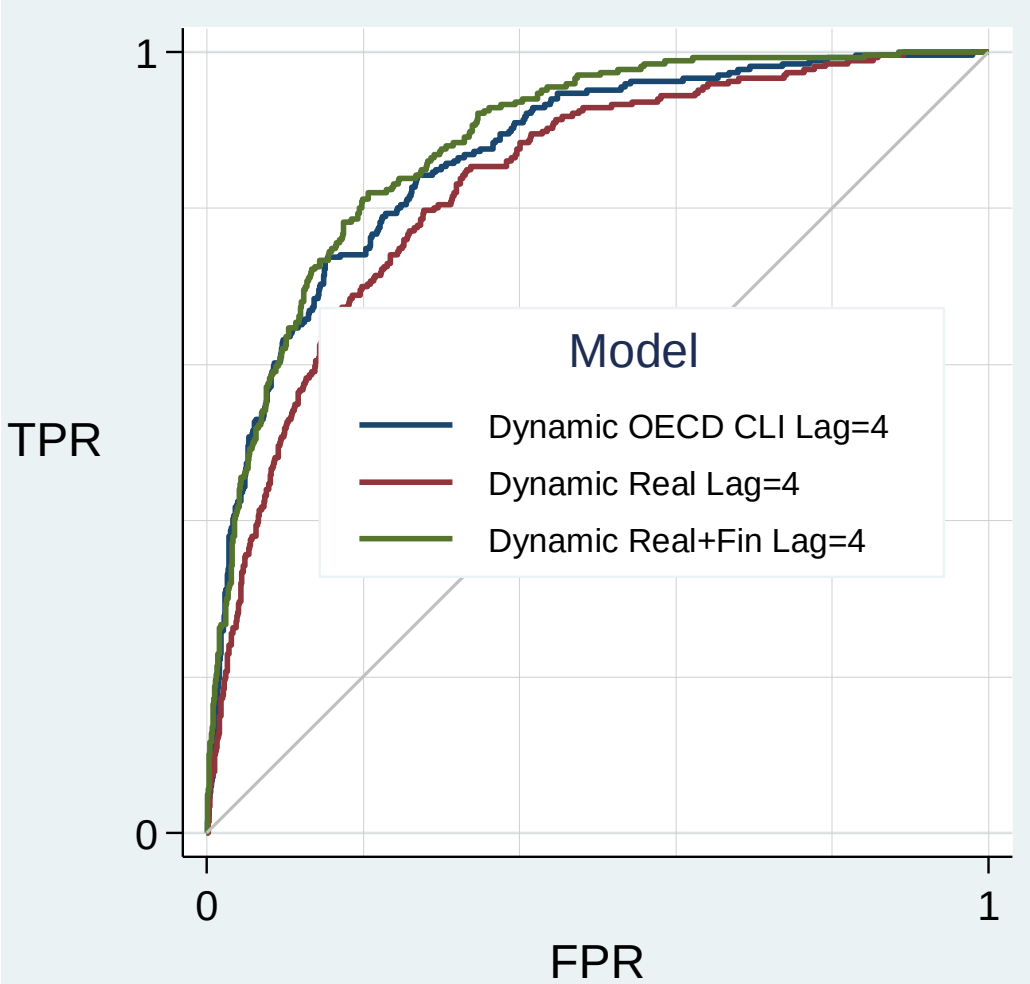
# Different explanatory variables

| | AUROC |
|---|---|
| *OECD CLI* | 0.864 |
| *REAL* | 0.830 |
| *REAL + FIN* | 0.881 |

Prob (Areas are equal) = 0.000

Note:
*OECD CLI* = country OECD leading indicator
*REAL* = real sector variables
*REAL+FIN* = real and financial sector variables

Lag = 4 quarters



# Different types of model

Area under ROC

| | Lag=1 | Lag=2 | Lag=4 |
|---|---|---|---|
| *Static* | 0.981 | 0.957 | 0.882 |
| *Dynamic* | 0.984 | 0.957 | 0.881 |
| *(Dynamic – Static)* | 0.003** | 0.000 | 0.001 |

Note:
** - difference is statistically significant at 5%

$$Pr\{y_{it} = 1|\alpha_i\,, x_{it-k}\,, y_{it-k}\} = F(y_{it-k}\,\gamma + x'_{it-k}\beta + \alpha_i)$$

Static model: $\gamma$=0

# Models with different lags *Dynamic REAL+FIN*

| Variable | Lag = 1 quarter | Lag = 2 quarters | Lag = 4 quarters |
|---|---|---|---|
| Lag (state of the economy) | 2.683*** | 0.931** | –0.476 |
| Investment growth rates, % | –0.080** | –0.136*** | –0.030* |
| GDP growth rates, % | –0.748*** | –0.167 | |
| Consumer confidence, % | –0.674*** | –0.667*** | –0.511*** |
| US OECD CLI, % | –0.418*** | –0.317*** | |
| REER, 2005=100 | 0.028** | 0.032*** | 0.025*** |
| Stock market growth[1], % | –0.070*** | –0.059*** | –0.077*** |
| Spread between money market interest rate and government bond interest rate, p.p. | 0.242*** | 0.326*** | 0.356*** |
| Current account balance to GDP, % | | | –0.125*** |
| Bank loans to GDP ratio, % | | 0.012*** | 0.025*** |
| Constant | –4.582*** | –5.251*** | –5.942*** |
| | | | |
| Number of observations | 1941 | 1881 | 1690 |
| Pseudo R-squared | 0.729 | 0.543 | 0.323 |
| | | | |
| AUROC | 0.984 | 0.957 | 0.881 |
| Log pseudo L | –218.7 | –360.8 | –486.7 |
| LR-test, no FE (P-value) | 0.462 | 0.002 | 0.000 |

Notes. * – significant at 10%; ** – significant at 5%; *** – significant at 1%

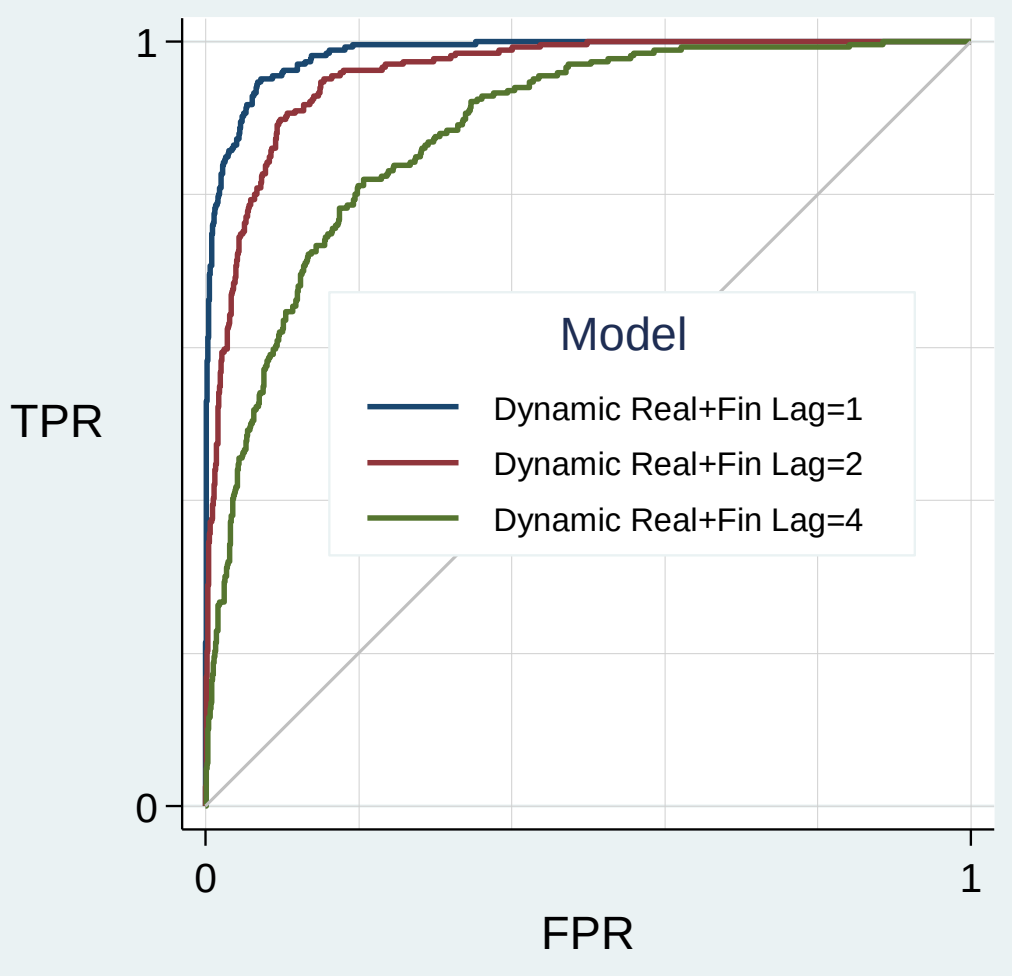
[1] - growth per quarter. Other variables are in growth rates per year

# Models with different lags - ROC

| | AUROC |
|---|---|
| Lag=1 Q | 0.984 |
| Lag=2 Q | 0.957 |
| Lag=4 Q | 0.881 |

Prob (Areas are equal) = 0.000

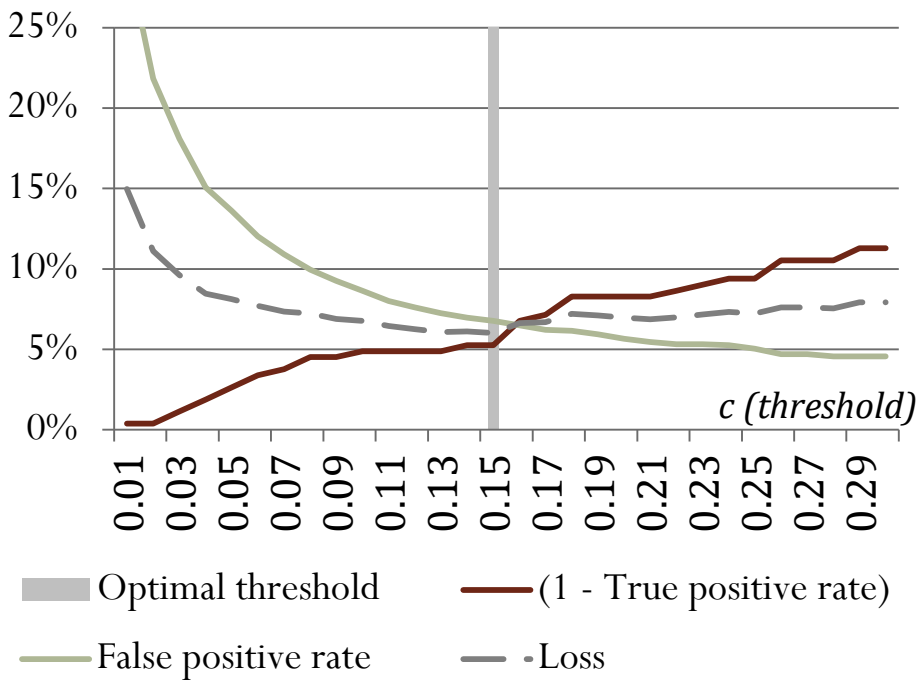
*Dynamic Real+Fin*



# Optimal threshold

## Regulator loss function

$$L(c) = \theta \underbrace{[1 - TPR(c)]}_{\text{Type I errors}} + (1 - \theta) \underbrace{FPR(c)}_{\text{Type II errors}} \rightarrow min$$




Assumed: $\theta = 0.5$

Get $c^*$ that minimizes $L(c)$

# Optimal threshold: in-sample classification results

| | 1Q lag | 2Q lag | 4Q lag |
|---|---|---|---|
| Optimal threshold | 0.15 | 0.19 | 0.15 |
| Noise-to-signal ratio | 7.1% | 10.8% | 25.1% |
| Recessions correctly predicted | 94.7% | 89.8% | 81.2% |
| Expansions correctly predicted | 93.2% | 90.3% | 79.6% |

# Main results

- Business cycle turning points could be predicted on the country panel data in a uniform way, and the quality of these predictions is comparable to the analogues single-country models
- Models accounting for *real and financial sector variables* perform better at all forecasting horizons.
  - OECD composite leading indicators forecast recessions worse than proposed multivariate models
- *Lags of the dependent variable* do matter (dynamic mechanism)
  - However, they are helpful only for small lags (1 quarter)
- Quality of in-sample fit decreases with lag increase
  - Trade-off between forecasting accuracy and the earliness of the recession signal
  - However, the model with the most distant lead - four quarter - correctly predicts more than 80% of recessions with the noise-to-signal ratio of 25%,
- At different forecasting horizons it is optimal to use different list of predictors
  - With lag increase the predictive power of confidence indicators deteriorates (expectations are not accurate for the long horizons). The role of global shocks also decreases (they affect quickly). The role of external trade and internal financial imbalances, on the contrary, goes up

# Appendix

# Optimal threshold: in-sample classification results

| | 1Q lag | 2Q lag | 4Q lag | «Best lag» |
|---|---|---|---|---|
| Optimal threshold | 0.15 | 0.19 | 0.15 | 0.15 |
| Noise-to-signal ratio | 7.1% | 10.8% | 25.1% | 6.9% |
| Recessions correctly predicted | 94.7% | 89.8% | 81.2% | 94.4% |
| Expansions correctly predicted | 93.2% | 90.3% | 79.6% | 93.5% |

Prob (AUROCs for 1Q lag model and «Best lag» model are equal) = 0.852 (no significant improvement)

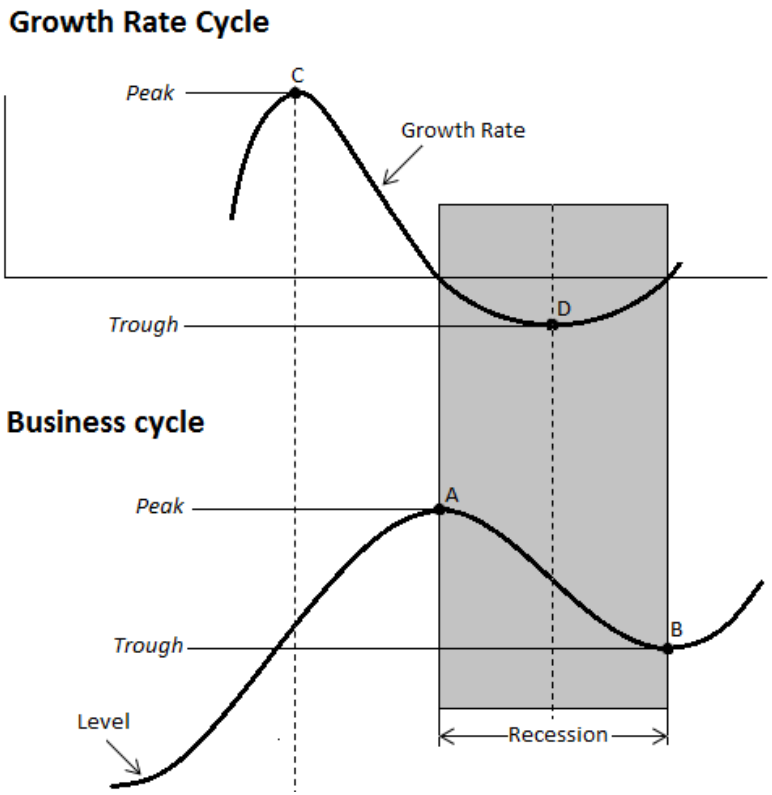
# Out-of-sample classification results

- Coefficients and threshold estimates are based on 1980-2007 period, forecast for 2008-2013

| | 1Q lag | 2Q lag | 4Q lag | «Best lag» |
|---|---|---|---|---|
| Optimal threshold | 0.13 | 0.08 | 0.14 | 0.16 |
| Noise-to-signal ratio | 17.0% | 36.9% | 37.8% | 19.0% |
| Recessions correctly predicted | 93.9% | 76.0% | 58.3% | 93.0% |
| Expansions correctly predicted | 84.0% | 71.9% | 78.0% | 82.4% |

# Robustness check – alternative definition of the business cycle

- Classical (business) cycle
  - Harding and Pagan (2002) modified Bry–Boschan (1971) dating algorithm for the quarterly data
  - This rule reproduces NBER dates quite closely (Harding and Pagan, 2005)
  - I use BBQForExcel Program by Adrian Pagan (downloaded from his website)
  - This algorithm dates turning points 1-2 quarters ahead the "2 quarters of negative GDP growth rates" rule used before



# ROC-curves for classical (business) cycle recession dates

| | AUROC |
|---|---|
| Lag=1 Q | 0.944 |
| Lag=2 Q | 0.879 |
| Lag=4 Q | 0.800 |

Prob (Areas are equal) = 0.000

Area under ROC decreased significantly, however 80% of coefficients preserved their signs and significance

*Dynamic Real+Fin*