Assessing Model Risk with Effective Validation
Moody's Analytics operates independently of the credit ratings activities of Moody's Investors Service. We do not comment on credit ratings or potential rating changes, and no opinion or analysis you hear during this presentation can be assumed to reflect those of the ratings agency.
Presenters

Olga Loiseau-Aslanidi PhD, Director
Head of APAC Risk Modelling
Economics & Business Analytics | Singapore

Anamaria Pieschacon PhD, Director
Global Head of Model Validation
Economics & Business Analytics | USA

Petr Zemcik PhD, Senior Director
Head of EMEA Risk and Economics
Economics & Business Analytics | UK
Agenda

1. Model Risk in Spotlight
2. Effective Model Validation
3. Application to IFRS 9 Model
4. Key Takeaways
1

Model Risk in Spotlight
Institutions Rely on Models to Guide Decisions

Manage risk, identify opportunities and comply with regulation

- Application Scorecards
- Credit Policies
- Risk Based Limit Management and Pricing
- Risk and Profitability Based Decisioning
- Credit Line Assignment
- Risk Appetite Framework

- Behavioral Scorecard
- Credit Transition Matrix
- Credit Line Management
- Fraud Detection
- Loss Forecasting
- Scenario Generation
- Stress Testing
- Early Warning Indicators
- Propensity and Churn Modeling

- Scenario Generation
- Stress Testing
- Reverse Stress Testing
- IFRS 9 Impairment Modeling
- ICAAP with IRRBB
- Credit Risk Concentration
- Economic and Regulatory Capital

- Collection Scorecard
- Optimal Workout
- Credit Policies
- Roll Rate Analysis
- Tracking Collectors Efficiency

- Collection & Recovery
- Portfolio Management
- Regulatory Reporting
- Origination
COVID-19 Calls for Model Revision
Mitigating model risk is a basis for effective crisis management

Understand

- Changes in Market Conditions
  - Beware of potential model failures and model interdependencies
  - Quantify what COVID-19 means for the economy
  - Generate multiple future paths to revise existing adverse scenarios

Identify

- Affected Models in Scope
  - Which models I should be most worried about?
  - Which aspects of models are most affected?
  - Credit risk and liquidity risk models are most vulnerable

Enhance

- Validation and Benchmarking
  - Assess models' stability and validity
  - Timely and consistent model adjustments such as recalibration using most recent data, overlays
  - Incorporate regulators’ mitigating actions
  - Enhance model monitoring

Act

- Portfolio Management
  - Identify most vulnerable exposures
  - Planning for vulnerable exposures and portfolios under stress
  - Optimize capital allocation

Proactive Overhaul of Model Risk Management
Credit Risk Models Are Among Most Vulnerable
Need to improve model resilience during pandemic and beyond
Effective Model Validation
Robust Model Governance as a Precondition for Effective Model Risk Management

- More Models
- Greater Model Complexity
- Significant Financial Impact
- Increased Data Availability
- Amplified Supervision
Effective Model Validation

Managing Model Risk Involves Effective Challenge of Models

Effectiveness depends on a combination of incentives, competence, and influence.
Intensity should be proportional to the materiality of the portfolio

Depth of Validation

In all cases,

» MRM team should establish model performance thresholds for periodic monitoring.

» MRM team should run periodic performance tests and perform formal annual validation.

MRM team can hire external validation if they lack in-house expertise
3 Pillars for Effective Model Validation

- Independence
- Purposeful
- Rigor
- Expertise
Expertise & Purposeful Rigor

Loan Lifecycle Management Models
Application, Pricing, Origination, Monitoring, Loss Mitigation, Disposition

Other Advisory Services
Gap Analysis, Best Practices and Model Governance

Business & Strategic Planning Models
Credit Policy, Marketing, etc.

Regulatory Capital & Stress Testing Models
Basel, CCAR, PRA, EBA etc.

Financial Reporting
IFRS 9 and CECL

Credit Portfolio Management Models
Risk Appetite, Concentration Risk, Counterparty, Operational, etc.
Model developers and owners should coordinate all stages of model lifecycle, including implementation.

Validators should provide effective challenge to existing models, based on purpose and materiality.

To avoid conflicts of interest, validation should be performed by a team independent from model development.
Our Validation Process

**Qualitative**
- Evaluation of conceptual soundness

**Quantitative**
- Replication and outcomes analysis

**Validation Report**
- Assessment based on the qualitative, quantitative and benchmarking analysis

**Benchmarking**
- Comparison of inputs and outputs of estimates from alternatives allows to assess and manage model risk
Model Evaluation – Action Ratings

**Satisfactory**
The model has no critical findings and is suitable for deployment.

**Satisfactory with Recommendations**
The model’s performance is satisfactory and is suitable for deployment. Nevertheless, the validators have identified areas where the model could undergo improvements that may improve its overall performance.

**Needs Improvement**
The validators have identified multiple critical findings that have a negative impact on the model’s performance. The current model provides at least a minimally adequate level of performance and can be used in its present form.

**Unsatisfactory**
There are important flaws in the model’s underlying data, conceptual framework, or development process. Either i) the model cannot perform its intended function and should not be used in any decision-making capacity, or ii) there is not enough evidence to show that the model can perform its intended function and it should not be used in any decision-making capacity until such evidence becomes available.
## Final Assessment: Model Ratings by Category

### Issues Identified and Recommended Actions – Generic Example

#### Overall Rating

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation</td>
<td></td>
<td>The documentation needs to include XYZ.</td>
</tr>
<tr>
<td>Data Cleaning and Treatments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Selection Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Replication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring and Performance Tracking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The report will explicitly describe that the above risk categories do not hold equal weighting. The categories shown may not reflect actual categories used.
Our Validation Process

01 Preliminary Model Review
- Model document review/understanding
- Discussion with model owners/stakeholders

02 Qualitative Validation
- Evaluate
  » Purpose, scope, materiality
  » Model selection process
  » Data, conceptual soundness
  » Assumptions & limitations
  » Uncertainty & mitigating controls
  » Review model governance, ongoing monitoring/tests
- Identify and discuss any gaps with stakeholders

03 Quantitative Validation
- Replication
- In-sample and out-of-sample performance evaluation
- Stability and robustness
- Sensitivity Analysis
- Benchmarking*

04 Consolidation
- Review and verify additional analysis submitted by model owners
- Document and categorize the findings by severity, issue recommendations
- Push documents and scripts to production

Components
- Qualitative Validation
- Quantitative Validation
- Consolidation

Deliverables
- Preliminary Model Review
- Qualitative Validation
- Quantitative Validation
- Consolidation
- Initial model assessment
- Qualitative commentary on possible model deficiencies, implementation errors
- Categorize by severity and issue recommendations
- Independent analysis
- Independent implementation
- Commentary on identified shortcomings
- Final document with action ratings
- Recommendations and summary of findings
We Measure Model Risk by Benchmarking
3 Application to IFRS 9 Models
Impairment Model

Macroeconomic Scenario Forecast → Scenario Probability Weights

- Probability of Default (Survival Probability)
- Loss Given Default (Probability of Cure)
- Exposure at Default (Behavioral Component)
- Discount Factor (Effective/contractual Interest Rate)

= Expected Credit Loss

Unbiased Point-in-Time Estimates

Stage 1, 2 or 3
Credit Risk Models
An Integrated Process

- Macro-economic Scenarios
- Credit Risk Models
- Data
- Expected Credit Loss Model
- Sensitivity Analysis
- Results and Reports

IFRS 9: Macroeconomic Scenarios & Expected Credit Loss Calculation

- Portfolio Data
- Macroeconomic Scenarios
- IRB Models / Basel Models
- Stress Testing Models
- IFRS 9 Models
Scenario Severity Shift

Deviations from Baseline (Standard deviation=2.4)

Source: Moody’s Analytics
**PD Modelling Approaches**

**Segment level**

Modelling approach with three key factors influencing vintage segment performance:

- **Lifecycle**
  - Dynamic evolution of vintages as they mature

- **Quality of Vintage**
  - Variable capturing the heterogeneity across cohorts: vintage dummies, portfolio characteristics and/or economic conditions at origination

- **Forward-looking Indicator**
  - Sensitivity of performance to the evolution of macroeconomic and credit series

**PD = f**

**Account level**

PD is forecasted using customer and loan characteristics, and macroeconomic indicators using panel data econometric techniques:

- **Customer and Loan Level Characteristics**
  - Characteristics such as LTV, score, months on book, education, etc.
  - Select pre-macro model using single factor and multifactor analysis

- **Macroeconomic Drivers**
  - Variable selection algorithm to select macroeconomic drivers

**PD = f**

**Transition Matrix Approach**

1. **Segmentation**
   - Switch to bucketing based on DPD & LTV
   - No further segmentation

2. **Data Inputs**
   - Internal portfolio
   - Macro data

3. **TTC Matrix Creation**
   - Initial estimation
   - Smoothing
   - Scaling
Looking at Forecast Properties

<table>
<thead>
<tr>
<th>PD &amp; Driver Correlation</th>
<th>Driver Forecasts</th>
<th>PD Forecasts</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD</td>
<td>Macro Driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Issue**

- Policy variables, e.g. CPI
- Changes in past correlations
- Non-cyclical sectors
- Growth rates:
  - Low range level variables, e.g. RMM
  - QoQ growth rate
- Long-term forecast property of transformation
LGD Design Approaches

Balance and Recoveries
For a facility $i$, time $t$ and workout period $w$:

$$LGD_i = 1 - \frac{balance_{i,t} - balance_{i,t+w}}{balance_{i,t}}$$

Default Vintages & Macro Drivers

By Assumption
LGD of 50-60% for PF, 30-40% for RE and 65-75% for CC; fully insured products usually get LGD of 5-10%.

Estimates of recovery costs range from 1-2%.

Roll Rate Modelling

$$RR_{it} = 1 - LGD_{it}$$
EAD Design Approaches

Fixed Term Products - Amortization

Revolving Products - CCF

\[ EAD_{i,t+h} = BAL_{i,t+h} + CCF \times UNDRAWN_{i,t} \]
Evaluation of SICR

Quantitative Approach

Characteristics of the metric:
» Forward-looking (scenarios)
» Capture risk of default
» Lifetime information
» Available at origination and at reporting date

What is the optimal $d$ to identify SICR?
» Buffer is the optimal value of $d$ that maximizes an accuracy ratio from good:bad odds analysis
» We examine differences (in logit) between
  – the lifetime PD at the reporting date $\rightarrow$ Lifetime PD(T)
  – the lifetime PD at the same age as the reporting date forecasted at origination $\rightarrow$ Lifetime PD_0(T)
for different historical reporting dates

<table>
<thead>
<tr>
<th>Status</th>
<th>Criteria</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Default</td>
<td>Lifetime PD(T) ≤ Lifetime PD_0(T) + Buffer</td>
<td>1</td>
</tr>
<tr>
<td>Non-Default</td>
<td>Lifetime PD(T) &gt; Lifetime PD_0(T) + Buffer</td>
<td>2</td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Qualitative Approach

» DPD
» Forbearance
» Watch list
» …
ECL Calculation

ECL by scenario (s) & instrument (i):

$$ECL(i|s) = \sum_t [PD(i, t|s) \times LGD(i, t|s) \times EAD(i, t|s) \times DF(i, t|s)]$$

Probability-Weighted ECL by instrument:

$$ECL(i) = p_1ECL(i|s_1) + p_2ECL(i|s_2) + ... + p_SECL(i|s_S)$$
IFRS 9 Validation Process

Robustness & Sensitivity Analysis

Portfolio Behavior to Changing Macroeconomic Conditions

Report

Qualitative
- Methodology
- Data analysis
- Model replication
- Model performance
- Benchmark model development

Quantitative
- Data use, description & treatment
- Regulatory compliance
- Model governance

Final Assessment
- Written report
- Observation, findings and recommendations and or remedial actions
## IFRS 9 Case Study – Impact of COVID-19

### Baseline Feb 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,090</td>
<td>99.00</td>
<td>8,275,327,246</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>717</td>
<td>0.83</td>
<td>69,352,356</td>
<td>0.89</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.21</td>
</tr>
</tbody>
</table>

### Baseline Apr 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,047</td>
<td>98.90</td>
<td>8,266,730,875</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>760</td>
<td>0.93</td>
<td>77,948,726</td>
<td>1.68</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.82</td>
</tr>
</tbody>
</table>

### Upside Feb 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,093</td>
<td>99.01</td>
<td>8,275,597,498</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>714</td>
<td>0.83</td>
<td>69,082,104</td>
<td>0.79</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.21</td>
</tr>
</tbody>
</table>

### Upside Apr 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,082</td>
<td>98.99</td>
<td>8,273,841,624</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>725</td>
<td>0.85</td>
<td>70,837,977</td>
<td>1.31</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.82</td>
</tr>
</tbody>
</table>

### Downside Feb 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,079</td>
<td>98.97</td>
<td>8,272,959,874</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>728</td>
<td>0.86</td>
<td>71,719,727</td>
<td>1.35</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.21</td>
</tr>
</tbody>
</table>

### Downside Apr 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.07</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91,770</td>
<td>98.34</td>
<td>8,219,603,740</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>1,037</td>
<td>1.50</td>
<td>125,075,861</td>
<td>1.88</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.81</td>
</tr>
</tbody>
</table>

### Prob-weighted Feb 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,086</td>
<td>99.00</td>
<td>8,274,895,046</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>721</td>
<td>0.83</td>
<td>69,784,556</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.21</td>
</tr>
</tbody>
</table>

### Prob-weighted Apr 2020

<table>
<thead>
<tr>
<th>IFRS 9 Stage</th>
<th>#</th>
<th>%</th>
<th>Exposure</th>
<th>ECL=0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,020</td>
<td>98.84</td>
<td>8,261,408,180</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>787</td>
<td>1.00</td>
<td>83,271,421</td>
<td>1.76</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>0.17</td>
<td>13,986,747</td>
<td>12.81</td>
</tr>
</tbody>
</table>
Proactive Overhaul of Model Risk Management

Understand
- Changes in Market Conditions

Identify
- Affected Models in Scope

Enhance
- Validation and Benchmarking

Act
- Portfolio Management
Thank You

Questions? Contact us at help@economy.com
Contact Us: Content Solutions - Economics & Business Analytics Offices

West Chester, EBA-HQ
+1.610.235.5299
121 North Walnut Street, Suite 500
West Chester PA 19380
USA

New York, Corporate-HQ
+1.212.553.1653
7 World Trade Center, 14th Floor
250 Greenwich Street
New York, NY 10007
USA

London
+44.20.7772.5454
One Canada Square
Canary Wharf
London E14 5FA
United Kingdom

Toronto
+1.416.681.2133
200 Wellington Street West, 15th Floor
Toronto ON M5V 3C7
Canada

Prague
+420.23.474.7500
Pernerova 691/42
186 00 Prague 8 - Karlin,
Czech Republic

Sydney
+61.2.9270.8111
Level 10
1 O’Connell Street
Sydney, NSW, 2000
Australia

Singapore
+65.6511.4400
6 Shenton Way
#14-08 OUE Downtown 2
Singapore 06889

Shanghai
+86.21.6101.0172
Unit 2306, Citigroup Tower
33 Huayuanshigqiao Road
Pudong New Area, 200120
China

moodysanalytics.com
© 2020 Moody’s Corporation, Moody’s Investors Service, Inc., Moody’s Analytics, Inc. and/or their licensors and affiliates (collectively, “MOODY’S”). All rights reserved.

CREDIT RATINGS ISSUED BY MOODY’S INVESTORS SERVICE, INC. AND/OR ITS CREDIT RATINGS AFFILIATES ARE MOODY’S CURRENT OPINIONS OF THE RELATIVE FUTURE CREDIT RISK OF ENTITIES, CREDIT COMMITMENTS, OR DEBT OR DEBT-LIKE SECURITIES, AND MATERIALS, PRODUCTS, SERVICES AND INFORMATION PUBLISHED BY MOODY’S (COLLECTIVELY, “PUBLICATIONS”) MAY INCLUDE SUCH CURRENT OPINIONS. MOODY’S INVESTORS SERVICE DEFINES CREDIT RISK AS THE RISK THAT AN ENTITY MAY NOT MEET ITS CONTRACTUAL FINANCIAL OBLIGATIONS AS THEY COME DUE AND ANY ESTIMATED FINANCIAL LOSS IN THE EVENT OF DEFAULT OR IMPAIRMENT. SEE MOODY’S RATING SYMBOLS AND DEFINITIONS PUBLICATION FOR INFORMATION ON THE TYPES OF CONTRACTUAL FINANCIAL OBLIGATIONS ADDRESSED BY MOODY’S INVESTORS SERVICE CREDIT RATINGS. CREDIT RATINGS DO NOT ADDRESS ANY OTHER RISK, INCLUDING BUT NOT LIMITED TO: LIQUIDITY RISK, MARKET VALUE RISK, OR PRICE VOLATILITY. CREDIT RATINGS, NON-CREDIT ASSESSMENTS (“ASSESSMENTS”), AND OTHER OPINIONS INCLUDED IN MOODY’S PUBLICATIONS ARE NOT STATEMENTS OF CURRENT OR HISTORICAL FACT. MOODY’S PUBLICATIONS MAY ALSO INCLUDE QUANTITATIVE MODEL-BASED ESTIMATES OF CREDIT RISK AND RELATED OPINIONS OR COMMENTARY PUBLISHED BY MOODY’S ANALYTICS, INC. AND/OR ITS AFFILIATES. MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS AND PUBLICATIONS DO NOT CONSTITUTE OR PROVIDE INVESTMENT OR FINANCIAL ADVICE, AND MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS AND PUBLICATIONS ARE NOT AND DO NOT PROVIDE RECOMMENDATIONS TO PURCHASE, SELL, OR HOLD PARTICULAR SECURITIES. MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS AND PUBLICATIONS DO NOT COMMENT ON THE SUITABILITY OF AN INVESTMENT FOR ANY PARTICULAR INVESTOR. MOODY’S ISSUES ITS CREDIT RATINGS, ASSESSMENTS AND OTHER OPINIONS AND PUBLISHES ITS PUBLICATIONS WITH THE EXPECTATION AND UNDERSTANDING THAT EACH INVESTOR WILL, WITH DUE CARE, MAKE ITS OWN STUDY AND EVALUATION OF EACH SECURITY THAT IS UNDER CONSIDERATION FOR PURCHASE, HOLDING, OR SALE.

MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS, AND PUBLICATIONS ARE NOT INTENDED FOR USE BY RETAIL INVESTORS AND IT WOULD BE RECKLESS AND INAPPROPRIATE FOR RETAIL INVESTORS TO USE MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS OR PUBLICATIONS WHEN MAKING AN INVESTMENT DECISION. IF IN DOUBT YOU SHOULD CONTACT YOUR FINANCIAL OR OTHER PROFESSIONAL ADVISER.

ALL INFORMATION CONTAINED HEREIN IS PROTECTED BY LAW, INCLUDING BUT NOT LIMITED TO, COPYRIGHT LAW, AND NONE OF SUCH INFORMATION MAY BE COPIED OR OTHERWISE REPRODUCED, REPACKAGED, FURTHER TRANSMITTED, TRANSFERRED, DISSEMINATED, REDISTRIBUTED OR RESOLD, OR STORED FOR SUBSEQUENT USE FOR ANY SUCH PURPOSE, IN WHOLE OR IN PART, IN ANY FORM OR MANNER OR BY ANY MEANS WHATSOEVER, BY ANY PERSON WITHOUT MOODY’S PRIOR WRITTEN CONSENT.

MOODY’S CREDIT RATINGS, ASSESSMENTS, OTHER OPINIONS AND PUBLICATIONS ARE NOT INTENDED FOR USE BY ANY PERSON AS A BENCHMARK AS THAT TERM IS DEFINED FOR REGULATORY PURPOSES AND MUST NOT BE USED IN ANY WAY THAT COULD RESULT IN THEM BEING CONSIDERED A BENCHMARK.

All information contained herein is obtained by MOODY’S from sources believed by it to be accurate and reliable. Because of the possibility of human or mechanical error as well as other factors, however, all information contained herein is provided "AS IS" without warranty of any kind. MOODY’S adopts all necessary measures so that the information it uses in assigning a credit rating is of sufficient quality and from sources MOODY’S considers to be reliable— including, when appropriate, independent third-party sources. However, MOODY’S is not an auditor and cannot in every instance independently verify or validate information received in the rating process or in preparing its Publications.

To the extent permitted by law, MOODY’S and its directors, officers, employees, agents, representatives, licensors and suppliers disclaim liability to any person or entity for any indirect, special, consequential, or incidental losses or damages whatsoever arising from or in connection with the information contained herein or the use of or inability to use any such information, even if MOODY’S or any of its directors, officers, employees, agents, representatives, licensors or suppliers is advised in advance of the possibility of such losses or damages, including but not limited to (a) loss of present or prospective profits or (b) any loss or damage arising where the relevant financial instrument is not the subject of a particular credit rating assigned by MOODY’S.

To the extent permitted by law, MOODY’S and its directors, officers, employees, agents, representatives, licensors and suppliers disclaim liability for any direct or compensatory losses or damages caused to any person or entity, including but not limited to by any negligence (but excluding fraud, willful misconduct or any other type of liability that, for the avoidance of doubt, by law cannot be excluded) on the part of, or any contingency within or beyond the control of, MOODY’S or any of its directors, officers, employees, agents, representatives, licensors or suppliers, arising from or in connection with the information contained herein or the use of or inability to use any such information.

NO WARRANTY, EXPRESS OR IMPLIED, AS TO THE ACCURACY, TIMELINESS, COMPLETENESS, MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OF ANY CREDIT RATING, ASSESSMENT, OTHER OPINION OR INFORMATION IS GIVEN OR MADE BY MOODY’S IN ANY FORM OR MANNER WHATSOEVER.

MOODY’S Investors Service, Inc., a wholly-owned credit rating agency subsidiary of Moody’s Corporation ("MCO"), hereby discloses that most issuers of debt securities (including corporate and municipal bonds, debentures, notes and commercial paper) and preferred stock rated by Moody’s Investors Service, Inc. for credit ratings opinions and services rendered by it fees ranging from $1,000 to approximately $2,700,000. MCO and Moody’s Investors Service also maintain policies and procedures to address the independence of Moody’s Investors Service credit ratings and credit rating processes. Information regarding certain affiliations that may exist between directors of MCO and rated entities, and between entities that hold credit ratings from Moody’s Investors Service and have also publicly reported to the SEC an ownership interest in MCO of more than 5%, is posted annually at www.moodys.com under the heading “Investor Relations — Corporate Governance — Director and Shareholder Affiliation Policy.”

Additional terms for Australia only: Any publication into Australia of this document is pursuant to the Australian Financial Services License of MOODY’s affiliate, Moody’s Investors Service Pty Limited ABN 61 003 399 657AFSL 336969 and/or Moody’s Analytics Australia Pty Ltd ABN 94 105 136 972 AFSL 385369 (as applicable). This document is intended to be provided only to “wholesale clients” within the meaning of section 761G of the Corporations Act 2001. By continuing to access this document from within Australia, you represent to MOODY’s that you are, or are accessing the document as a representative of, a “wholesale client” and that neither you nor the entity you represent will directly or indirectly disseminate this document or its contents to retail clients within the meaning of section 761G of the Corporations Act 2001. Further, you agree to the terms and conditions of use of MOODY’s credit rating is an opinion as to the creditworthiness of a debt obligation of the issuer, not on the equity securities of the issuer or any form of security that is available to retail investors.

Additional terms for Japan only: Moody’s Japan K.K. ("MJKK") is a wholly-owned credit rating agency subsidiary of Moody’s Group Japan K.K., which is wholly-owned by Moody’s Overseas Holdings Inc., a wholly-owned subsidiary of MCO. Moody's SF Japan K.K. ("MSFJ") is a wholly-owned credit rating agency subsidiary of MJKK. MSFJ is not a Nationally Recognized Statistical Rating Organization (“NRSRO”). Therefore, credit ratings assigned by MSFJ are Non-NRSRO Credit Ratings. Non-NRSRO Credit Ratings are assigned by an entity that is not a NRSRO and, consequently, the rated obligation will not qualify for certain types of treatment under U.S. laws. MJKK and MSFJ are credit rating agencies regulated by the Japan Financial Services Agency and their registration numbers are FSA Commissioner (Ratings) No. 2 and 3 respectively.

MJKK and MSFJ (as applicable) hereby disclose that most issuers of debt securities (including corporate and municipal bonds, debentures, notes and commercial paper) and preferred stock rated by MJKK or MSFJ (as applicable) have, prior to assignment of any credit rating, agreed to pay to MJKK or MSFJ (as applicable) for credit ratings opinions and services rendered by it fees ranging from JPY125,000 to approximately JPY250,000,000. MJKK and MSFJ also maintain policies and procedures to address Japanese regulatory requirements.

To the extent permitted by law, MJKK and MSFJ (as applicable) hereby disclose that most issuers of debt securities (including corporate and municipal bonds, debentures, notes and commercial paper) and preferred stock rated by MJKK or MSFJ (as applicable) have, prior to assignment of any credit rating, agreed to pay to MJKK or MSFJ (as applicable) for credit ratings opinions and services rendered by it fees ranging from JPY125,000 to approximately JPY250,000,000.

MOODY’S ANALYTICS

Effective Validation Webinar – May 2020 37