Exogenous Maturity Vintage (EMV) Modelling Based on Through the Cycle Maturity

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Lubomir Burian

lubomir.burian@rbs.com, lubomir.burian@rbs.co.uk

Summary

Purpose of Our Research

The aim of our work was to develop a PD model development methodology that could be applied in IFRS9 modelling, stress testing and determination of the future bank's exposures.

EMV Model Obtained from PLS Decomposition

Partial Least Squares regression is used to decompose the observed cohort level default rate (organised in the panel data format) into exogenous, maturity and vintage components. Each of these components can be modelled separately.

We tested this methodology and we believe that we proved that this approach is unreliable and should not be used.

EMV Model based on TTC Maturity

The second approach, we based on a construction of TTC (through the cycle) maturity component. The deviations from the TTC values were modelled with the use of macro-variables. Our opinion is that this modelling methodology can be applied on cohort (vintage) level or more specific model in pool level.

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Data

I. Monte-Carlo Simulation:

Since this is a simulation, data is generated and the outcome tested.

The settings for this simulation were obtained from the trial run of decomposition method that we believe a few lenders use.

II. Our EMV model using TTC Maturity

Internal data from RBS loans portfolio.

Rationale for EMV Methodology

EMV Model can be written as an additive model as follows:

$$Vintage\ DR^{OutcomeD}_{vintage,quarter} = E_{OutcomeD} + M_{quarter} + V_{vintage}$$

The model as above has the following features:

- The model predicts the stressed DR on vintage level
- Components quantify the their own effect
- Vintage component estimates the effect of time of origination (often driven by macro-economics)
- Exogenous component captures the effect of macro-economic cycle
- Maturity component reflects the dependency of default rate on age of the loan
- Attrition model is necessary for production of the portfolio default rate (portfolio DR is a volume weighted vintage DR)

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Structure of Panel Data Format

Vintage	Date	Quarter	Performing	Flow to Default	Def Rate
2005Q1	2005Q1	1	129821	5217	4.02%
2005Q1	2005Q2	2	117511	4999	4.25%
2005Q1	2005Q3	3	102345	5506	5.38%
2005Q1	2005Q4	4	94561	4999	5.29%
2005Q1	2006Q1	5	81025	3705	4.57%
…	…	…	…	…	
2005Q1	2014Q4	40	581	8	1.38%
2005Q2	2005Q2	1	187541	6890	3.67%
2005Q2	2005Q3	2	167890	7020	4.18%
…	…	…	…	…	…
2005Q2	2015Q1	40	96	1	1.04%
2005Q3	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…
2009Q2	2009Q2	1	112021	6296	5.62%
2009Q2	2009Q3	2	98246	6321	6.43%
2009Q2	2009Q4	3	84658	6089	7.19%
2009Q2	2010Q1	4	71564	4801	6.71%
…	…	…	…	…	…
2009Q2	2015Q4	27	2131	11	0.52%
2009Q3	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…

Structure of panel data:

- Data in this table is indicative. It does not hold RBS data.
- Each cohort (vintage) has its own panel in the table
- Panel Data is typically unbalanced
- The observed DR is relating to the vintage
- Observed vintage default rates relate to 3 different points:
  - Macro-economy
  - Age of the loan
  - Risk Appetite

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EMV Decomposition Method

Vintage	Date	Qtr	Exogenous Comp. Dummies					Maturity Comp. Dummies				Vintage Comp. Dummies			
			dE (2005Q1)	dE (2005Q2)	…	dE (2015Q1)	…	dM [1]	dM [2]	…	dM [40]	dV (2005Q1)	dV (2005Q2)	…	dV (2015Q1)
2005Q1	2005Q1	1	1	0		0		1	0		0	1	0		0
2005Q1	2005Q2	2	0	1		0		0	1		0	1	0		0
2005Q1	2005Q3	3	0	0		0		0	0		0	1	0		0
2005Q1	2005Q4	4	0	0		0		0	0		0	1	0		0
2005Q1	2006Q1	5	0	0		0		0	0		0	1	0		0
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
2005Q1	2014Q4	40	0	0		0		0	0		1	1	0		0
2005Q2	2005Q2	1	0	1		0		1	0		0	0	1		0
2005Q2	2005Q3	2	0	0		0		0	1		0	0	1		0
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
2005Q2	2015Q1	40	0	0		1		0	0		1	0	1		0
2005Q3	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…

EMV Decomposition Method

Panel Data demonstrated in the previous chart can be used to decompose the vintage default rate into three components (E, M and V).

This can be achieved by logistic regression, PLS or any other regression method.

- The parameter estimates for the Exogenous dummies (*date*) form an Exogenous Component. This component effectively form a time-series.
- The parameter estimates for the Vintage dummies (*vintage*) form a Vintage Component.
- The parameter estimates for the Maturity dummies (*quarter*) form a Maturity Component.

Here is indication of the SAS code:

```
proc ___ data=<panel_data>;
class vintage date quarter;
model Def_Rate = vintage date quarter;
run;
```

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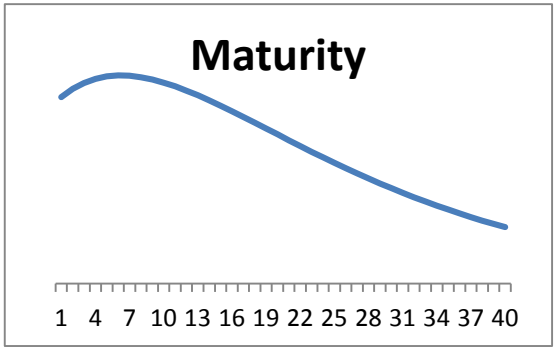
EMV Decomposition Method: Monte-Carlo Test

We realised that the E and V components have a shape of a random walk. We tested the decomposition approach using the following steps:



1. E component is generated using random walk process
2. V component is generated using random walk process
3. Scale for M component is randomly chosen.
   Scale changes the magnitude of the M component.
4. Panel data is generated using the values from 1), 2) and 3). Data contained 80 quarter vintage histories.

$$Vintage\ DR^{OutcomeD}_{vintage,quarter} = E_{OutcomeD} + M_{quarter} + V_{vintage}$$

5. A decomposition is run using PLS regression. In this step, the E, M and V components are retrieved form the regression method.
6. E from step 1 is compared with E obtained from step 5.
   V from step 2 is compared with V obtained from step 5,
   similarly for M...

We decided to repeat this process 10000 times and summarise the comparisons.

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EMV Decomposition: Monte-Carlo Test Results

We calculated the “weight” of each component to estimate the component’s influence in the overall EMV structure:

$$weight\ E = {}^{\sigma_E}/_{(\sigma_E + \sigma_M + \sigma_V)} \qquad weight\ V = {}^{\sigma_V}/_{(\sigma_E + \sigma_M + \sigma_V)}$$

$$weight\ M = {}^{\sigma_M}/_{(\sigma_E + \sigma_M + \sigma_V)}$$

We compared the values of *weights* from the generated components and components retrieved from the decomposition. **Only in 29.3% of cases from 10000 iterations, the weights of all components were less than 5% apart.**

Vintage	Exogenous	Maturity	+/- 10%	+/- 5%	+/- 1%
OK	OK	OK	57.6%	29.6%	2.4%
OK	OK	outside	4.4%	3.6%	2.0%
OK	outside	OK	6.5%	3.6%	0.7%
OK	outside	outside	2.9%	9.0%	7.9%
outside	OK	OK	6.1%	4.2%	0.7%
outside	OK	outside	3.0%	8.2%	8.1%
outside	outside	OK	18.3%	22.8%	10.3%
outside	outside	outside	1.3%	19.0%	67.9%

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Through the Cycle Approach – Hazard to Default

Our TTC EMV approach is based in 3 steps.

1) TTC Maturity model:

$$Vintage\ DR^{OutcomeD}_{vintage,quarter} = TTC\ Maturity^{OutcomeD}_{vintage} + \varepsilon^{OutcomeD}_{vintage,quarter}$$

2) Model for Exogenous Component:

$$\varepsilon^{OutcomeD}_{vintage,quarter} = \beta_0 + \sum_i \beta_i * stationary\ MacroVar_i^{OutcomeD} + \tau^{OutcomeD}_{vintage,quarter}$$

3) Model for Vintage Component:

$$\tau^{OutcomeD}_{vintage,quarter} = \gamma_0 + \sum_j \gamma_j * stationary\ MacroVar_j^{vintage} + \omega^{OutcomeD}_{vintage,quarter}$$

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Other Notes

The above is the indication of our EMV modelling with TTC Maturity:

- In this short presentation we indicated the modelling of flow to default.
- Similar method could be applied in modelling the attrition – outflow from performing book without entering default. This could lead to another EMV model.
- This EMV design consist of 3 steps. Each of them can be tailored to its purpose.
- TTC Maturity could be modelled very simplistically or with survival analysis that would use the method of survival analysis. More complex methods could include variables from bureau or internally derived variables.
- Exogenous and Vintage components could be modelled with use of panel regression methods.
- Step 2 and 3 could be merged.
- Attrition model is necessary for production of the portfolio default rate (portfolio DR is a volume weighted vintage DR)

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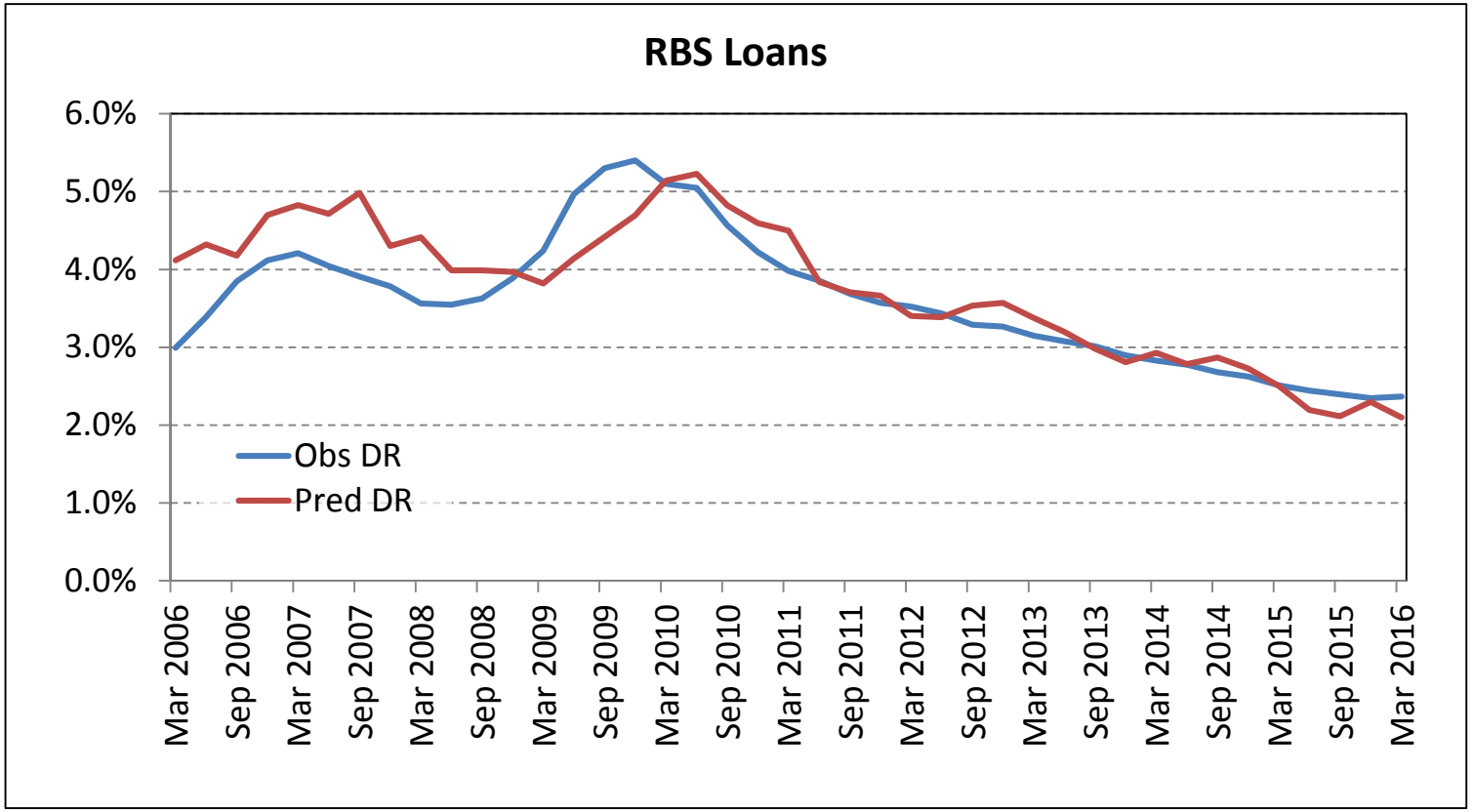
EMV – Illustration of Model Fit (TTC Approach)

Development of Observed and Predicted Default Rate

The chart shows the indicative development of a stressed default rates. Data used in this chart were modified.

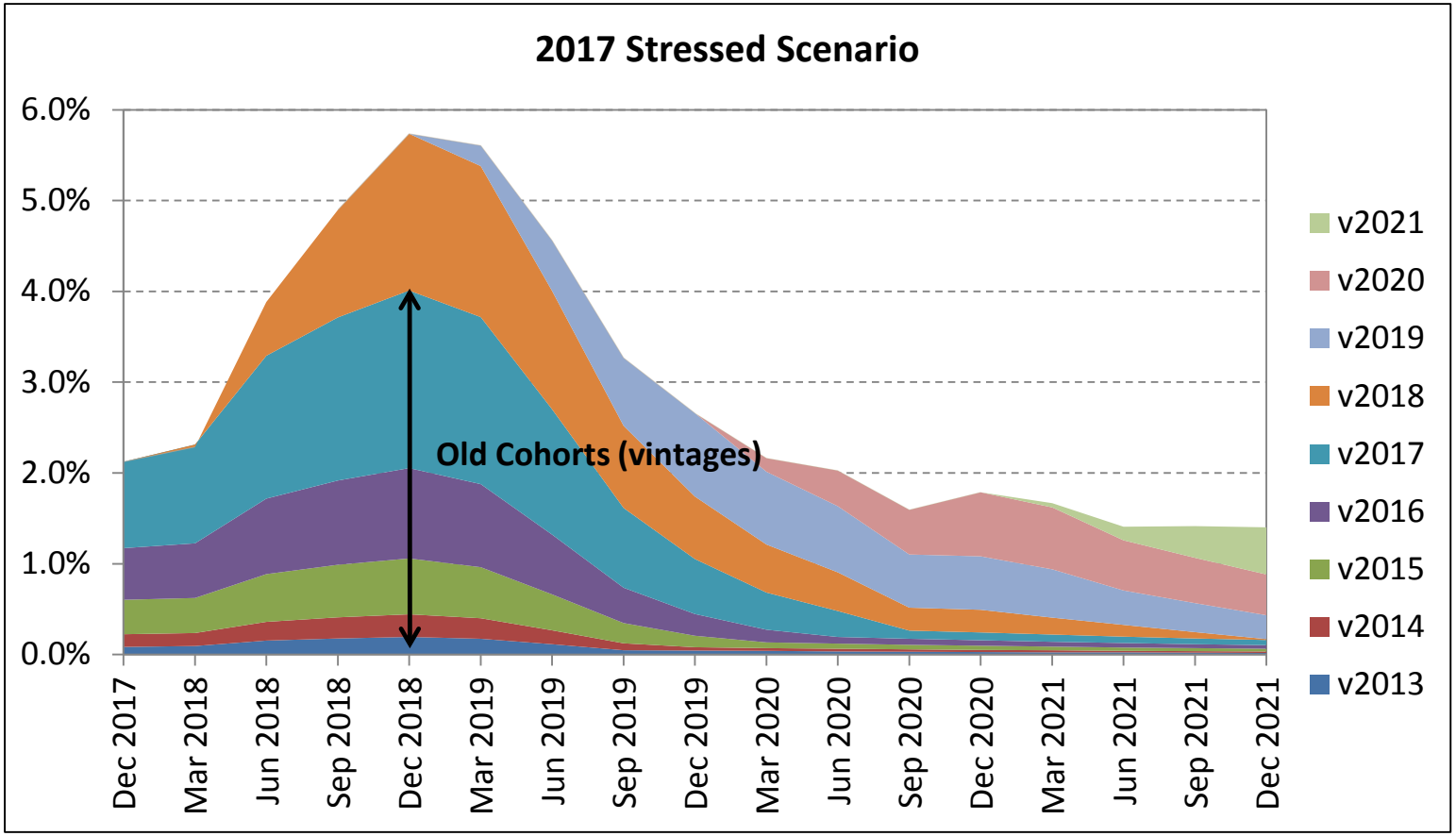


EMV - Illustration

Stressed Default Rate Development per Cohort (Vintage) – One of RBS 2017 Stressed Scenario

The chart shows the indicative development of a stressed default rate. Data used in this chart were modified.

Each vintage is marked with a unique colour and it highlights the contribution of each vintage to the stressed default rate. This stressed scenario starts at 2017Q4.



Questions / Comments

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lubomir.burian@rbs.com, lubomir.burian@rbs.co.uk