How to predict financial stress? An assessment of Markov switching models

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The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Canada, the European Central Bank, the Banque de France or the Eurosystem.

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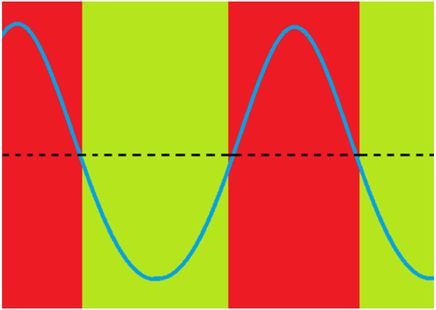
Focus of the paper



Continuous metric (Markov switch, eg for business cycle)

vs. binary models (Logit, eg for banking crises)

Focus of the paper

1. Can we use Markov switching to predict the financial cycle ?
2. Which variables predict the entry into / exit from high financial stress ?
   - What are the *vulnerabilities* associated with subsequent *realised financial stress* ?
3. Were those predictors useful even before the 2008 crisis ?
4. Do we gain additional predictive power by looking at the whole financial cycle instead of using standard binary crisis indicators ?

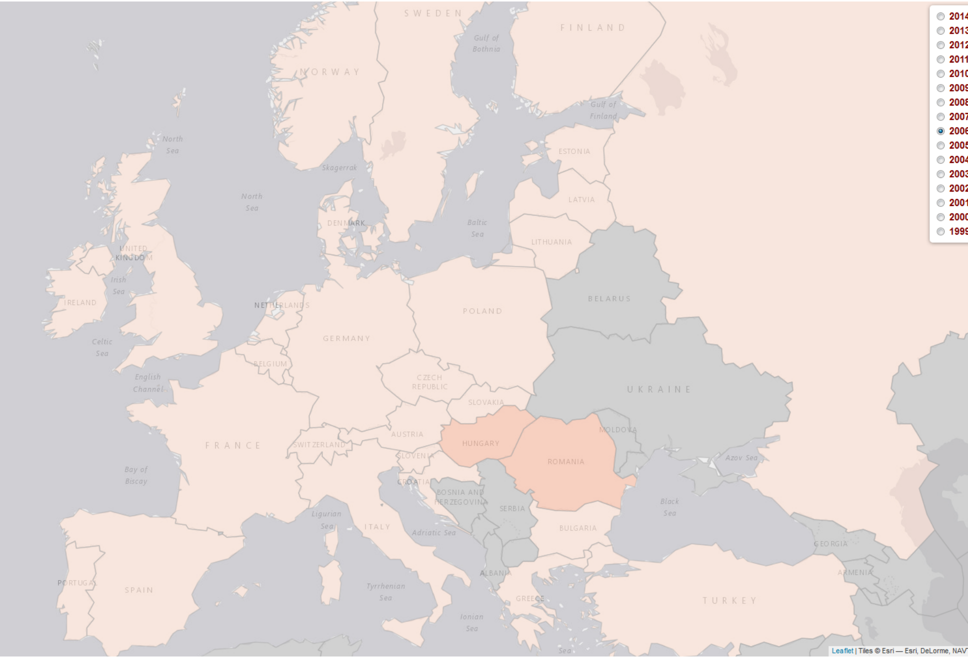
Related literature

- **Dating business cycle turning points** : Hamilton (1989), Filardo (1994), Diebold et al (1994), Chauvet and Piger (2008), Gadea and Perez-Quiros (2012)
- **Measuring financial market stress** : Hollo et al (2012), Hartmann et al (2013), Duprey et al (2017)
- **Comparing early warning models** : Abiad (2003) evaluates the signalling ability of MS models for Asian currency crises

Section 1

Preliminary : Measuring financial stress

end of 2006



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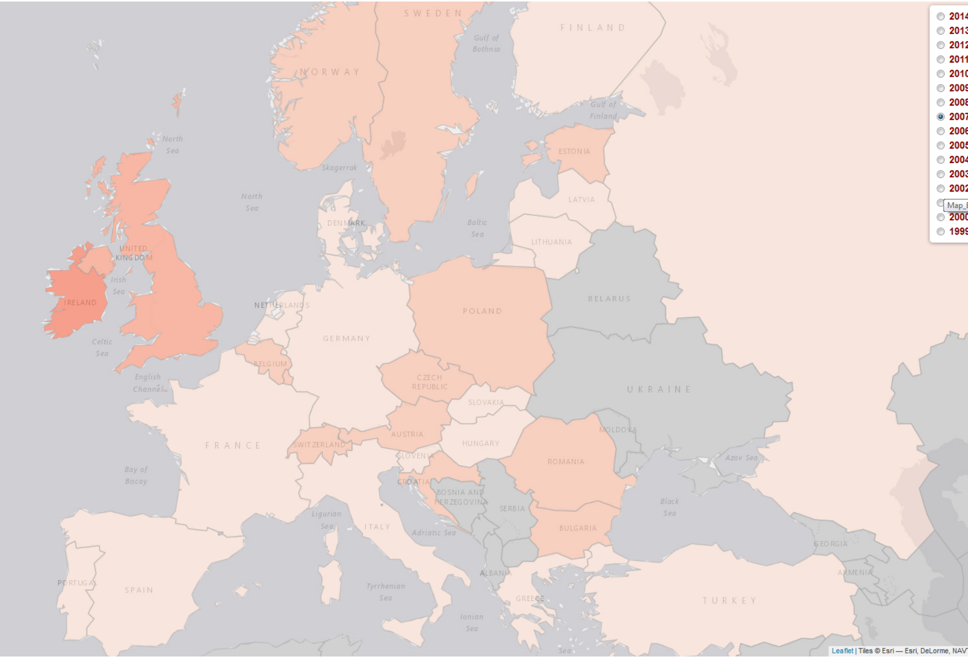
end of 2007



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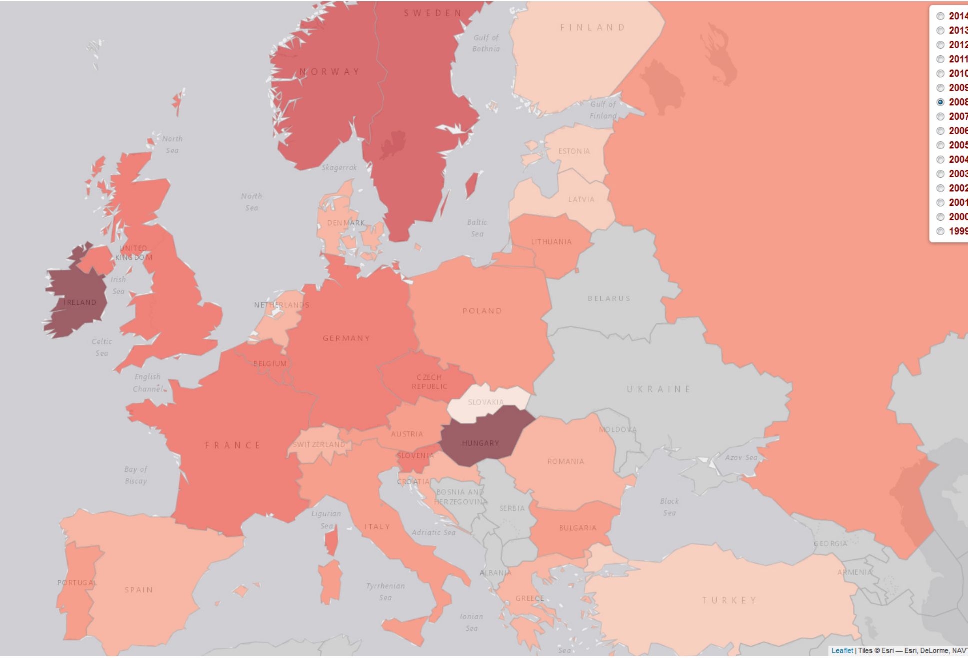
end of 2008



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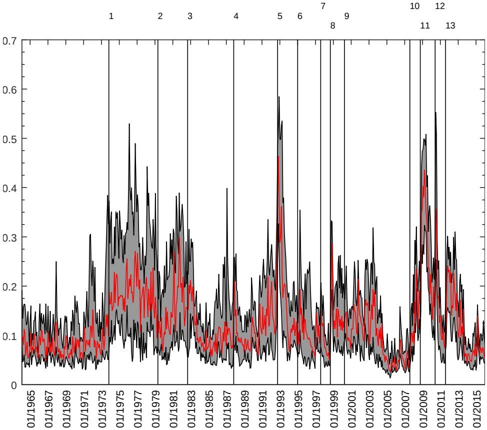
CLIFS : Country Level Indices of Financial Stress

for European Union 15 countries, Duprey et al. (2017)



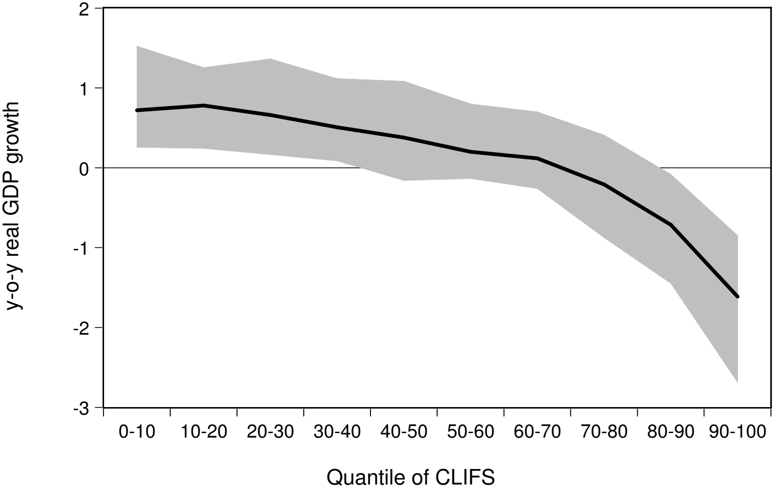
1 - first oil shock ; 2 - second oil shock ; 3 - Mexican debt crisis ; 4 - Black Monday ; 5 - crisis of the European exchange rate mechanism ; 6 - Peso crisis ; 7 - Asian crisis ; 8 - Russian crisis ; 9 - dot com bubble ; 10 - subprime crisis ; 11 - Lehman Brothers ; 12 - 1st bailout Greece ; 13 - 2nd bailout Greece

Dataset on ECB's website :

`https://sdw.ecb.europa.eu/browse.do?node=9693347`

Real GDP growth per quantiles of CLIFS

for European Union 15 countries



Section 2

Markov-switching models for early-warning

Standard early-warning model : Logit

Input : Low or high financial stress state $S_t = \{0, 1\}$

$$P\left(S_{c,t} = 1 \middle| \mathbf{X}_{c,t-1}\right) = \frac{\exp(\theta_{l,0} + \theta_{l,1}\mathbf{X}_{c,t-1})}{1 + \exp(\theta_{l,0} + \theta_{l,1}\mathbf{X}_{c,t-1})}$$

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Problem 1 : We need an exogenous sequence of events to predict

$\rightarrow$ Subjectivity bias

Standard early-warning model : Logit

Input : Low or high financial stress state $S_t = \{0, 1\}$

$$P\left(S_{c,t} = 1 \mid \mathbf{X}_{c,t-1}\right) = \frac{\exp(\theta_{l,0} + \theta_{l,1}\mathbf{X}_{c,t-1})}{1 + \exp(\theta_{l,0} + \theta_{l,1}\mathbf{X}_{c,t-1})}$$

Problem 2 : We need enough crises dummies

$\rightarrow$ Crises events are rare

Standard early-warning model : Logit

Input : Low or high financial stress state $S_t = \{0, 1\}$

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Problem 3 : We want to distinguish probability to enter/exit a crisis

$\rightarrow$ Post-crisis bias, unconditional probabilities

Time-Varying Transition Probability Markov Switching (TVTP-MS)

Input : Country Level Index of Financial Stress (CLIFS)

$$CLIFS_t = \begin{cases} \mu^0 + \sum_c \left(\gamma_c^0 \mathbb{1}_c\right) + \beta^0 CLIFS_{t-1} + \sigma^0 \epsilon_t \text{ in state } S_t = 0 \\ \mu^1 + \sum_c \left(\gamma_c^1 \mathbb{1}_c\right) + \beta^1 CLIFS_{t-1} + \sigma^1 \epsilon_t \text{ in state } S_t = 1 \end{cases}$$

where : $\epsilon_t \to \mathcal{N}(0,1)$. 2-states Markov chain :

$$P\left(S_t \,|S_{t-1}, \mathbf{X}_{t-1}\right) = \begin{bmatrix} 1 - p_t & p_t = \frac{\exp(\theta_{p,0}+\theta_{p,1}\mathbf{X}_{t-1})}{1+\exp(\theta_{p,0}+\theta_{p,1}\mathbf{X}_{t-1})} \\ q_t = \frac{\exp(\theta_{q,0}+\theta_{q,1}\mathbf{X}_{t-1})}{1+\exp(\theta_{q,0}+\theta_{q,1}\mathbf{X}_{t-1})} & 1 - q_t \end{bmatrix}$$

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Solves 1 and 2 : no subjectivity bias + more stress episodes

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Input : Country Level Index of Financial Stress (CLIFS)

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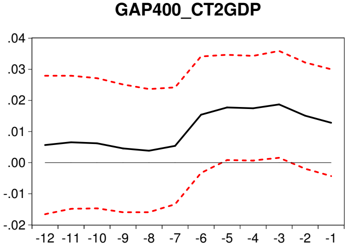
Solves 3 : no post-crisis bias with conditional probabilities

Specification of the TVTP-MS model

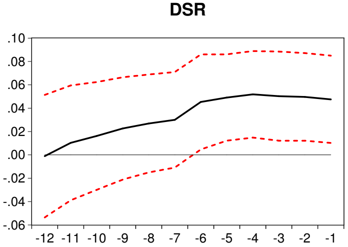
- Create a fictitious country by stacking all 15 EU countries
  - Assume identical financial cycle process for all countries
  - And better out-of-sample properties
- Baseline specification with only switching mean
  - Financial stress metric CLIFS made of variances
  - Test of 36 predictors (credit, housing, macro, market, banking)
- EU15 countries since 1970 quarterly
  - Robustness with Eurozone since 1998 monthly

Forecasting financial stress up to 12 quarters ahead

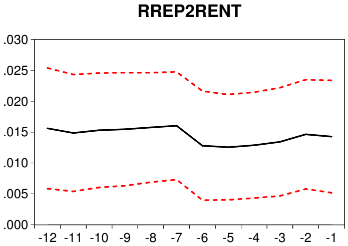
Parameters of the probability to enter



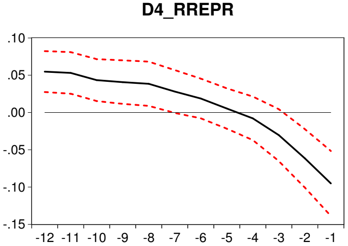
(a) Credit to GDP gap ($\lambda = 400000$)



(b) Debt service ratio



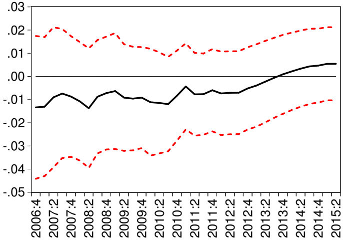
(c) Residential property price to rents



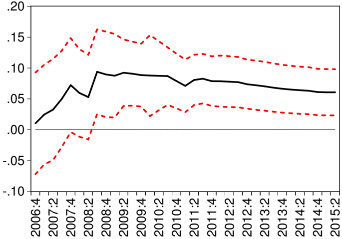
(d) Residential property price growth

Stability over time and out-of-sample computations

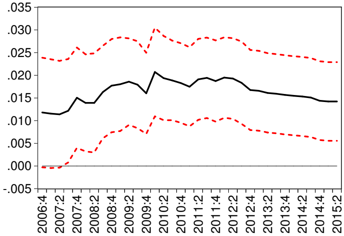
Parameters of the probability to enter



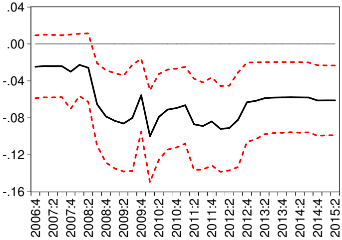
(e) Credit to GDP gap ($\lambda = 400000$)



(f) Debt service ratio

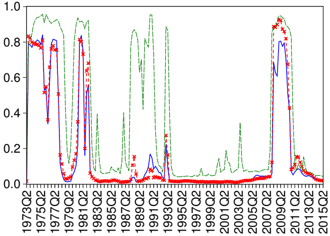


(g) Residential property price to rents

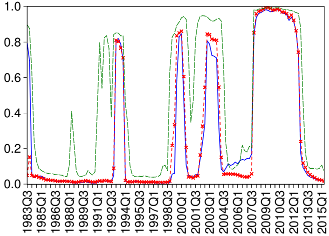


(h) Residential property price growth

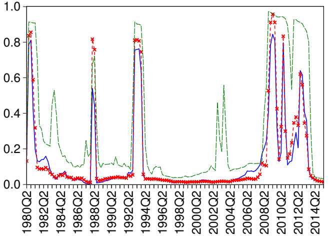
Probability of high financial stress in the next quarter



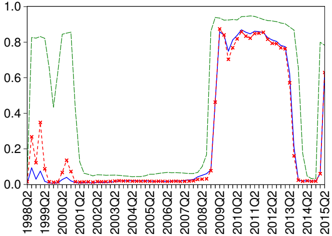
(i) United Kingdom



(j) Ireland



(k) Spain



(l) Greece

Section 3

Better early-warning properties than Logit ?

Compare the predictive ability of TVTP-MS and Logit

Using signal classification theory (AUROC)

Difficulties :

- Both models are cross-country, but not nested
- Either predict a binary indicator or a continuous measure

Solutions :

- Mapping binary and continuous measures of financial stress

$$S_t = \begin{cases} 1 \text{ if } ma(CLIFS_t) > p90 \\ 0 \text{ if } ma(CLIFS_t) \leq p90 \end{cases}$$

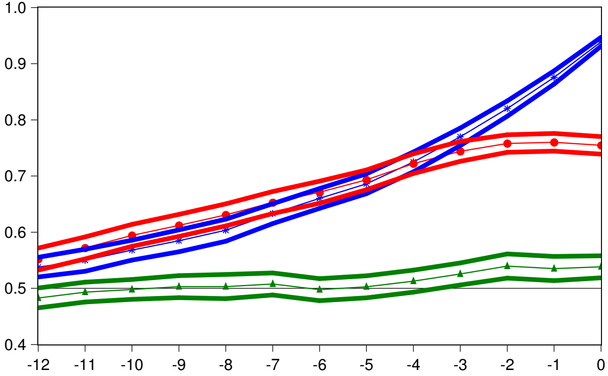
What we compare :

- The predicted probabilities of high financial stress $\hat{P}_{Logit}\left(S_t = 1 | \mathbf{X}_{t-1}\right)$ and $\hat{P}_{TVTP-MS}\left(S_t = 1 | \mathbf{X}_{t-1}\right)$

- With the episodes of high financial stress $S_t = \{0, 1\}$

Predictive ability of the logit versus MS model

AUROC



quarters ahead of stress period

red : Logit blue : TVTP-MS green : no predictors in MS

Wrap-up

Why Markov switching ?

- Both event classification and prediction at the same time
- Captures the intensity of financial stress
- Distinguish the probability to enter/exit financial stress

Which predictors ?

- Related to bank credit (debt service ratio) and housing
- Harder to find predictor of exiting stress (confidence/market data)
- But main predictors not statistically significant before 2007

Good enough ?

- In-sample prediction better (a few quarters prior to event)
- Out-of-sample estimation of probabilities robust