Z-Risk Engine®

Unlocking Credit Cycles

Centralized IFRS9 Credit Model Solutions Can Enhance Point-in-Time Accuracy and Substantially Reduce Implementation and Operating Expenses

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Overview: Implementing Dual PIT-TTC Ratings With Credit Cycles

- PIT-TTC approach: BarCap 2003-2008, RBS 09-2014 –signed off officially in both bank's Basel II Waivers – Implemented at a major Asian Bank, 2017-2018 for their corp/commercial enterprise IFRS9 solution
- Bank's early PIT conversions for 'hybrid' credit models for IFRS9 PIT requirements show substantial inaccuracy
- Centralized IFRS9 implementation can save 30-40% of bank's IFRS9 expenses
- Adding LR Climate Risk to IFRS9 & Stress Testing – 'Mixed Model' Approach with LR Structural Change

Bank's Current IFRS9/Stress Testing Models - Non-PIT Prediction Inaccuracies Can Be Substantial

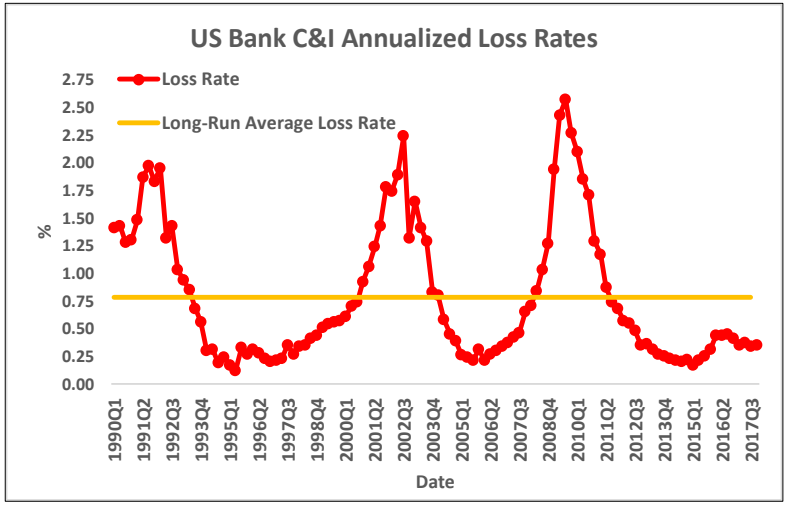
Common Deficiencies in Wholesale/Commercial-Credit Models, Sizes and Directions of the Related Errors, and Remedies for Each Deficiency[1]

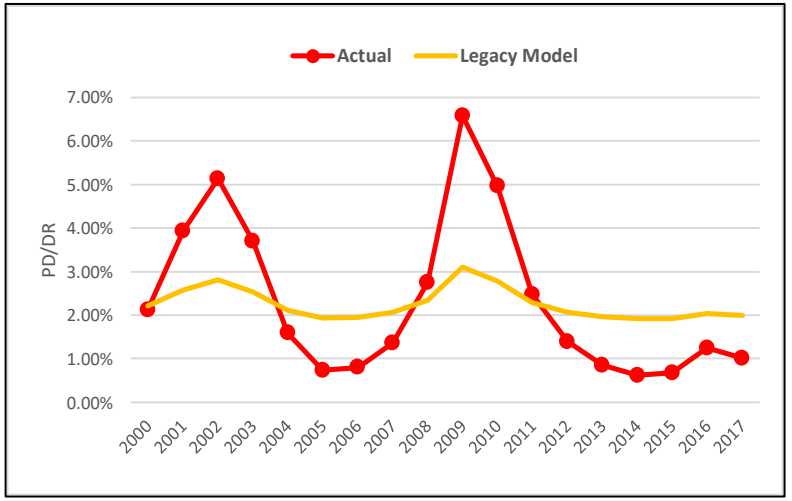
Deficiency	Errors in Lifetime ECL	Errors in Stress Relative to Baseline Loss Rates	Remedy
Hybrid (non-PIT) credit models	Depends on credit-cycle state and model PIT-ness; ***~50%* overestimate** for 25%-PIT models at peak in last 3 credit cycles – **~60% underestimate** at the trough in last 2 credit cycles	**~85% underestimate** in CCAR, severely adverse scenario with 25%-PIT models	**Add market-value-related, PIT inputs to models**
MEV drivers exclude market-value-based ones	See above	**~75% underestimate** in CCAR severely adverse scenario with only GDP drivers	**Add market-value-based, MEV drivers**
Only one or a few, converging, deterministic scenarios	**~30% underestimate**	NA	**Replace with many, statistical scenarios**

[1] Errors estimated by comparing results from models with and without the named deficiency, but otherwise the same. Models without the deficiency include the identified remedy. Estimates are for a portfolio broadly representative of US bank, commercial-and-industrial loans. Stress and baseline scenarios arise from the CCAR-2019, severely adverse and baseline, MEV assumptions. Hybrid model is 25% PIT, about the same as S&P and Moody's ratings. Source: Authors' calculations using ZRE methods drawing on CreditEdge EDFs from Moody's, selected, macroeconomic data from FRED, CCAR macroeconomic assumptions from the Fed, and US Bank, C&I, charge-off rates from the Fed/OCC.

Credit Cycles Are Real ! PIT Models Are Extremely Important

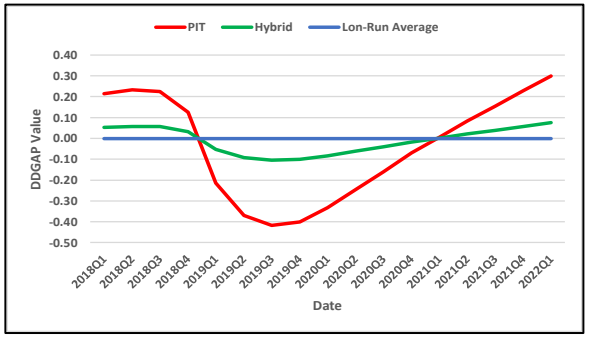
- Cyclical fluctuations in default/loss rates are large, **with peak-to-trough variations of ~10x**
- Legacy models understate cyclical variations
- Problem traces to temporal stability of credit-model inputs; book-value, financial ratios and judgmental assessments vary much less over the cycle than default & loss rates;
- Predicting 15-20% of systematic cycle outcomes is very powerful





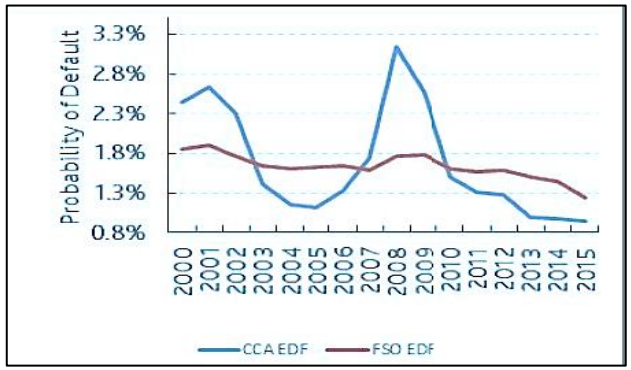
Differences Between PIT & Hybrid Models

PIT and hybrid models differ substantially in the systematic cyclicality of inputs

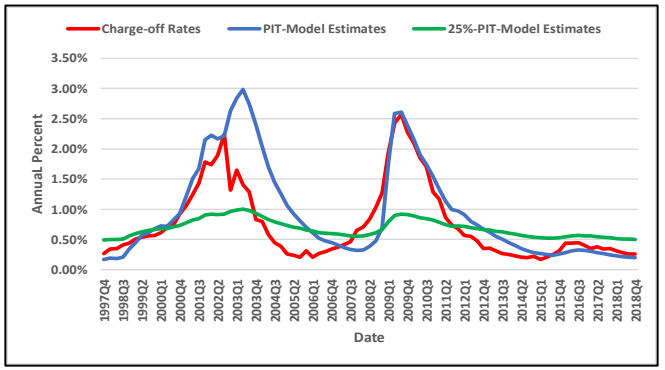


PIT and 25%-PIT DDGAPs; *Source: Authors' calculations applying ZRE methods to Moody's Credit Edge data and, Severely-Adverse-Scenario assumptions*

And this leads to very different cyclicality & accuracy of outputs

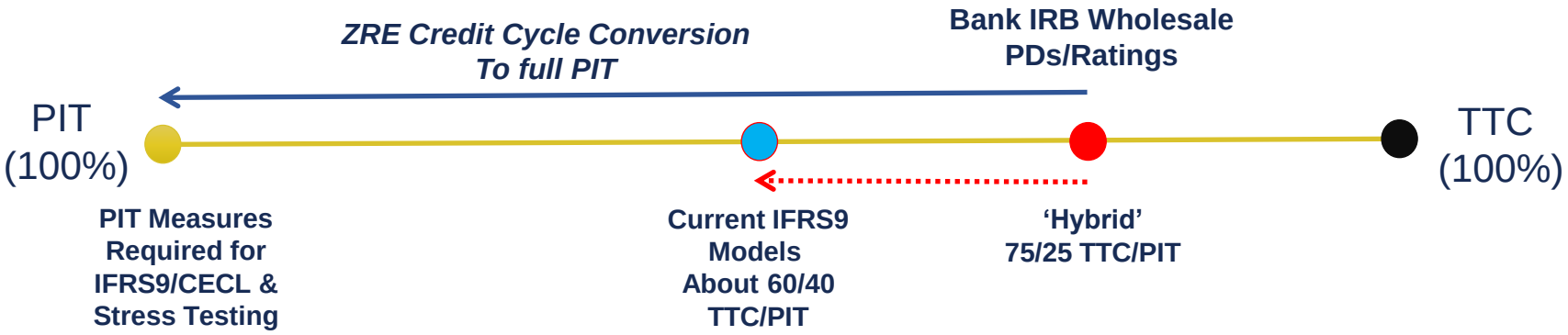


Average PDs from the Credit-Cycle-Adjusted (CCA) and Financial-Statement-Only (FSO) RiskCalc Models Applied to UK Firms; *Source: Levy, A. and Zhang, J. (2018) "Measuring and Managing the Impact of IFRS 9 and CECL Requirements on Dynamics in Allowance, Earnings, and Bank Capital," Moody's*

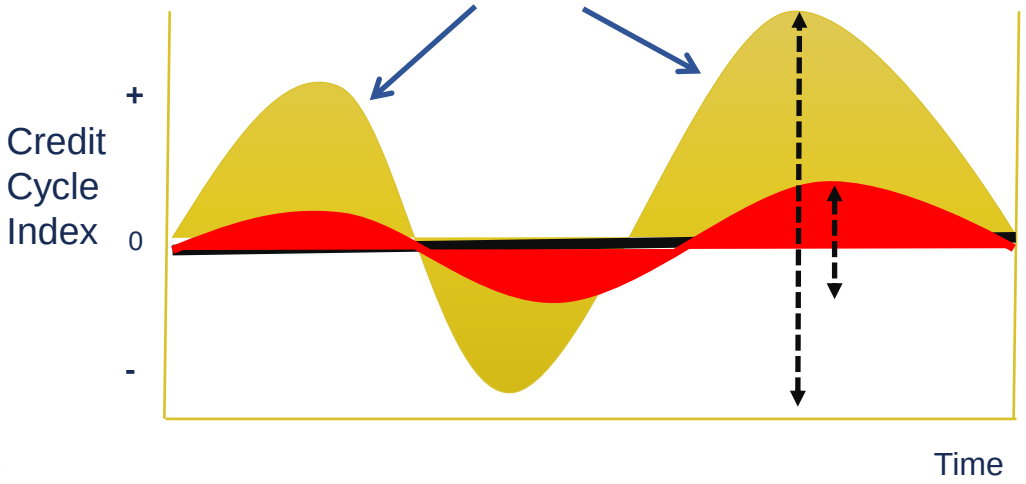


Back Tests Over 1997Q4-2018Q4 Comparing PIT- and Hybrid-Model Estimates With Actual Values of US-Bank, C&I Charge-Off Rates; *Source: Author's calculations using ZRE methods, Moody's CreditEdge data, and US Federal Reserve data at* https://www.federalreserve.gov/releases/chargeoff/chgallsa.htm

ZRE Applies Industry/Region Credit Cycles to 'Hybrid' Wholesale Bank Ratings or PDs to Predict Full PIT



Z credit-cycle indices allow banks to convert hybrid/TTC indicators to 100% PIT - Current hybrid ratings are not PIT and Bank's initial IFRS9 models fall well short of full PIT also at about 50/50



PIT/TTC Approach Models Detailed Industry/Regions

Industry and Region Systematic Factors are Combined to Develop Credit Cycle Indices

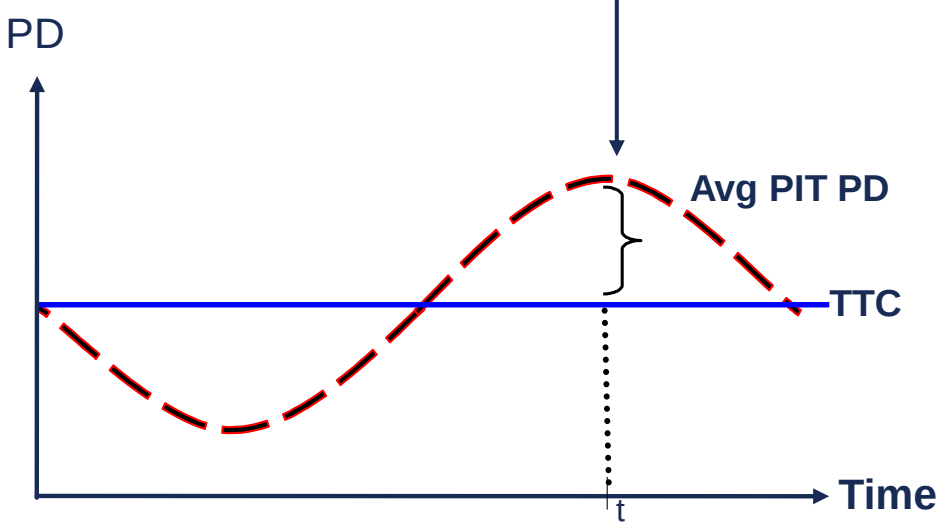
Industry Sector Z_I

- Aerospace & Defence
- Banking
- Chemicals & Plastic Products
- Construction
- Consumer Products
- Oil & Gas
- Finance, Real Estate & Insurance
- Hotels & Leisure
- Basic Industries
- Machinery & Equipment
- Media
- Medical
- Steel & Metal Products
- Mining
- Motor Vehicle & Parts
- Retail & Wholesale Trade
- Business & Consumer Services
- Technology
- Transportation
- Utilities
- Commercial Real Estate

$$\frac{\text{Spot Median } Z_{S/R} \text{ Gap}}{\text{LR Median } Z_{S/R} \text{ Gap}}$$

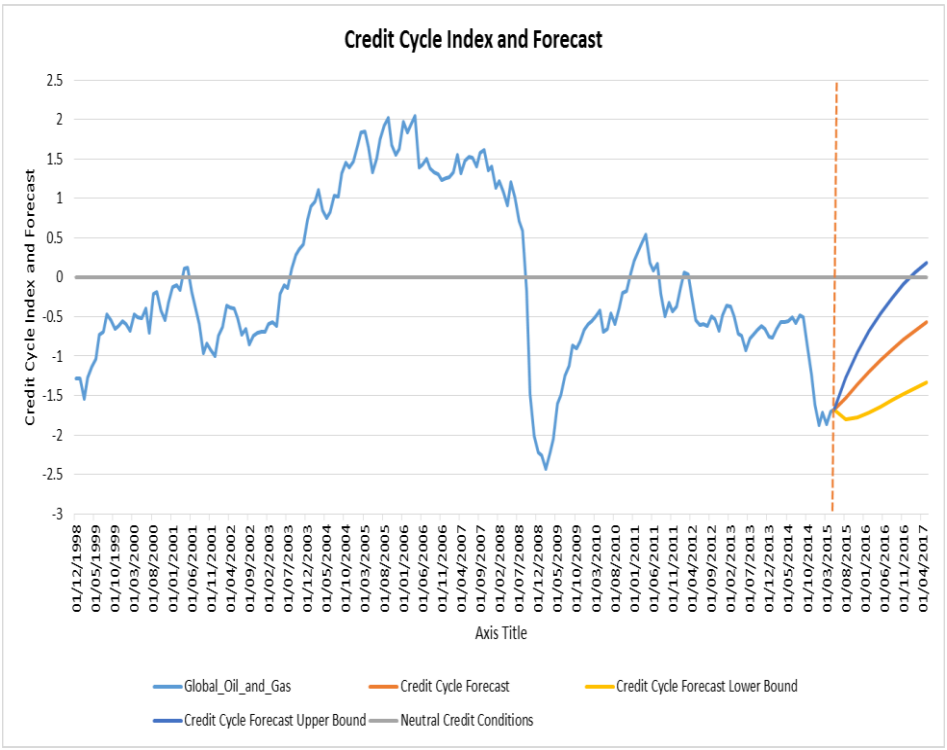
Regional Z_R (Corp/FI)

- Asia
- Continental Europe
- United Kingdom
- Latin America
- North America
- Pacific



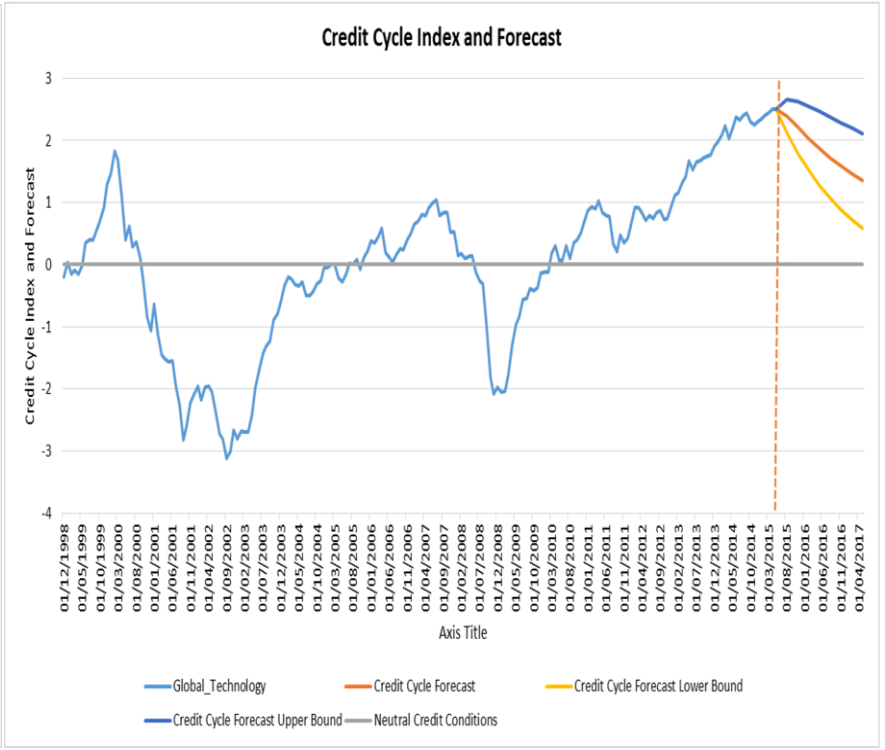
PIT PDs are Key – PIT Current Credit Conditions Can Vary Substantially Across Detailed Industry/Region Sectors

Conditions will eventually improve for Global Oil and Gas sector –



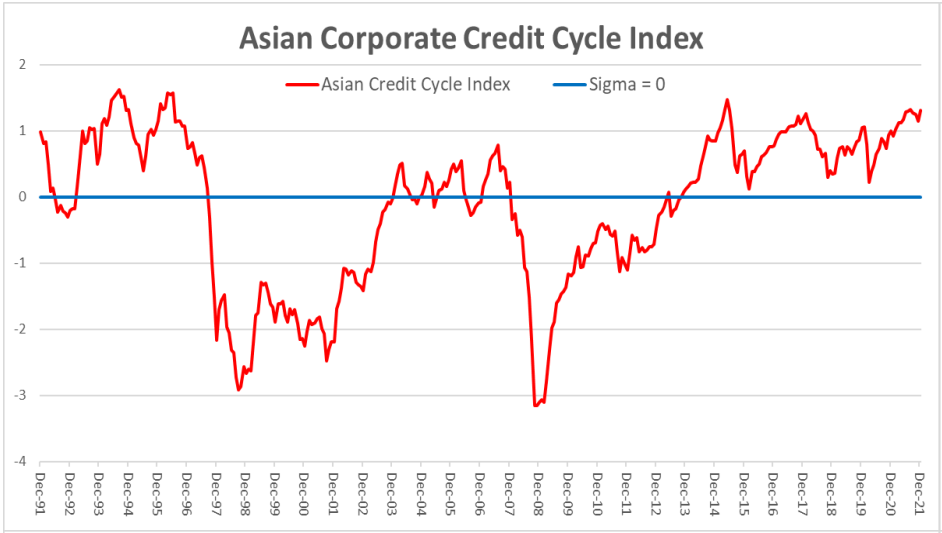
Sources: Moody's Analytics CreditEdge™, UK/US Government Statistics, Z-Risk Engine™ models

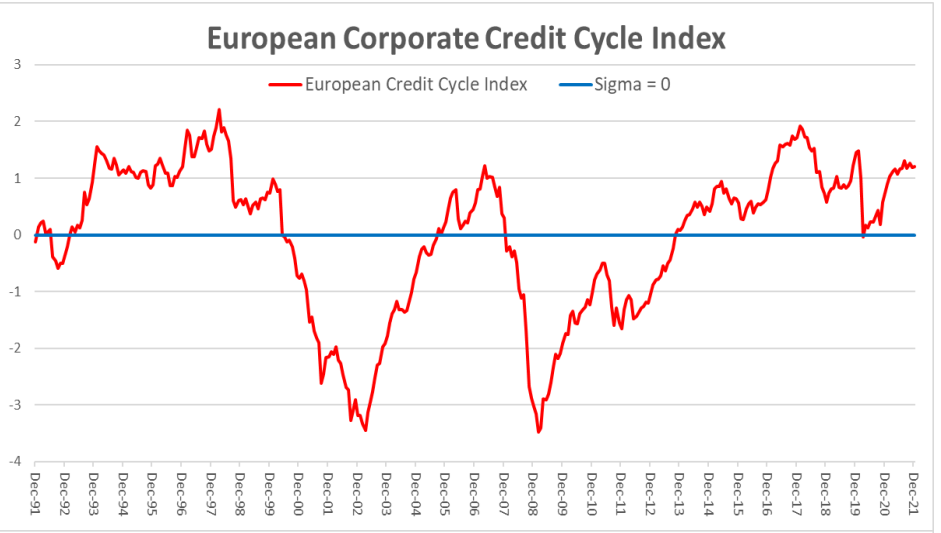
Conditions will eventually deteriorate in Global Technology sector – just like the past

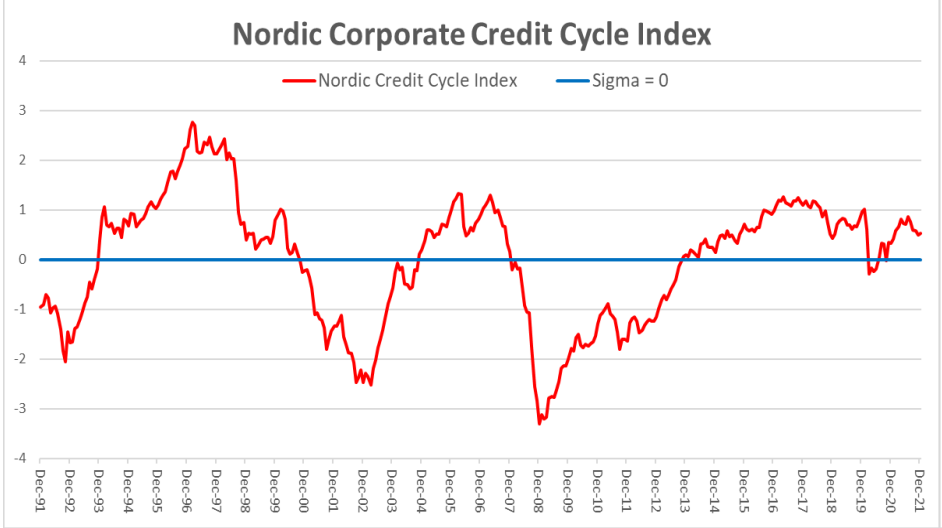


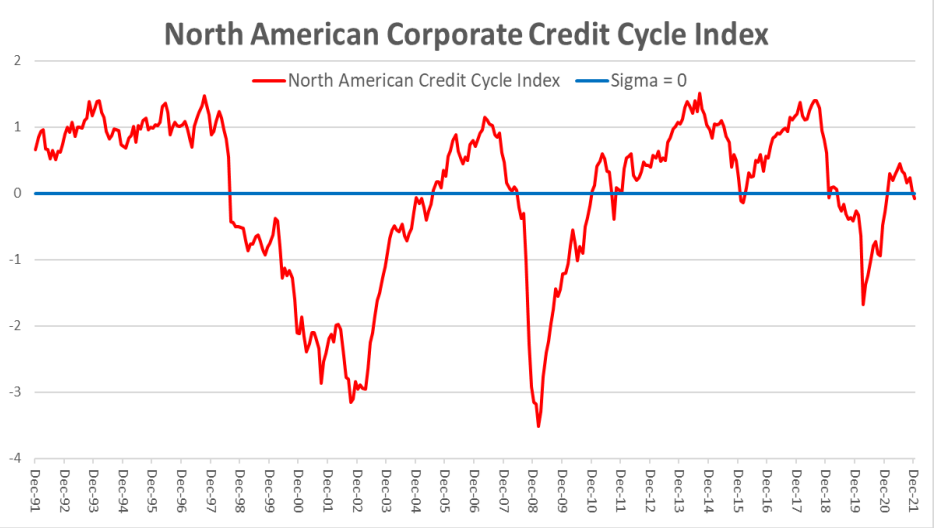
Sources: Moody's Analytics CreditEdge™, UK/US Government Statistics, Z-Risk Engine™ models

Examples of Regional, Corporate Z Credit Cycles

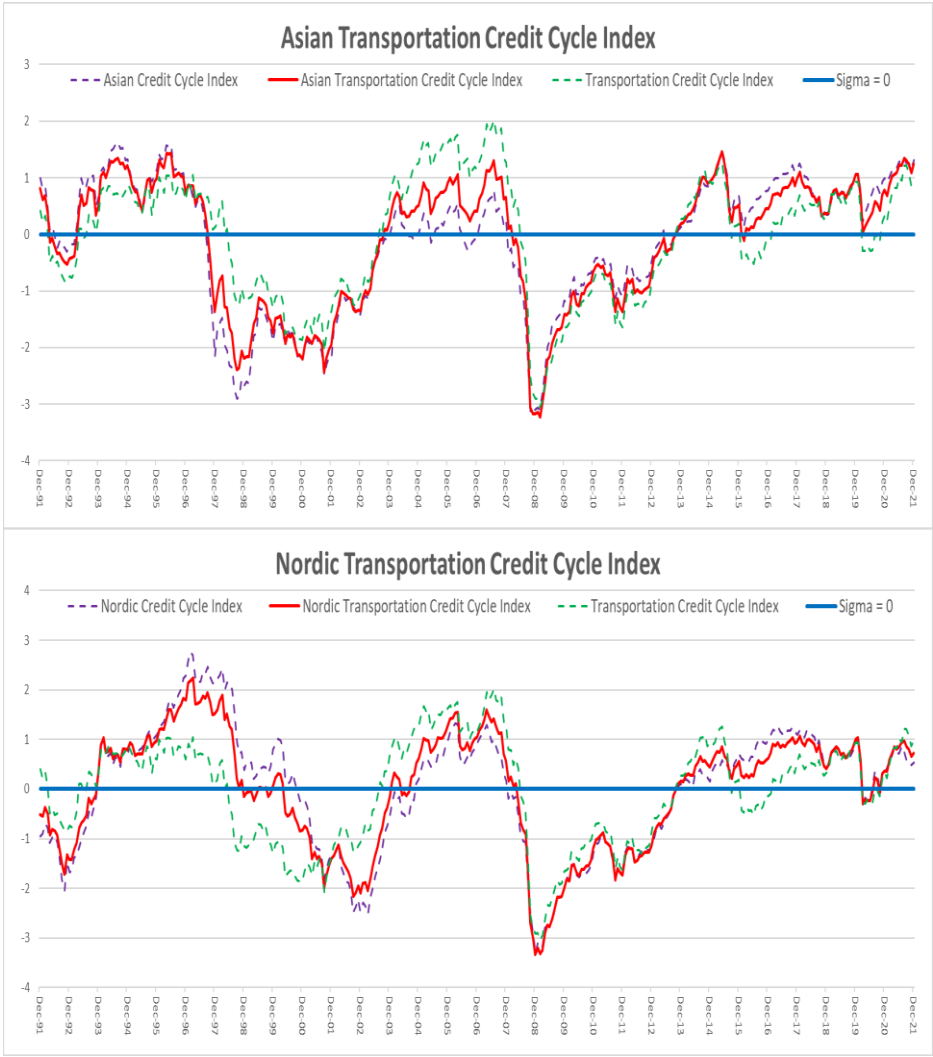


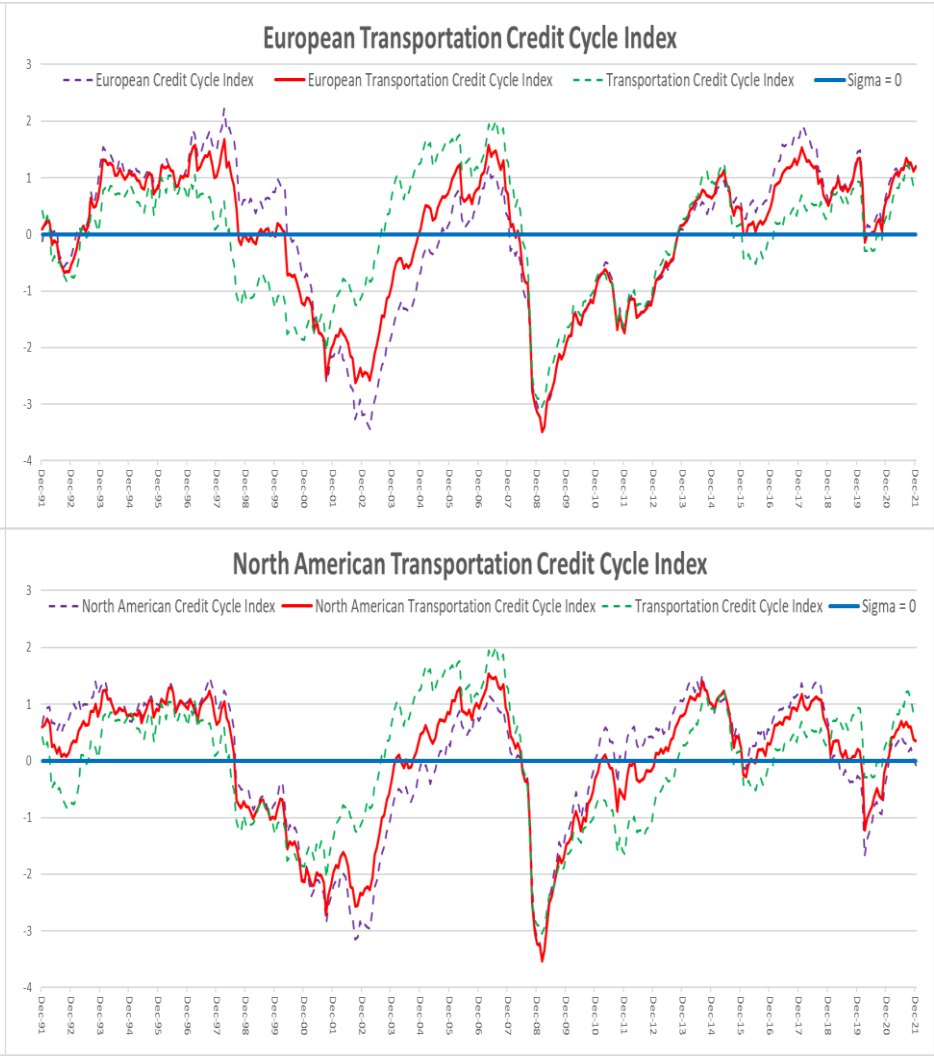






Examples of Regional, Corporate Transportation Z Credit Cycles





IFRS9 Expense Budgets Can Be Reduced by Roughly 30-40%

- Most current bank IFRS9 credit models create **2 sets of PD models** – IRB & a second-stage (partial PIT adjustment) IFRS9 model for each IRB model
- Centralized, E2E batch model approach can undertake **full PIT adjustments in a single, automated model batch**
- Reduced staff expenses
- Open-source Python implementation **further reduces external vendor software** costs & E2E processing **reduces staff cleansing data** for DQ issues
- Centralized approach:

    - Supports, IFRS9, Stress Testing & Climate in a single automated batch

    - Managed service or a Python Source code with perpetual IP

Illustrative Benchmark – Two-Stage IRB-IFRS9 Model Development & Implementation Expenses Reduced by 30%

£900 bil European Bank – IRB/IFRS9 Model Development, Validation & Implementation

	2020	2021	2022	2023	2024	2020-24
Data/Quant Analysts	50	50	35	20	20	
Model Validation Analysts	20	20	15	12	12	
Ba/Model Developers	25	25	18	14	14	
Project Managers	7	7	6	5	5	
Total	**102**	**102**	**74**	**51**	**51**	**380 FTE**
Avg Annual Staff Cost - £110k						
Total 5 Year Wholesale Model Budgets Required						**£41.8 MIL**

Illustrative Benchmark – Centralized IRB-IFRS9 Model Development & Implementation Expenses Reduced by 30%

£900 bil European Bank – IRB/IFRS9 Model Development, Validation & Implementation

	2020	2021	2022	2023	2024	2020-24
Data/Quant Analysts	36	36	22	14	14	
Model Validation Analysts	14	14	10	8	8	
Ba/Model Developers	18	18	12	10	10	
Project Managers	5	5	4	3	3	
Total	**73**	**73**	**48**	**35**	**35**	**264 FTE**
Avg Annual Staff Cost - £110k						
Total 5 Year Wholesale Model Budgets Required						**£29 MIL**

Illustrative Benchmark – Two-Stage IRB-IFRS9 Model Development & Implementation Expenses Reduced by 30%

£900 bil European Bank – IRB/IFRS9 BAU Operating Expenses

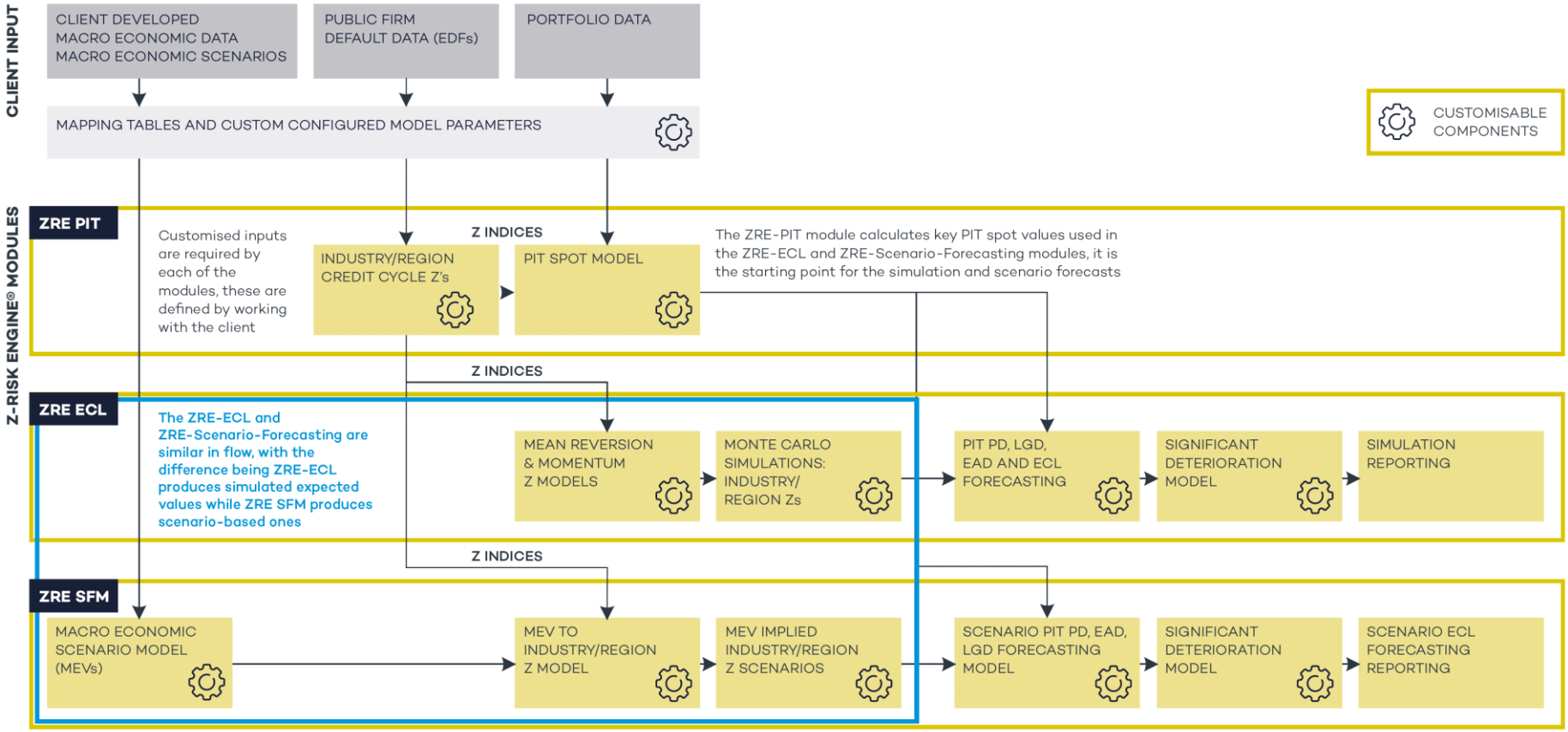
	2021	2022	2023	2024	2025	2021-25
External Software Costs* **	£1 MIL	£1 MIL	£1 MIL	£1 MIL	£1MIL	£5 MIL
Quant Modellers	4	4	4	4	4	20
BAU Support/ Testing BAS	4	4	4	4	4	20
System Operating Coders	5	5	5	5	5	25
Data Analysts (Reporting and DQ Cleanup)	8	8	8	8	8	40
Project Managers	3	3	3	3	3	15
Total	**24**	**24**	**24**	**24**	**24**	**120 FTE**
Avg Staff Cost - £90k/Year						£10.8 MIL
Total 5 Year Software And Support Operating Budgets Required						**£15.8 MIL**

Illustrative Benchmark – Centralized IRB-IFRS9 Model Development & Implementation Expenses Reduced by 30%

£900 bil European Bank – IRB/IFRS9 BAU Operating Expenses

	2021	2022	2023	2024	2025	2021-25
External Software Costs*	0	0	0	0	0	0
Quant Modellers	3	3	3	3	3	15
BAU Support/ Testing BAS	3	3	3	3	3	15
System Operating Coders	3	3	3	3	3	15
Data Analysts (Reporting and DQ Cleanup)	4	4	4	4	4	20
Project Managers	2	2	2	2	2	10
Total	**15**	**15**	**15**	**15**	**15**	**75 FTE**
Avg Staff Cost - £90k/Year						£6.75 MIL
Total 5 Year Software And Support Operating Budgets Required						**£6.75 MIL**

Single Centralized E2E Automated Solution, Reduces Implementation Costs – Supports IFRS9, Stress Testing & Climate Risk



Musings On Climate Risk Modeling for Banks

- Market Failure Dominates – Planetary Intervention Required
- Major Structural Change Required – 'Carbon-Addiction' to Net--Zero
- Time Horizon:
  - IAM models to 2100 (Nordhaus roughly 7% GDP reduction)
  - Net Zero – 2050
  - Current ZRE longest exposure in production to 2061
  - Regulator climate stress tests – 2030/40/50
- 'Green Premiums' (B. Gates) Help Quantify/Set Carbon Pricing
- 'Mixed Model' – Empirical I/O + Industry P/L + 'Structured Levers'
- Use Credit Losses as Metric
- 2-3 Years PIT – beyond 3 years TTC Mean Reversion – LR Systematic Changes to TTC 'Anchors'

Z-Risk Engine™ Required Module Inputs & Outputs

Input-Output Template for ZRE																				
Classification Information			ZRE Inputs										Selected ZRE Outputs							
			Basel Parameters				Other Facility & Borrower Attributes						ECL (Thousands CU)		ECL Explain (Thousands CU)					
FAC #	Portfolio	Product	TTC PD	DT LGD	DT CCF	DT FCF	Maturity in Years	Limit (Millions CU)	Expected Usage	Primary Region	Primary Industry	EIR	One-Year	Lifetime	(1) Basel EL	(2) PIT Adjustment	(3) Tenor Adjustment	(4) Forward-Looking Adjustment	(5) Skewness Adjustment	(6) Lifetime ECL = (1)+(2)+(3)+(4)+(5)
1	SME	Term	0.72%	40%	100%	100%	6.00	5.00	100%	United Kingdom	Media	3.58%			14.38					
2	LC	Revolving	0.17%	20%	45%	100%	2.00	70.00	50%	United Kingdom	Business and Consumer Services	3.07%			16.75					
3	LC	Term	0.27%	40%	100%	100%	1.50	70.00	100%	US & Canada	Consumer Products	3.21%			74.57					
4	SME	Contingent	0.72%	30%	100%	20%	5.75	12.00	50%	United Kingdom	Retail and Wholesale Trade	3.43%			5.18					
5	SME	Term	0.17%	40%	100%	100%	5.25	2.00	100%	United Kingdom	Business and Consumer Services	3.13%			1.32					
6	SME	Term	4.04%	40%	100%	100%	3.00	5.00	100%	United Kingdom	Construction	6.23%			80.75					
7	LC	Backstop	0.72%	40%	75%	100%	0.50	70.00	0%	United Kingdom	Transportation	3.58%			150.95					
8	LC	Backstop	4.04%	40%	75%	100%	1.00	80.00	0%	US & Canada	Aerospace and Defence	6.23%			968.95					
9	SME	Term	2.42%	40%	100%	100%	1.00	15.00	100%	United Kingdom FI	Finance, Insurance, and Real Estate	4.94%			145.26					
10	LC	Revolving	0.27%	50%	45%	100%	6.50	80.00	20%	United Kingdom	Medical	3.27%			59.66					
11	SME	Term	0.51%	50%	100%	100%	4.75	12.00	100%	United Kingdom	Hotels and Leisure	3.51%			30.61					
12	LC	Term	0.72%	20%	100%	100%	4.00	70.00	100%	US & Canada	Oil and Gas	3.29%			100.63					

ZRE Input or Output	Description
TTC PD	through-the-cycle probability of default (PD) as required in Basel capital calculations
DT LGD	downturn loss-given-default rate (LGD) as required in Basel capital calculations
DT CCF	downturn credit-conversion factor (CCF) as required in determining DT exposure at default (EAD) used in Basel capital calculations
DT FCF	downturn, funding conversion factor = expected proportion of contingent exposure that becomes funded in a downturn (aka DT product CCF)
Maturity	remaining term of the facility in years
Limit	maximum drawn or outstanding amount under a facility (aka commitment or authorized commitment)
Expected Usage	credit-line, expected usage other than in default; expressed as percentage of limit
Primary Region	primary location of the principal borrower's business
Primary Industry	primary industry of the principal borrower's business
EIR	effective interest rate of the facility
ECL One Year	expected credit losses during the next 12 months (or up to maturity if shorter); expressed as a present value using the EIR for discounting
ECL Lifetime	expected credit losses over the facility's remaining lifetime; expressed as a present value using the EIR for discounting
ECL Explain	step-wise decomposition of difference between Basel, one-year expected loss (EL) and IFRS 9/CECL, lifetime EC
PIT Adjustment	change in one-year ECL caused by adjusting Basel parameters to PIT values
Tenor Adjustment	change in ECL caused by calculating losses over the facility's remaining life using a random-walk (RW) without drift, credit-cycle model in estimating quarterly PDs, ELGDs, and EEADs separately and then calculating the quarterly ECLs as a product of those separate expectations
Forward-Looking Adjustment	change in lifetime ECL caused by using forward-looking, credit-cycle projections in place of unpredictable, RW ones in estimating quarterly PDs. ELGDs, and EEADs separately and then calculating quarterly ECLs as a product of those separate expectations
Skewness Adjustment	change in lifetime ECL caused by using many, probabilistic, joint, PD, ELGD, and EEAD simulations in estimating quarterly ECLs; skewness effect traces to convexity of PDs and correlation among PDs, LGDs, and EADs
Lifetime ECL	expected losses over the life of the facility; expressed as a present value using the EIR for discounting

Industries	Regions
Aerospace and Defense	Asia
Banking	Asia FI
Basic Industries	Europe
Business and Consumer Services	Europe FI
Chemicals and Plastic Products	United Kingdom
Construction	United Kingdom FI
Consumer Products	Latin America
Finance, Insurance, and Real Estate	Latin America FI
Hotels and Leisure	US & Canada
Machinery and Equipment	US & Canada FI
Media	Pacific
Medical	Pacific FI
Metals	South Africa
Mining	South Africa FI
Motor Vehicles and Parts	
Oil and Gas	
Retail and Wholesale Trade	
Technology	
Transportation	
Utilities	

Assumptions

PIT-ness of each PD model.
Conservatism biases of models.
Cycle sensitivities of LGDs and EADs.

Z-RiskEngine.com For Benchmark Case Studies & Research

See below three case studies offering extended discussions of the modeling inaccuracies described in this presentation

- Stress and ECL errors caused by hybrid credit models: **https://www.z-riskengine.com/media/1117/zre_inaccuracies-caused-by-hybrid-credit-factors_sep19.pdf**
- Stress errors caused by non-PIT MEVs as scenario drivers: **https://www.z-riskengine.com/media/1116/zre_stress_understatement_using_gdp_drivers.pdf**
- ECL errors caused by a small number of converging scenarios: **https://www.z-riskengine.com/media/1113/variance-compression-bias-in-expected-credit-loss-estimates.pdf**