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# PD Model Backtesting & Cyclicity

## Rabobank: Group Risk Management

Paul Frenken, Phuong Lam,  
Jan Piplack and Erik Winands

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Rabobank Nederland

# Agenda



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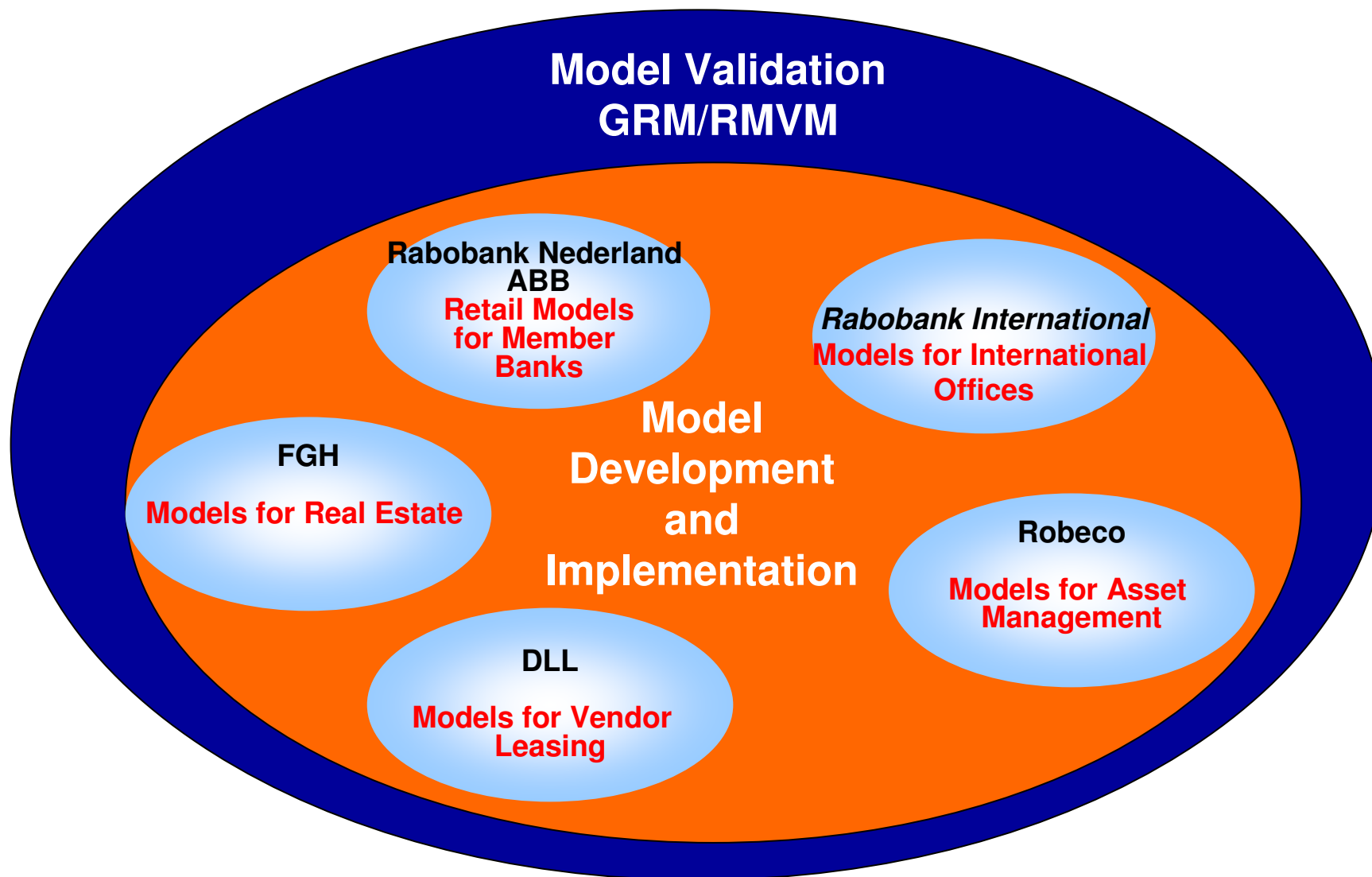
## Topics

- Introduction
- Model cycle
- Backtesting
- Impact business cycle
- Discussion

# Model validation



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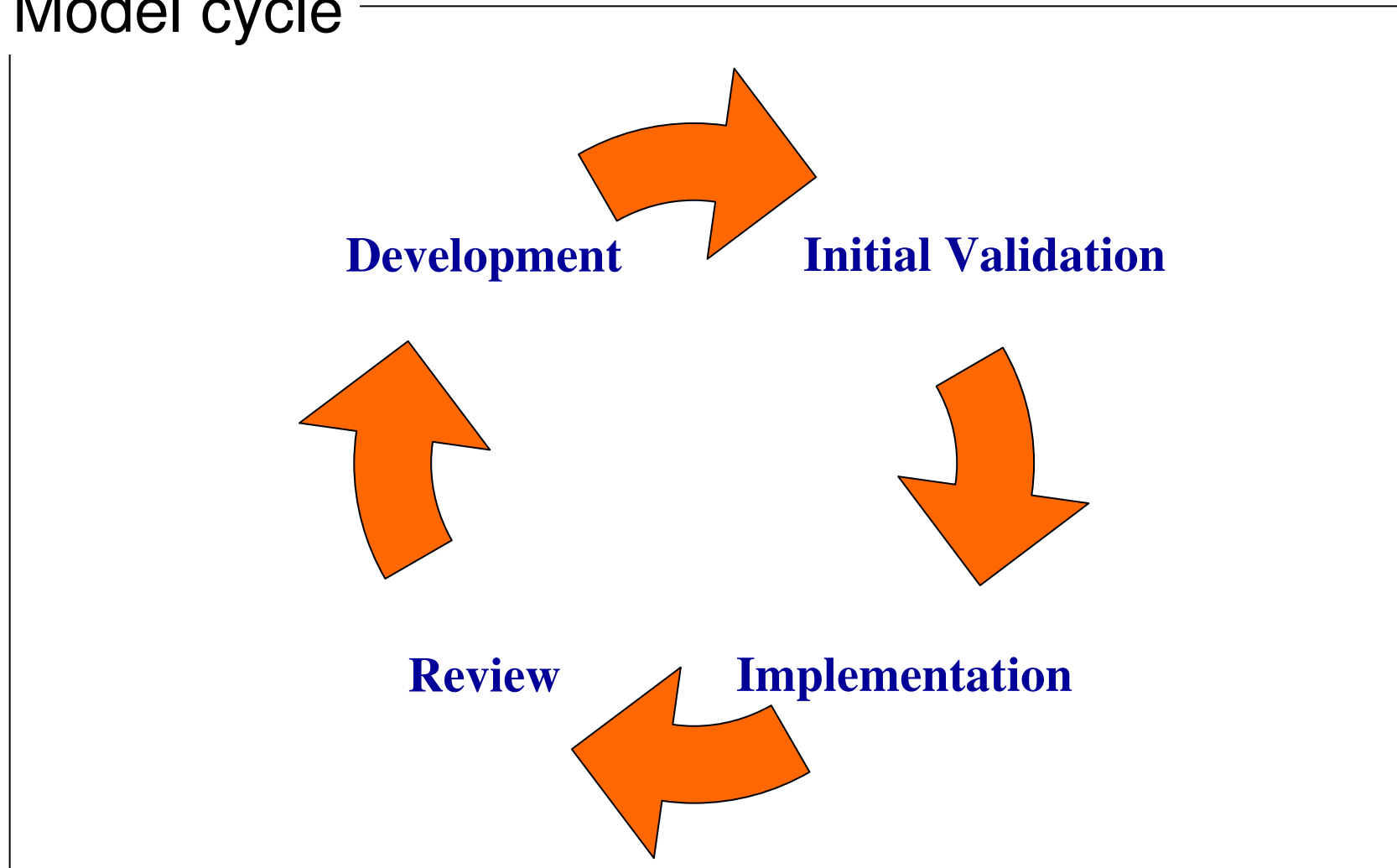


# Model cycle



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## Model cycle

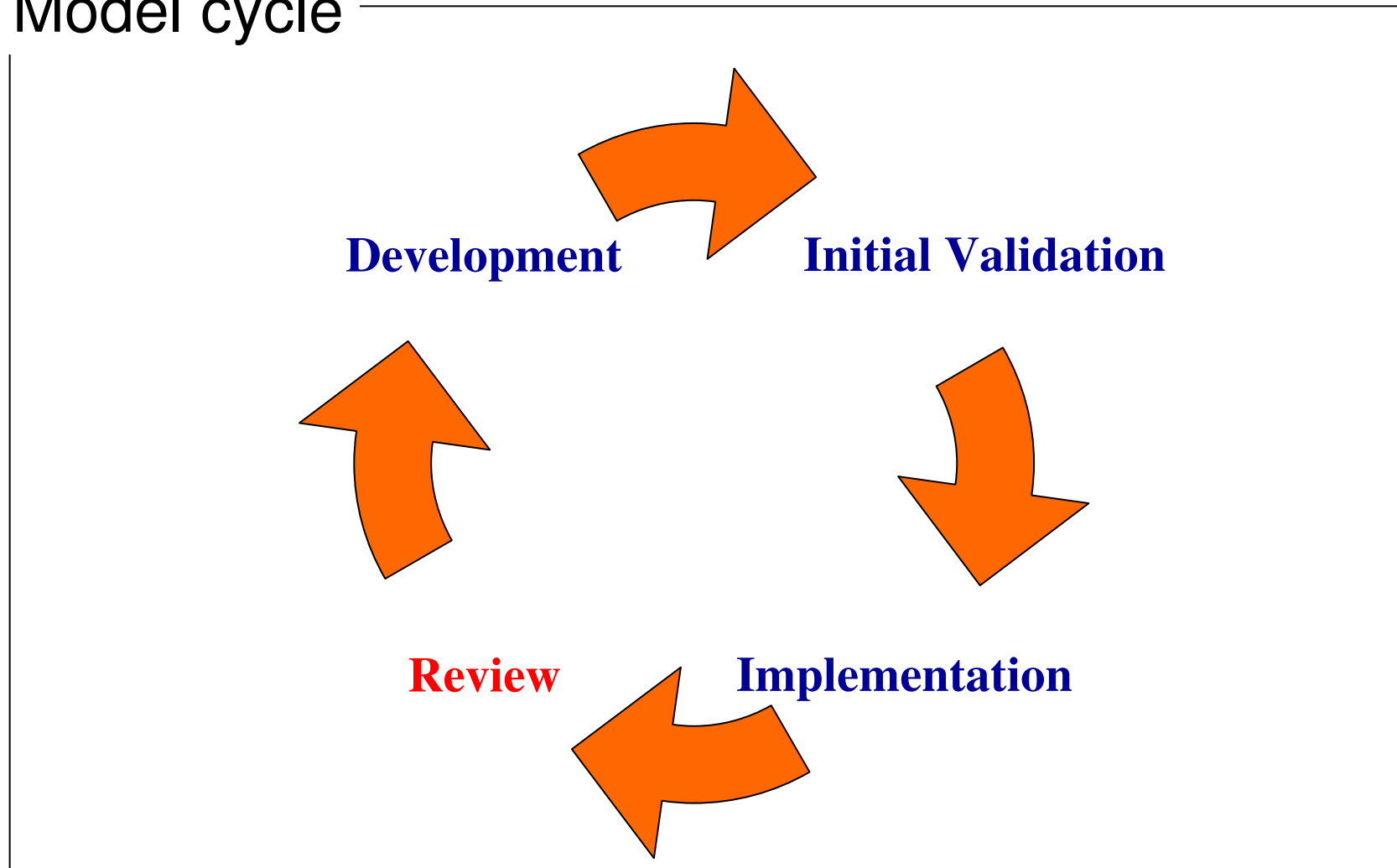


# Model cycle



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## Model cycle



# Model cycle



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## Model review

- Review performance of model
  - Monitoring (quick scan of model inputs and outputs)
  - Backtesting (compare prediction with observed values)
  - Full assessment (evaluate every aspect of model as well as performance)
  
- At least annually
  
- Feedback to senior management

# Model cycle



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Model review

## Decision Rules

**Clear decision rules for model failure**

**When acceptable**

**When to make smaller adjustment**

**When to redevelop**

# Backtesting



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## PD models

Rating philosophy:

- Predefined buckets are filled with comparable facilities
- A constant PD is assigned to each bucket
- Facilities are able to migrate to other buckets

Vintage	Bucket PD
1	1%
2	2%
$\geq 3$	1,5%

# Backtesting



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## Definition parameters

- $N$  = # number of observations
- PD = Probability of Default
- $d$  = # of defaults
- $T$  = test statistic
- $b$  = # rejected buckets

# Backtesting



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## Test on bucket level

Goal: testing model performances on bucket level  
risk rating buckets fixed: linked to PD (per bucket)

$$T \sim \text{Binomial}(N, PD)$$

**With acceptability zone of  $1 - 2\alpha$  (double sided),  
choose acceptance levels  $T_1$  and  $T_2$  such that**

$$T_1 : \sum_{d=0}^{T_1} \binom{N}{d} \times [PD]^d \times [1-PD]^{N-d} \leq \alpha < \sum_{d=0}^{T_1+1} \binom{N}{d} \times [PD]^d \times [1-PD]^{N-d}$$

$$T_2 : \sum_{d=0}^{T_2-1} \binom{N}{d} \times [PD]^d \times [1-PD]^{N-d} < 1-\alpha \leq \sum_{d=0}^{T_2} \binom{N}{d} \times [PD]^d \times [1-PD]^{N-d}$$

# Backtesting



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## Test on composed bucket level

### **Goal: testing # rejected buckets**

One-sided test on whether too many rating buckets are rejected.

Calculate probability of number of rejected buckets:

- $T \sim \text{Binomial}(\# \text{buckets}, \alpha)$

Critical value  $T_1$  can be calculated such that

$$T_1 : \sum_{b=0}^{B_1-1} P(T \leq b) < 95\% \leq \sum_{b=0}^{B_1} P(T \leq b)$$

Acceptance zone  $[0, T_1]$

# Backtesting



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## Model test

**Goal: PD back testing on model level**

**Weighted average of all rating buckets.**

**For large sample # defaults approximately normally distributed:**

$$\sum_{i=1} T^{(i)} \sim Normal\left(\sum_i N^{(i)} * PD^{(i)}, \sum_i N^{(i)} * PD^{(i)} * (1 - PD^{(i)})\right)$$

**Critical values are chosen such that:**

$$T_1 : T_1 \leq \mu + z_\alpha \sigma < T_1 + 1$$

$$T_2 : T_2 - 1 < \mu + z_{1-\alpha} \sigma \leq T_2$$

# Impact of the business cycle



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## Cyclical

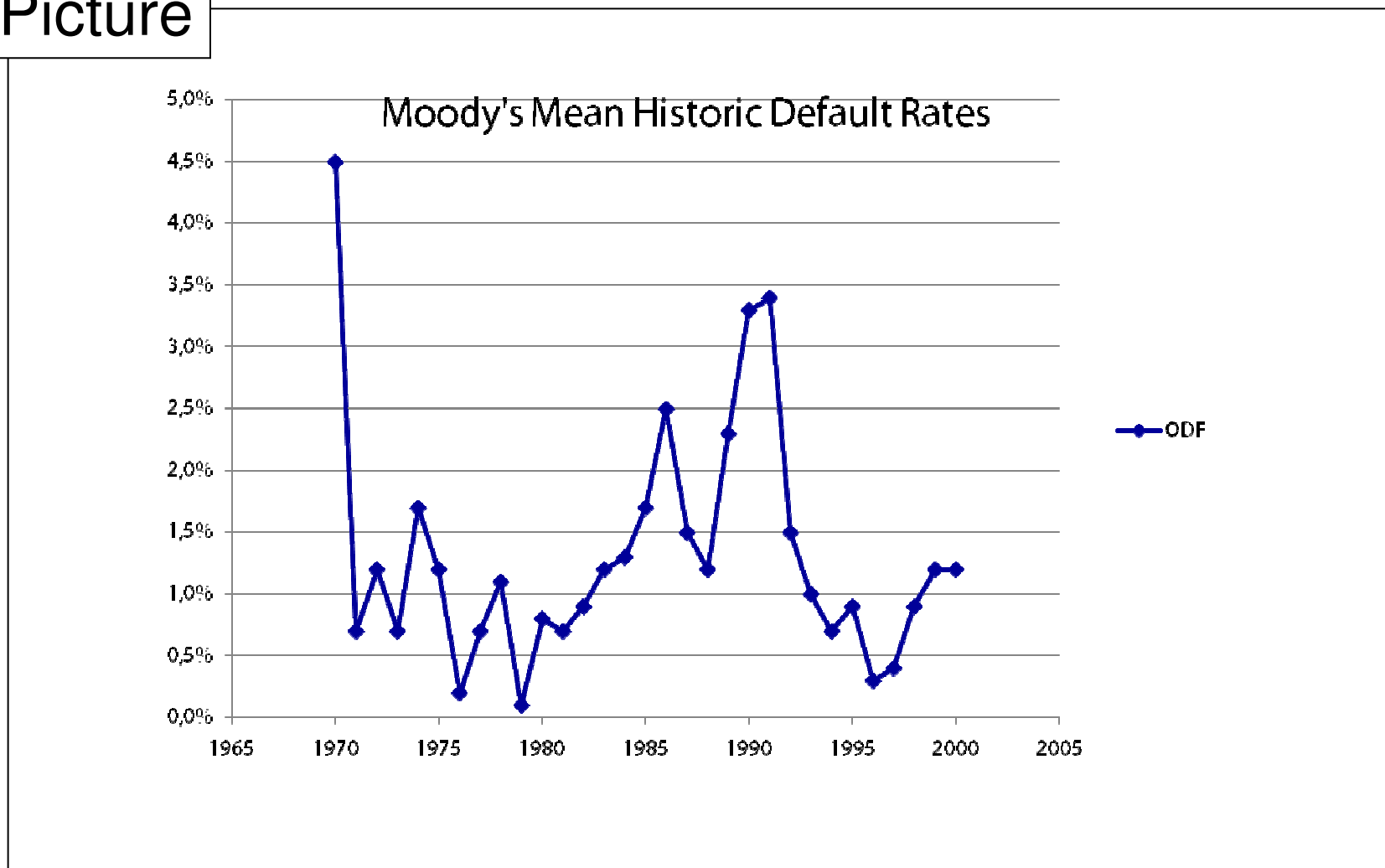
- Due to the business cycle, credit risk is cyclical by nature.
- We focus on cyclical in the default risk (and *not* in recovery risk).
- Cyclical has a systematic component, i.e., it affects the value of many counterparties at the same time.

# Impact of the business cycle



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Picture



# Impact of the business cycle



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## Main question

What is the influence of the business cycle on the rating models and on the backtesting of these models?

# Impact of the business cycle



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## Probability of default

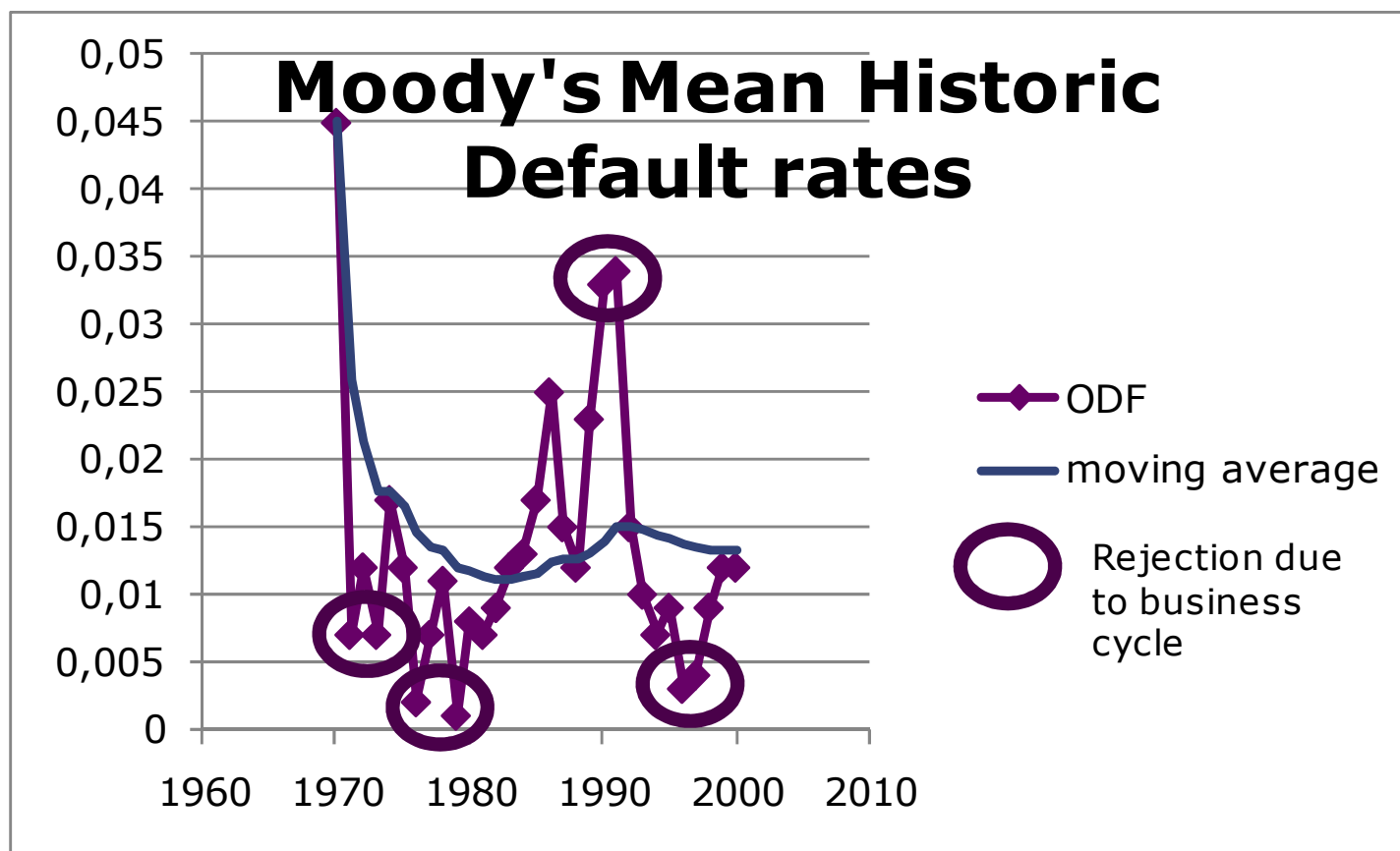
- The **point-in-time** PD is the likelihood that a loan will not be repaid and, thus, will fall into default within the coming year
- The **through-the-cycle** PD is the long-run probability of default which takes into consideration upturns and downturns in the economy

# Impact of the business cycle



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Picture



# Impact of the business cycle



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## Possible solution

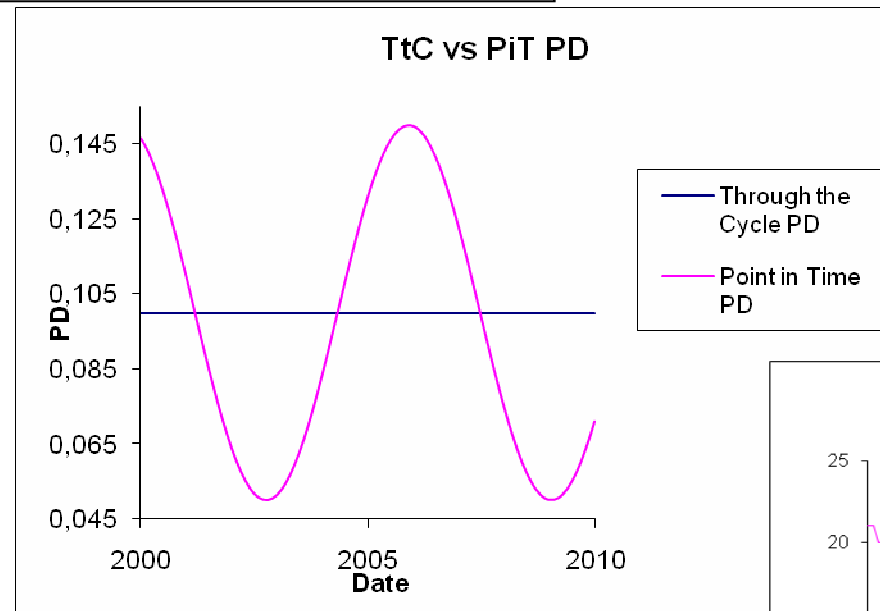
Convert through-the-cycle PDs to point-in-time PDs based on macro-economic variables which are used as a proxy for the economy's position in the business cycle.

# Impact of the business cycle



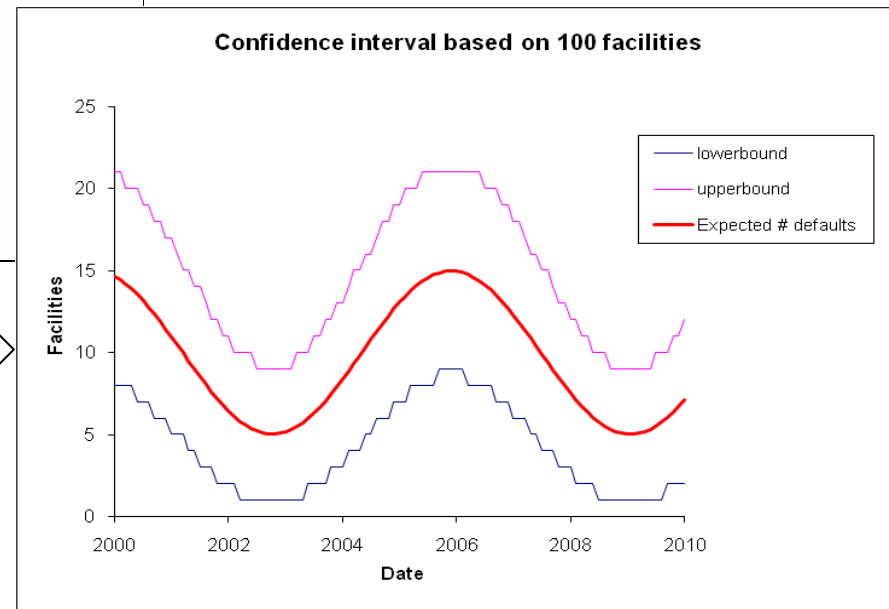
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## Possible solution



$$\sum_{i=1} T^{(i)} \sim \text{Normal}\left(\sum_i N^{(i)} * PD^{(i)}, \sum_i N^{(i)} * PD^{(i)} * (1 - PD^{(i)})\right)$$

Moving confidence interval over time

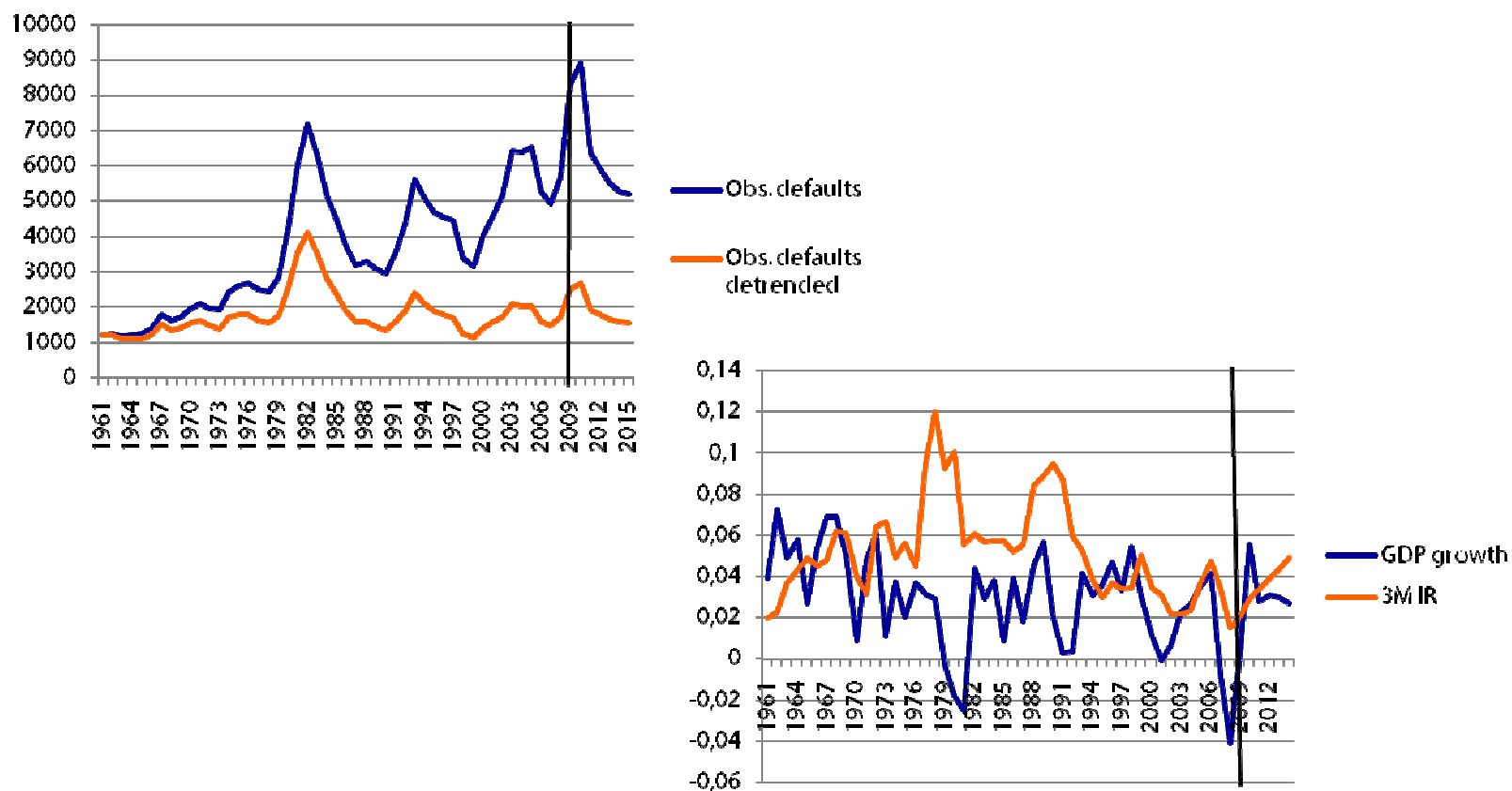




# Impact of the business cycle

## Possible solution

### Defaults and macro data in the Netherlands



# Conclusion



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## Business cycle and backtesting

1. Models estimate Through the cycle PDs while the (most recent) observed default frequencies are Point in Time.
2. The position of the business cycle has an impact on back testing.
3. We are currently working on a solution.

# Discussion



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## Business cycle and backtesting

- How should the business cycle be taken into account when back testing a PD model?

# Discussion



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## Challenges

- Which macro-economic variables can be used as a proxy for the cyclical behavior of the number of defaults and downgrades in a portfolio?
- Do the business cycles and proxies vary for each portfolio?
- How can the conversion from point-in-time PDs to through-the-cycle PDs be made based on these proxies?
- Other solutions to the problem of PiT versus TTC?