

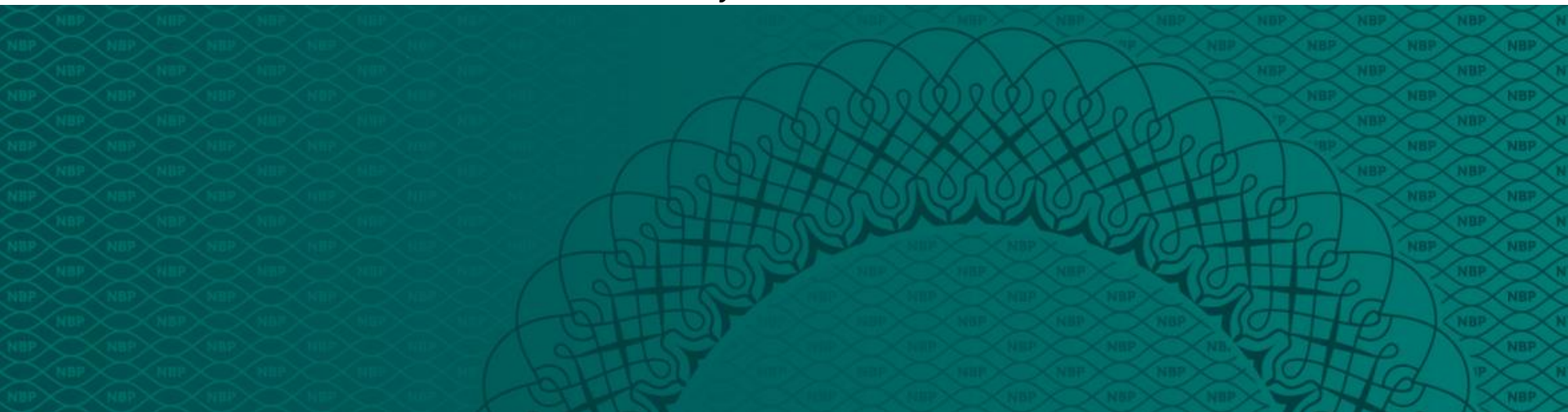
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# Early warning models of banking crises applicable to non-crisis countries

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## Countercyclical capital buffer



- **The standard approach recommended in Basel III and UE law attaches special weight to the credit gap, assuming certain characteristics of the financial cycle:**
  - CRD IV, article 135 and 136: The buffer guide shall reflect the credit cycle and the risks due to excess credit growth in the Member State. It shall be based on the **deviation of the ratio of credit-to-GDP from its long-term trend**.
  - ESRB/2014/1: a benchmark guide extracts trend with HP filter and  $\lambda = 400\,000$ , implying that **financial cycle exceeds 20 years**.
- However, it is not clear that:
  - **length of the financial cycle in all countries indeed exceeds 20 years,**
  - **a single variable is a satisfactory indicator.**

## Predicting banking crises:

Borio i Drehmann (2010), Drehmann et al. (2011) Drehmann i Juselius (2012), Juks & Melander (2012), Behn et al. (2013), Kalatie et al. (2015)

- **Which variables help in predicting banking crises in a broad group of countries?**

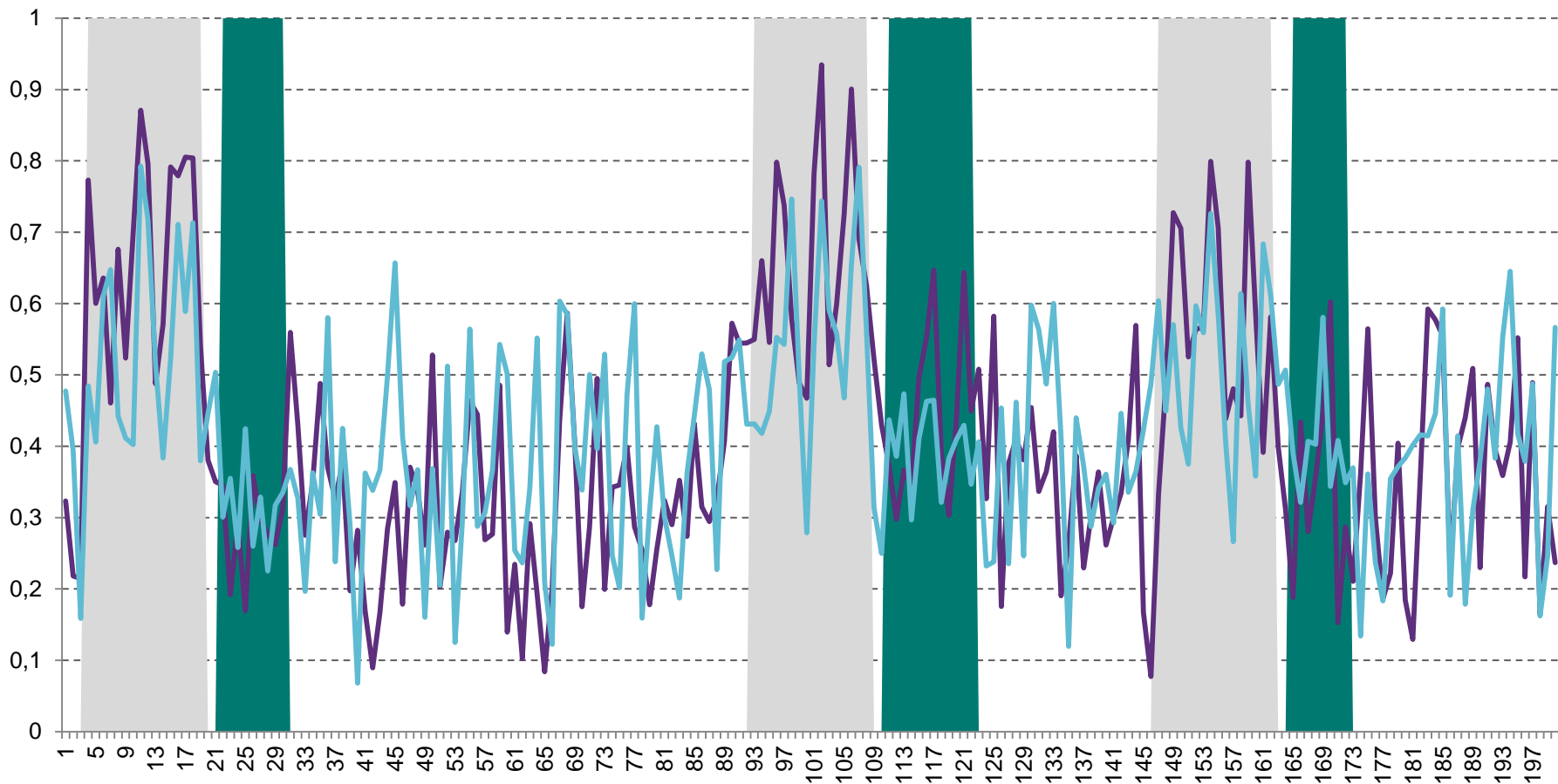
Most studies include crisis countries and exclude non-crisis countries

- **VIX:** Does low price of risk signals underpricing of risk and incoming crisis? (Minsky hypothesis)
  - **Value added of the financial sector:** does it reflect genuine value added or systemic risk taken by the sector? (Haldane et al. (2010), Basu et al. (2011))
  - **Which variables provide consistent, stable signals?**
- 
- **How much we can gain by including many variables?**

## Method

- **Logit model with single and many variables:**
  - **No country fixed effects, but we include country characteristics** by standardisation of variables (z-score based on empirical distribution of each variable in each country); model can be used by non-crises countries.
  - Variables: **level, dynamics and cyclical component**
  - **Cyclical component of the financial cycle:** length of the cycle extracted as a dominant frequency from periodogram of the variable dynamics Comin i Gertler (2006);
  - Model evaluation: **AUC, stability of signals out of sample, FP-FN trade-off and optimal threshold for signal**

## Early warnings – when and how?



## **Data: 47 countries, 1970-2014, unbalanced panel**

**Crises: Babecky et al. (2013)**

### **Macro:**

Credit extended to non-financial sector; credit to households – BIS.

GDP – Eurostat.

Debt service ratio (DSR) – BIS.

Residential prices to income – OECD.

Contribution of banking sector to GDP growth – Datastream and Eurostat

### **Financial:**

VIX - Datastream

Banking sector index beta – Datastream

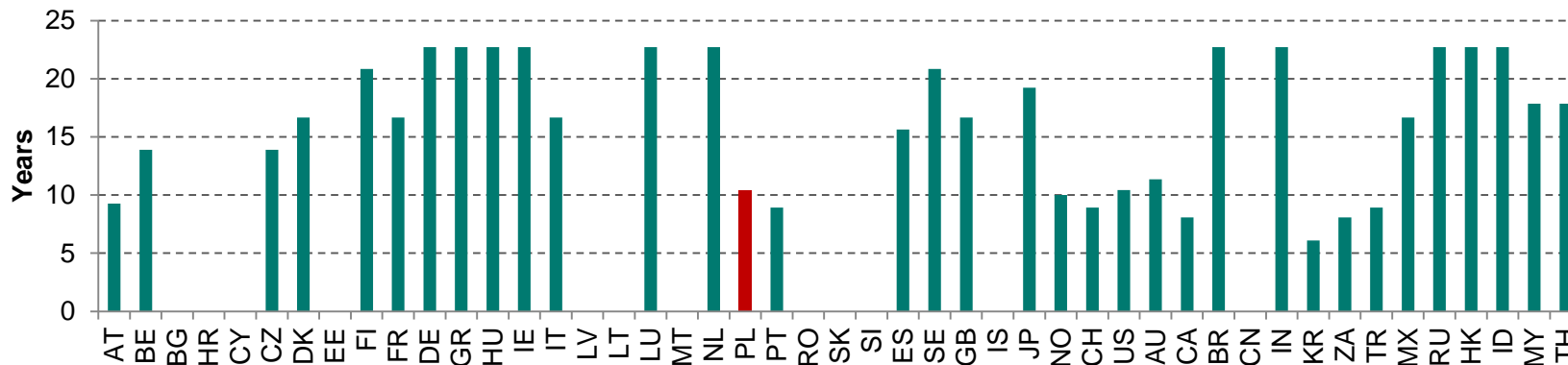
Volatility of banking sector index – Datastream

TED spread – Datastream

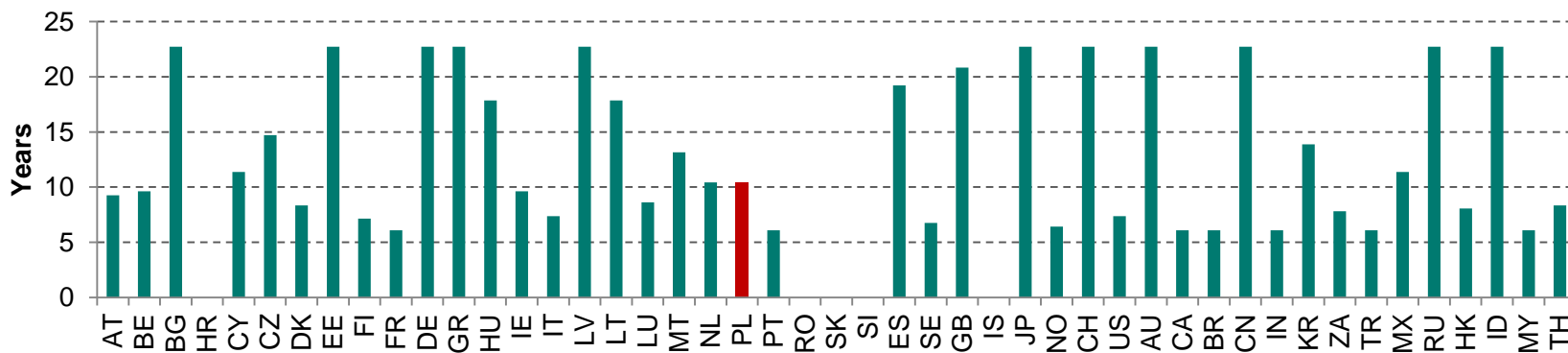
Volatility of banking sector index relative to market volatility – Datastream

# Length of the financial cycle varies across countries

## Credit gap



## Debt Service Ratio



## Single variable: stability of signals

| Variable                         | AUROC       | 95% confidence band |      | AUROC before2006 | AUROC after2006 |
|----------------------------------|-------------|---------------------|------|------------------|-----------------|
| <b>VIX</b>                       | <b>0,75</b> | 0,72                | 0,77 | <b>0,75</b>      | <b>0,67</b>     |
| <b>Credit (16)</b>               | <b>0,73</b> | 0,71                | 0,76 | <b>0,71</b>      | <b>0,85</b>     |
| <b>Credit to HH (12)</b>         | <b>0,69</b> | 0,67                | 0,72 | <b>0,66</b>      | <b>0,77</b>     |
| <b>Value Added (16)</b>          | <b>0,67</b> | 0,63                | 0,71 | <b>0,69</b>      | <b>0,63</b>     |
| <b>Value Added (gap)</b>         | <b>0,65</b> | 0,61                | 0,68 | <b>0,64</b>      | <b>0,70</b>     |
| <b>Value Added</b>               | <b>0,64</b> | 0,60                | 0,68 | <b>0,67</b>      | <b>0,68</b>     |
| <b>Ptl (16)</b>                  | <b>0,64</b> | 0,61                | 0,67 | <b>0,64</b>      | <b>0,64</b>     |
| <b>GDP (12)</b>                  | <b>0,63</b> | 0,60                | 0,66 | <b>0,57</b>      | <b>0,78</b>     |
| <b>Ptl (gap)</b>                 | <b>0,63</b> | 0,60                | 0,66 | <b>0,62</b>      | <b>0,72</b>     |
| <b>Credit gap (Basel III)</b>    | <b>0,63</b> | 0,59                | 0,66 | <b>0,64</b>      | <b>0,62</b>     |
| <b>Debt-service-ratio (4)</b>    | <b>0,61</b> | 0,58                | 0,64 | <b>0,59</b>      | <b>0,73</b>     |
| <b>Betas (gap)</b>               | <b>0,58</b> | 0,54                | 0,61 | <b>0,58</b>      | <b>0,58</b>     |
| <b>Betas (16)</b>                | <b>0,58</b> | 0,53                | 0,61 | <b>0,60</b>      | <b>0,45</b>     |
| <b>Relative volatility (16)</b>  | <b>0,57</b> | 0,53                | 0,61 | <b>0,60</b>      | <b>0,52</b>     |
| <b>Relative volatility (gap)</b> | <b>0,56</b> | 0,52                | 0,60 | <b>0,56</b>      | <b>0,59</b>     |
| <b>Debt-service-ratio (gap)</b>  | <b>0,54</b> | 0,51                | 0,56 | <b>0,53</b>      | <b>0,68</b>     |



## Single variable: accuracy of signals

| Variable                         | AUROC       | False Positive Rate | True Positive Rate | No. of crises periods in sample |
|----------------------------------|-------------|---------------------|--------------------|---------------------------------|
| <b>VIX</b>                       | <b>0,75</b> | <b>0.12</b>         | <b>0.35</b>        | 433                             |
| <b>Credit (16)</b>               | <b>0,73</b> | <b>0.07</b>         | <b>0.23</b>        | 406                             |
| <b>Credit to HH (12)</b>         | <b>0,69</b> | <b>0.12</b>         | <b>0.34</b>        | 319                             |
| <b>Value Added (16)</b>          | <b>0,67</b> | <b>0.11</b>         | <b>0.27</b>        | 168                             |
| <b>Value Added (gap)</b>         | <b>0,65</b> | <b>0</b>            | <b>0</b>           | 199                             |
| <b>Value Added</b>               | <b>0,64</b> | <b>0.01</b>         | <b>0.05</b>        | 199                             |
| <b>PtI (16)</b>                  | <b>0,64</b> | <b>0.08</b>         | <b>0.27</b>        | 324                             |
| <b>GDP (12)</b>                  | <b>0,63</b> | <b>0</b>            | <b>0</b>           | 331                             |
| <b>PtI (gap)</b>                 | <b>0,63</b> | <b>0.04</b>         | <b>0.12</b>        | 336                             |
| <b>Credit gap (Basel III)</b>    | <b>0,63</b> | <b>0.03</b>         | <b>0.09</b>        | 316                             |
| <b>Debt-service-ratio (4)</b>    | <b>0,61</b> | <b>0</b>            | <b>0</b>           | 282                             |
| <b>Betas (gap)</b>               | <b>0,58</b> | <b>0</b>            | <b>0</b>           | 244                             |
| <b>Betas (16)</b>                | <b>0,58</b> | <b>0.01</b>         | <b>0.02</b>        | 208                             |
| <b>Relative volatility (16)</b>  | <b>0,57</b> | <b>0</b>            | <b>0</b>           | 213                             |
| <b>Relative volatility (gap)</b> | <b>0,56</b> | <b>0</b>            | <b>0</b>           | 257                             |
| <b>Debt-service-ratio (gap)</b>  | <b>0,54</b> | <b>0</b>            | <b>0.01</b>        | 300                             |

## Best performing models: three variables

### Domestic and global factors (VIX)

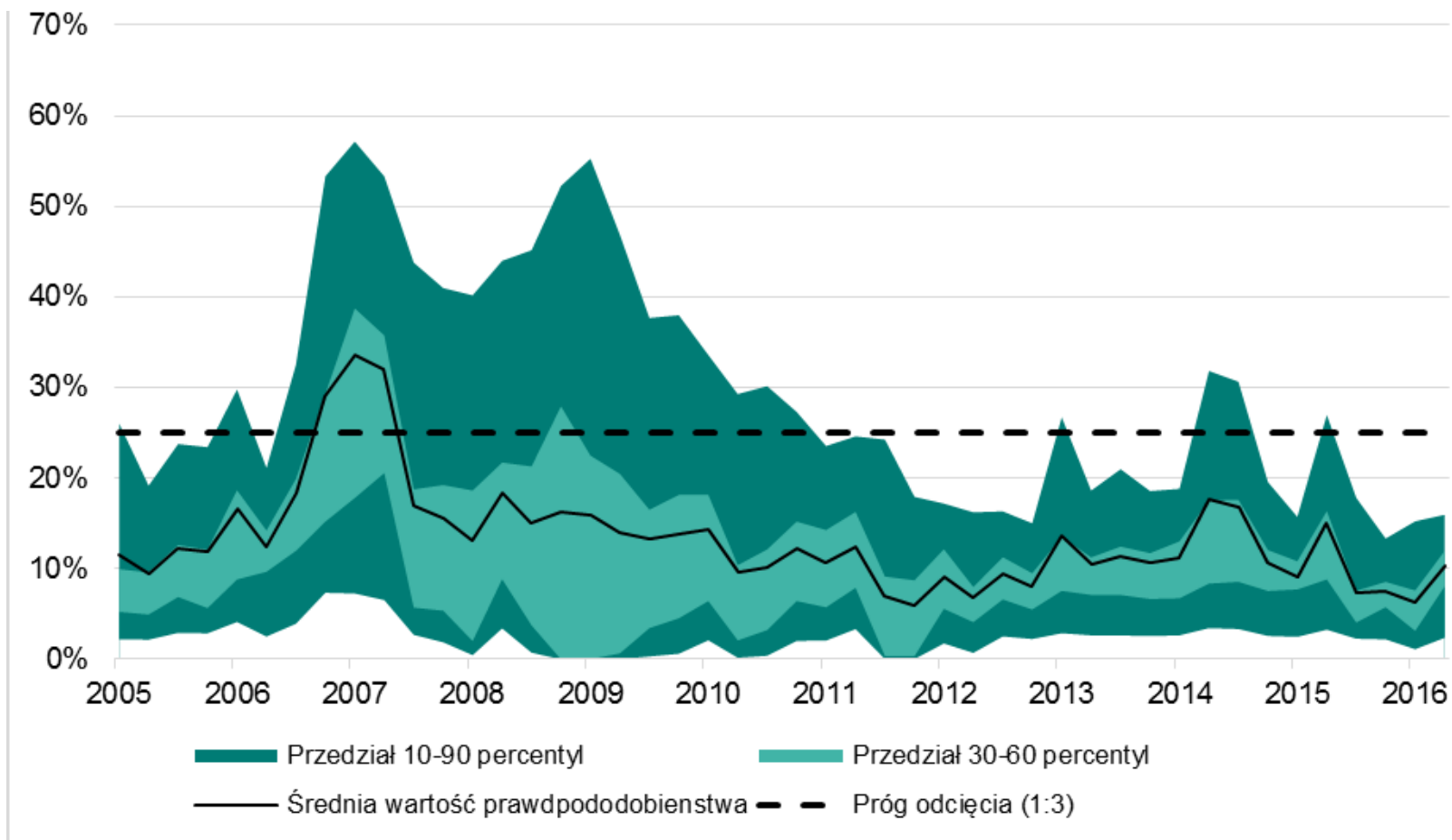
| Model                      | AUROC       | Conf. band |      | Thresh. 3:1 | FPR         | TPR         | No. crises |
|----------------------------|-------------|------------|------|-------------|-------------|-------------|------------|
| DSR (4), Ptl (16) & VIX    | <b>0.92</b> | 0.88       | 0.95 | 0.3         | <b>0.1</b>  | <b>0.76</b> | 156        |
| Betas (gap), DSR (4) & VIX | <b>0.92</b> | 0.88       | 0.95 | 0.28        | <b>0.11</b> | <b>0.79</b> | 121        |
| Ptl (gap), DSR (4) & VIX   | <b>0.92</b> | 0.88       | 0.95 | 0.3         | <b>0.09</b> | <b>0.76</b> | 156        |
| VA, DSR (4) & VIX          | <b>0.91</b> | 0.87       | 0.94 | 0.22        | <b>0.14</b> | <b>0.8</b>  | 96         |
| VA (16), DSR (4) & VIX     | <b>0.91</b> | 0.87       | 0.94 | 0.24        | <b>0.15</b> | <b>0.79</b> | 96         |
| DSR (4), Credit (16) & VIX | <b>0.89</b> | 0.85       | 0.92 | 0.19        | <b>0.14</b> | <b>0.77</b> | 178        |

### Only domestic variables

| Model                        | AUROC       | Conf. band |      | Thresh. 3:1 | FPR         | TPR         | No. crises |
|------------------------------|-------------|------------|------|-------------|-------------|-------------|------------|
| Ptl (gap), VA (16) & DSR (4) | <b>0,86</b> | 0,82       | 0,89 | 0,27        | <b>0,14</b> | <b>0,75</b> | 120        |
| VA (16), DSR (4) & Ptl (16)  | <b>0,84</b> | 0,8        | 0,87 | 0,31        | <b>0,11</b> | <b>0,65</b> | 96         |
| VA, Ptl (gap) & Credit (16)  | <b>0,83</b> | 0,78       | 0,86 | 0,22        | <b>0,18</b> | <b>0,72</b> | 134        |

Note: All models include Basel III credit gap for regulatory purposes (ESRB recommendation), but inclusion of this variables does not change the performance of the models

## Using many models



## Conclusions

- **Credit gap is good for crisis prediction, but not the best.**
  - **VIX** – low price of risk signals crises, best-performing indicator, but not as consistent as some other variables (i.e. credit growth)
  - **Financial sector's Value Added:** beware of the high growth in the *measured* value added of the financial sector, as it tends to precede crises.
- **More variables provide substantially better signals than one variable.**
  - AUC of 0.75 for the best single-variable vs. 0.92 for 3-variable model
  - Much higher True Positive Rate (0.75 vs. 0.35 for a single variable)