Introduction to Machine Learning and Artificial Intelligence in Stress Testing

Agenda

- Why do we need a fully automation solution?
- What is the solution?
- Solution highlights:
  1. Automation
  2. Scenario parameterisation
  3. Model selection and validation
  4. Lost estimation
  5. Reporting capability
- Who benefits from such solution?

Why do we need an integrated solution?

Business Challenge

- Facing continuous regulatory pressure to enhance stress testing methodology and integration with risk-appetite, **however:**
  - Bank's have lack of comprehensive view of the underlying risks and positions across books and portfolios
  - Current stress testing capabilities are generally isolated and fragmented with little or no interaction and consistency among different risk factors
  - Lack of transparency and governance on model assumptions and design, resulting in the 'Black Box' effect
  - Lack of confidence from senior management in embedding key decisions or contingency planning based on stress results

Integrated Stress Testing Framework

- An integrated stress testing framework leveraging machine learning and artificial intelligence is required to address the business needs:
  - Identification and measurement of the impact of material risks & opportunities on Bank's balance sheet (e.g. earnings, capital, among others)
  - Integrated, transparent, automated and consistent testing approach which enables more frequent testing (**real time analytics based on emerging risk**s)
  - Apparent model assumptions and a user friendly design to support decision making on a senior management level
  - Integrate stress testing result into management's decision making process, covering real time risk limit evaluation, risk appetite and capital planning

What is the ideal automated solution?

- ✓ **Aligned** to regulations requirements including: FED (CCAR), PRA (ICAAP), BASEL, Solvency II, contingency, recovery and resolution planning
- ✓ **Automates** stressing process using Machine Learning & Artificial Intelligence covering from scenario parameterisation of loss calculation to capital adequacy and management
- ✓ **Integrates** stress testing activity to management decision process and promotes stakeholder engagement and communication by providing real time feedback

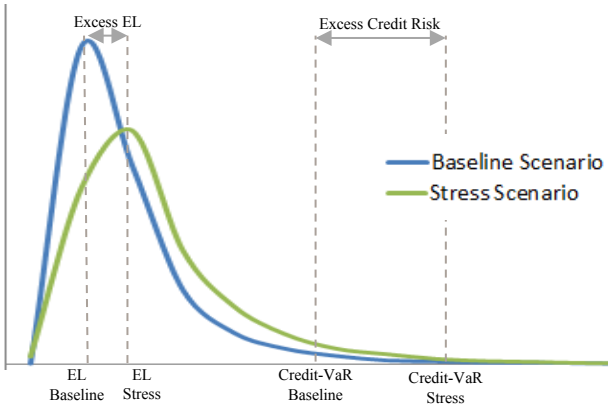
Scenario Parameterisation
Macro and Risk Satellite Model
Translate stress scenario narratives into macrocosmic variables and financial variables

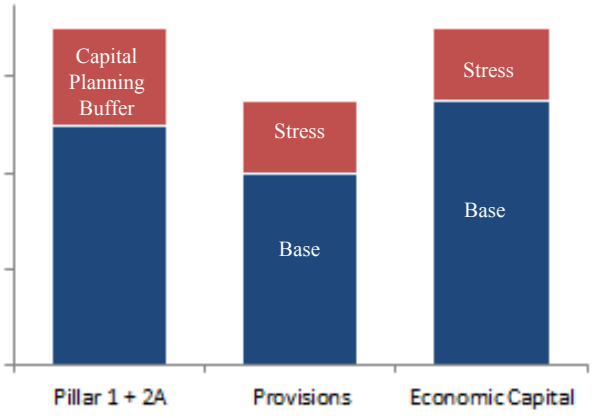
Loss Estimation
Map variables, correlations and risk appetite statements into asset quality and potential credit losses, provisions, RWA, PPNR, among others

Capital Adequacy
Measure the impact on bank's balance sheet, profit and loss, solvency ratios and define mitigating actions or investment opportunities

Macro and Risk Satellite Models

Loss Distribution





Solution highlights (1/6)

Automation leveraging Machine Learning and Artificial Intelligence

Key Benefit:

✓ Streamlined, repeatable, transparent and validated stress testing process

Stress Testing Process

1. Strategic Planning, Budgeting, Risk Appetite
2. Risk Identification and Scenario Design
3. Scenario Parameterisation
4. Loss estimation modelling and forecasting
5. Capital Adequacy and management

Solution Description:

Improves the efficiency of current Stress Testing capability by moving away from a mix of labour-intense data gathering and spreadsheets towards fully automated stress testing workflow – from input data, to model calculation, to reporting

"Traditionally"

Traditionally, stress testing is a labour-intense data gathering and fragmented process

Fully automated data gathering, loss calculation, model validation and reporting solution in a real time environment

Solution highlights (2/6)

Scenario Parameterisation using ensemble learning

Key Benefit:

✓ Great scalability through easy expansion into other financial sectors

Solution Description:

The parameterisation adopts a calibration of **ensemble leaning techniques** based from the traditional "Satellite" risk model framework with linkage to the core macroeconomic model.

Such an example can be Global VAR model:

- Comprises of 50 countries covering macro, financial, commodities and credit variables linked with financial or trade flows providing a Global overview.
- Calibrates on historical patterns, including pronounced stress periods.
- Allows for economic inter-linkages between countries where domestic, foreign and global variables interact simultaneously.
- Allows for correlated influences and idiosyncratic shocks.

Macroeconomic Model and Risk "Satellite" Model

Solution highlights (3/6)

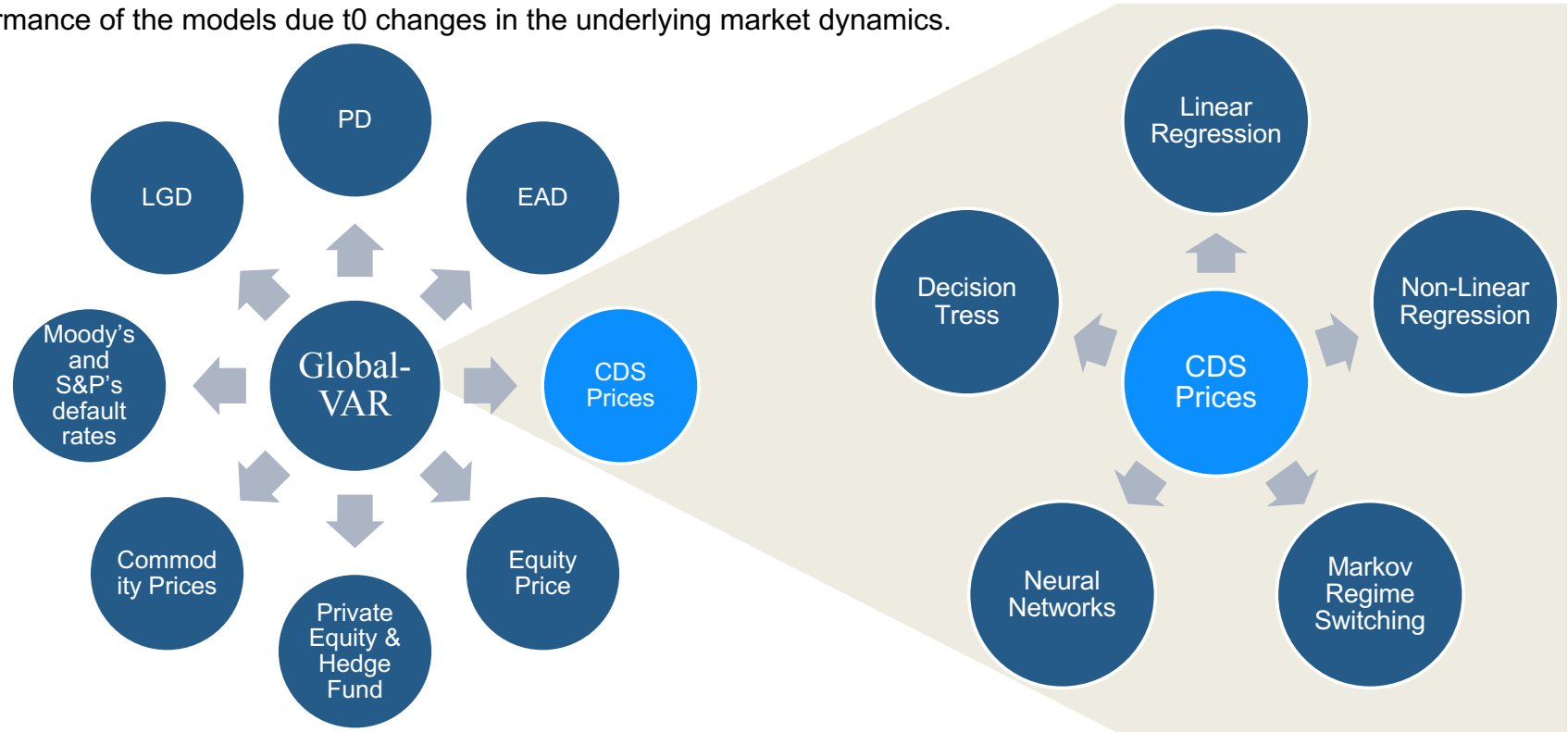
Model Selection and validation using ensemble techniques

Key Benefit:

✓ Provides fully specified, validated, transparent and back-tested industry solution

Solution Description:

Each “satellite” model is selected from a group of industry standard models which have been thoroughly benchmarked and validated on real-time **SR11-7** standards. The analysis is performed in order to identify early deterioration signs in the performance of the models due t0 changes in the underlying market dynamics.



Solution Highlights (4/6)

Model Selection and validation

Key Benefit: Real time SR11-7 assessment

✓ Provides quantitative justification of selecting the most appropriate model

Solution Description:

A periodic model evaluation is conducted for selecting the most appropriate model using a set of quantitative criteria that cover in- and out-of sample performance including a set of regulatory back testing criteria.

Models	Description Relationship between Macro Parameters and CDS Prices	Maintains Economic Interpretation	In-Sample Evaluation		Out of Sample Forecast Evaluation			Final Score
			Goodness of Fit	In-Sample Residual Analysis	Loss Functions	Tests of Predictive Ability	Risk Mgt .Loss Functions	
Moving Average	Benchmark Model	✓	–	–	✗	✗	✗	52%
Linear Regression	Linear Relationship	✓	–	–	–	–	–	61%
Non Linear Regression (Logic and Probit)	Non-linear relationship	✓	–	–	–	–	–	65%
Markov Regime Switching	Establishes a state relationship and separates between recessionary and expansion periods	✓	✓	–	✓	✓	–	71%
Neural Networks / Decision Regression Trees	Highly non-linear relationship	–	✓	–	✓	✓	–	70%

Key: PASS ✓ AVERAGE – FAIL ✗

Solution Highlights (5/6)

Loss estimation using machine learning algorithms

Solution Description:

Further Machine Learning algorithms can be deployed on the loss estimation framework. Such a framework for credit risk can based on Credit Metrics for quantifying portfolio credit risk. Capturing Economic and Regulatory Capital due to changes in the obligor's credit quality conditioned on the wealth of scenario definitions.

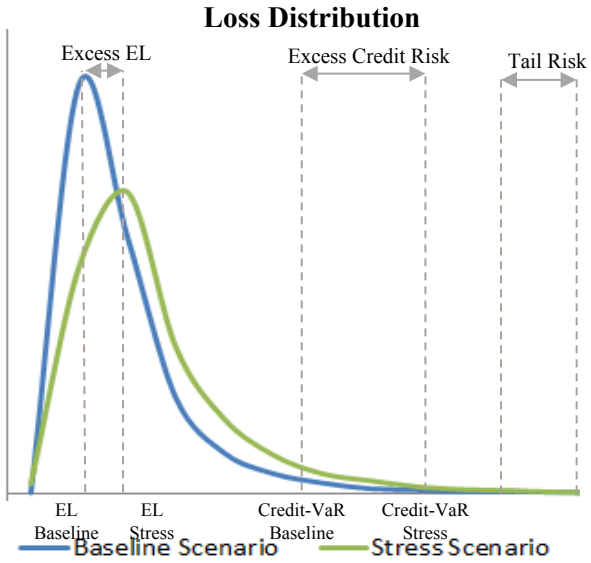
Macroeconomic Model and Risk "Satellite" Model

Inputs

- Transition Matrices
- Recovery Rates
- Exposure at Default
- Spread Curves
- Correlation
- FX Rates
- Equity Prices
- CDS Prices
- Input from risk appetite

Outputs:

Measurement of portfolio credit risk such as Expected Losses (EL), Provisions (UL), Risk-Weighted Assets and Risk Concentrations



Solution Highlights (6/6)

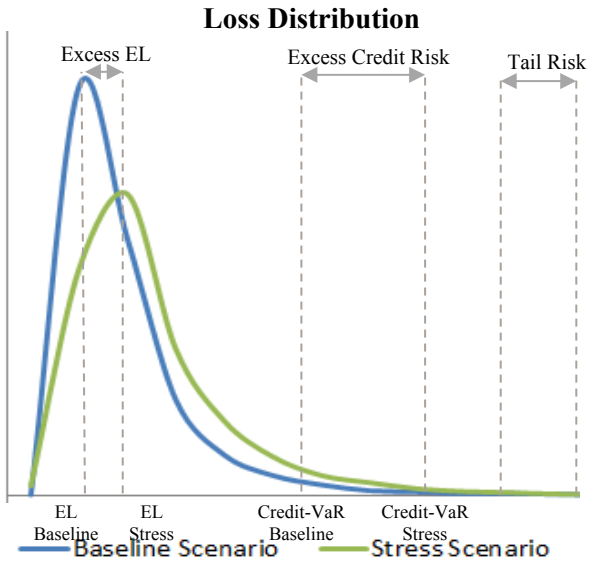
Reporting capability using Artificial Intelligence as catalyst

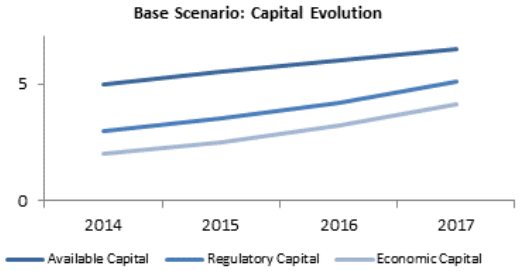
Key Benefit:

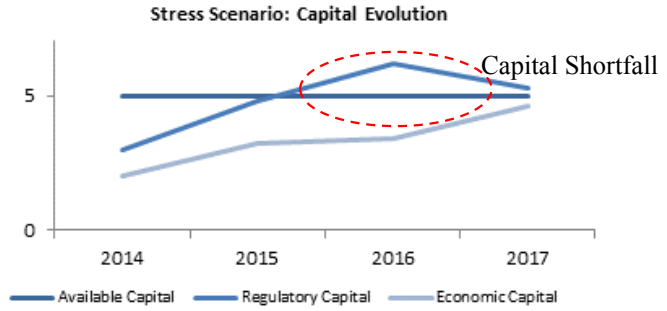
- ✓ Dynamic projections over a multi periods of revenues, balance sheet, and capital ratios using Artificial Intelligence on identification of emergency risks, propose mitigating controls

Inputs:
Measurement of portfolio characteristics such as Expected Losses (EL), Provisions (UL), Risk-Weighted Assets and Risk Concentrations

Outputs:
Generate reports demonstrating impact on regulatory & economic capital, balance sheet, profit and loss.







Who benefits from Machine Learning?

- Effective challenge of capital plan including scenarios, estimation methods, limitations and actions
- Real time “what-if” scenario and measurement of PTI sensitivity

- Capital Policy, Contingency Planning

- Promoting Independent review
- Real time identification of potential weaknesses or limitations and development of remediation plans

- Fully integration of stress testing into BAU driving real time strategic business planning and forecasting

- Forward & Reverse Stress Testing
- Formulation of Risk-Appetite,
- Enhanced documentation, validation and monitoring
- Monitoring of real time risk limits or hedging effectiveness

- Addresses key risks in the bank’s balance sheet, liquidity, leverage and funding
- Determines the bank’s intrinsic risk profile