

The Future of Actuarial Models

SEAC Fall 2021

Nate Worrell, Client Relationship Actuary

November, 2021

ASOP 56- "MODEL"

A simplified representation of relationships among real world variables, entities, or events using statistical, financial, economic, mathematical, non-quantitative, or scientific concepts and equations. A model consists of three components: an **information input component**, which delivers data and assumptions to the model; a **processing component**, which transforms input into output; and a **results component**, which translates the output into useful business information.

MOODY'S ANALYTICS



Information Input Component

Actuarial Assumptions

TABLE VI.—Showing the Observed Mortality, according to Age, the English Female Population, for two periods ending in 1830 and 1844 respectively; with which are compared the Carlisle Mortality Table for the period ending with 1787, and the Theoretical Table of "Village" Mortality.

Between Ages	All ENGLAND. Females.		CARLISLE. Both Sexes.	Theoretical VILLAGE TABLE Limits at 9 Years and 25 Years of Age.
	18 Years, 1813 to 1830.	7 Years, 1838 to 1844.		
0 to 5	4.22	6.04	8.23	5.54
5 " 10	.61	.90	1.02	.82
10 " 15	.48	.55	.54	.54
15 " 20	.70	.73	.64	.63
20 " 30				
30 " 40				
40 " 50				
50 " 60				
60 " 70				
70 " 80				
80 " 90				
90 " 100				

Classic

- Population Level
- Tabular
- Trend

Modern

- Behavioral Elements
- Formulaic
- Sensitivity

Future

- Individualistic
- Algorithmic
- Continuous
- Stochastic

Information Input Component

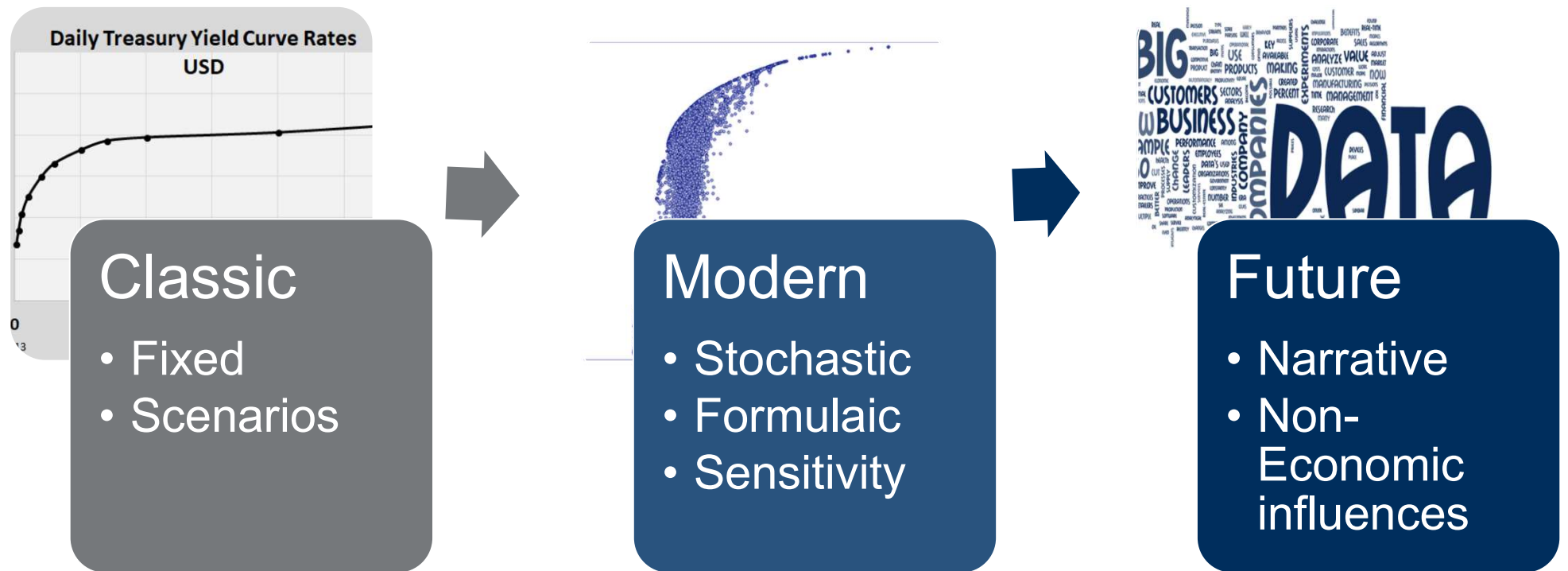
Actuarial Assumptions

Key Thoughts:

1. Assumption management systems will be key
2. Data and database fluency
3. Models all the way down. Algorithmic “Inputs” are “Outputs” of other models?
4. Assumptions about assumptions

Information Input Component

Economic Assumptions



Information Input Component

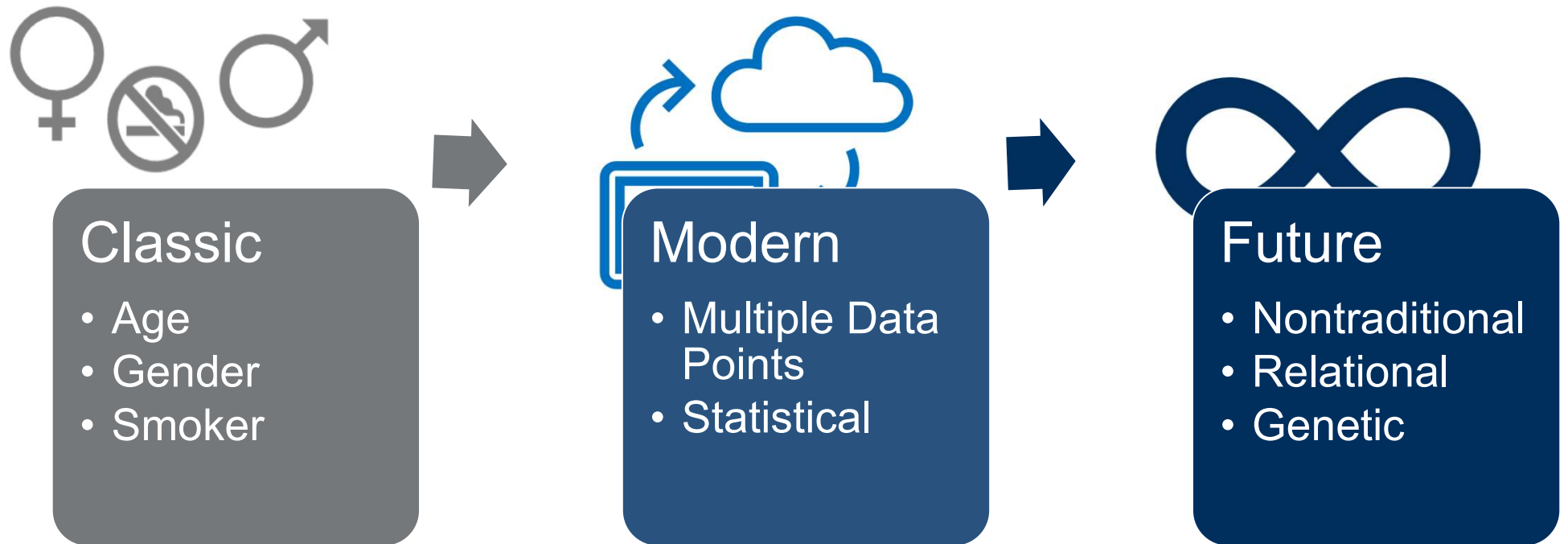
Economic Assumptions

Key Thoughts:

1. Increased intricacy
2. Models all the way down – scenario generation
3. Role of the non-economic assumptions
 1. Socio-political
 2. Climate

Information Input Component

DATA – POLICY EXTRACT



Information Input Component

Data

Key Thoughts:

1. Data management – storage, sources and slices
2. Real-time, dynamic, unconventional
3. Feedback loop between data and assumptions
4. Correlations

Processing Component

Calculations and Calculators



Calculation Universe

More than just solving for a number.



Actuarial Software + Network Computing

Open and closed systems

Moving to cloud

Spreadsheets

The golden era of Excel

VBA Macro.



TABLE XI.

COMPUTATION TABLES FOR SINGLE LIVES.

Age	l_x	D_x	N_x	S_x	C_x	M_x	R_x
0	1000000	1000000	1000000	1000000	1000000	1000000	1000000
1	999999	999999	999999	999999	999999	999999	999999
2	999998	999998	999998	999998	999998	999998	999998
3	999997	999997	999997	999997	999997	999997	999997
4	999996	999996	999996	999996	999996	999996	999996
5	999995	999995	999995	999995	999995	999995	999995
6	999994	999994	999994	999994	999994	999994	999994
7	999993	999993	999993	999993	999993	999993	999993
8	999992	999992	999992	999992	999992	999992	999992
9	999991	999991	999991	999991	999991	999991	999991
10	999990	999990	999990	999990	999990	999990	999990
11	999989	999989	999989	999989	999989	999989	999989
12	999988	999988	999988	999988	999988	999988	999988
13	999987	999987	999987	999987	999987	999987	999987
14	999986	999986	999986	999986	999986	999986	999986
15	999985	999985	999985	999985	999985	999985	999985
16	999984	999984	999984	999984	999984	999984	999984
17	999983	999983	999983	999983	999983	999983	999983
18	999982	999982	999982	999982	999982	999982	999982
19	999981	999981	999981	999981	999981	999981	999981
20	999980	999980	999980	999980	999980	999980	999980
21	999979	999979	999979	999979	999979	999979	999979
22	999978	999978	999978	999978	999978	999978	999978
23	999977	999977	999977	999977	999977	999977	999977
24	999976	999976	999976	999976	999976	999976	999976
25	999975	999975	999975	999975	999975	999975	999975
26	999974	999974	999974	999974	999974	999974	999974
27	999973	999973	999973	999973	999973	999973	999973
28	999972	999972	999972	999972	999972	999972	999972
29	999971	999971	999971	999971	999971	999971	999971
30	999970	999970	999970	999970	999970	999970	999970
31	999969	999969	999969	999969	999969	999969	999969
32	999968	999968	999968	999968	999968	999968	999968
33	999967	999967	999967	999967	999967	999967	999967
34	999966	999966	999966	999966	999966	999966	999966
35	999965	999965	999965	999965	999965	999965	999965
36	999964	999964	999964	999964	999964	999964	999964
37	999963	999963	999963	999963	999963	999963	999963
38	999962	999962	999962	999962	999962	999962	999962
39	999961	999961	999961	999961	999961	999961	999961
40	999960	999960	999960	999960	999960	999960	999960
41	999959	999959	999959	999959	999959	999959	999959
42	999958	999958	999958	999958	999958	999958	999958
43	999957	999957	999957	999957	999957	999957	999957
44	999956	999956	999956	999956	999956	999956	999956
45	999955	999955	999955	999955	999955	999955	999955
46	999954	999954	999954	999954	999954	999954	999954
47	999953	999953	999953	999953	999953	999953	999953
48	999952	999952	999952	999952	999952	999952	999952
49	999951	999951	999951	999951	999951	999951	999951
50	999950	999950	999950	999950	999950	999950	999950
51	999949	999949	999949	999949	999949	999949	999949
52	999948	999948	999948	999948	999948	999948	999948
53	999947	999947	999947	999947	999947	999947	999947
54	999946	999946	999946	999946	999946	999946	999946
55	999945	999945	999945	999945	999945	999945	999945
56	999944	999944	999944	999944	999944	999944	999944
57	999943	999943	999943	999943	999943	999943	999943
58	999942	999942	999942	999942	999942	999942	999942
59	999941	999941	999941	999941	999941	999941	999941
60	999940	999940	999940	999940	999940	999940	999940
61	999939	999939	999939	999939	999939	999939	999939
62	999938	999938	999938	999938	999938	999938	999938
63	999937	999937	999937	999937	999937	999937	999937
64	999936	999936	999936	999936	999936	999936	999936
65	999935	999935	999935	999935	999935	999935	999935
66	999934	999934	999934	999934	999934	999934	999934
67	999933	999933	999933	999933	999933	999933	999933
68	999932	999932	999932	999932	999932	999932	999932
69	999931	999931	999931	999931	999931	999931	999931
70	999930	999930	999930	999930	999930	999930	999930
71	999929	999929	999929	999929	999929	999929	999929
72	999928	999928	999928	999928	999928	999928	999928
73	999927	999927	999927	999927	999927	999927	999927
74	999926	999926	999926	999926	999926	999926	999926
75	999925	999925	999925	999925	999925	999925	999925
76	999924	999924	999924	999924	999924	999924	999924
77	999923	999923	999923	999923	999923	999923	999923
78	999922	999922	999922	999922	999922	999922	999922
79	999921	999921	999921	999921	999921	999921	999921
80	999920	999920	999920	999920	999920	999920	999920
81	999919	999919	999919	999919	999919	999919	999919
82	999918	999918	999918	999918	999918	999918	999918
83	999917	999917	999917	999917	999917	999917	999917
84	999916	999916	999916	999916	999916	999916	999916
85	999915	999915	999915	999915	999915	999915	999915
86	999914	999914	999914	999914	999914	999914	999914
87	999913	999913	999913	999913	999913	999913	999913
88	999912	999912	999912	999912	999912	999912	999912
89	999911	999911	999911	999911	999911	999911	999911
90	999910	999910	999910	999910	999910	999910	999910
91	999909	999909	999909	999909	999909	999909	999909
92	999908	999908	999908	999908	999908	999908	999908
93	999907	999907	999907	999907	999907	999907	999907
94	999906	999906	999906	999906	999906	999906	999906
95	999905	999905	999905	999905	999905	999905	999905
96	999904	999904	999904	999904	999904	999904	999904
97	999903	999903	999903	999903	999903	999903	999903
98	999902	999902	999902	999902	999902	999902	999902
99	999901	999901	999901	999901	999901	999901	999901
100	999900	999900	999900	999900	999900	999900	999900

Commutation Functions
Actuarial Tables, Indexes, Maps.

Programming Languages

Fortran, APL,

```
life ← {↑1 ωV.Λ3 4=+/,~1 0 1°.⊖~1 0 1°.⊕⊂ω}
```

Processing Component

Calculations and Calculators

Key Thoughts:

1. Efficiencies become more important
 1. Clustering
 2. Proxy Models
2. How to manage model risk in an ocean of calculations
3. Connectivity
4. TEAMWORK!

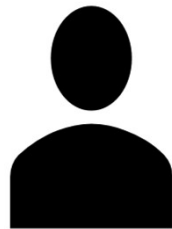
Results Component

Useful Business Information



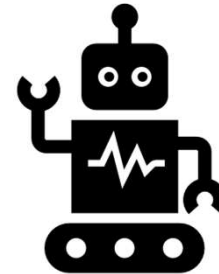
Numbers

Reserves
Capital
Profit
Price



Pictures

Static Charts
Interactive
Dashboards



Words

Automated
Disclosure
Commentary.
Caveats

Results Component

Useful Business Information

Key Thoughts:

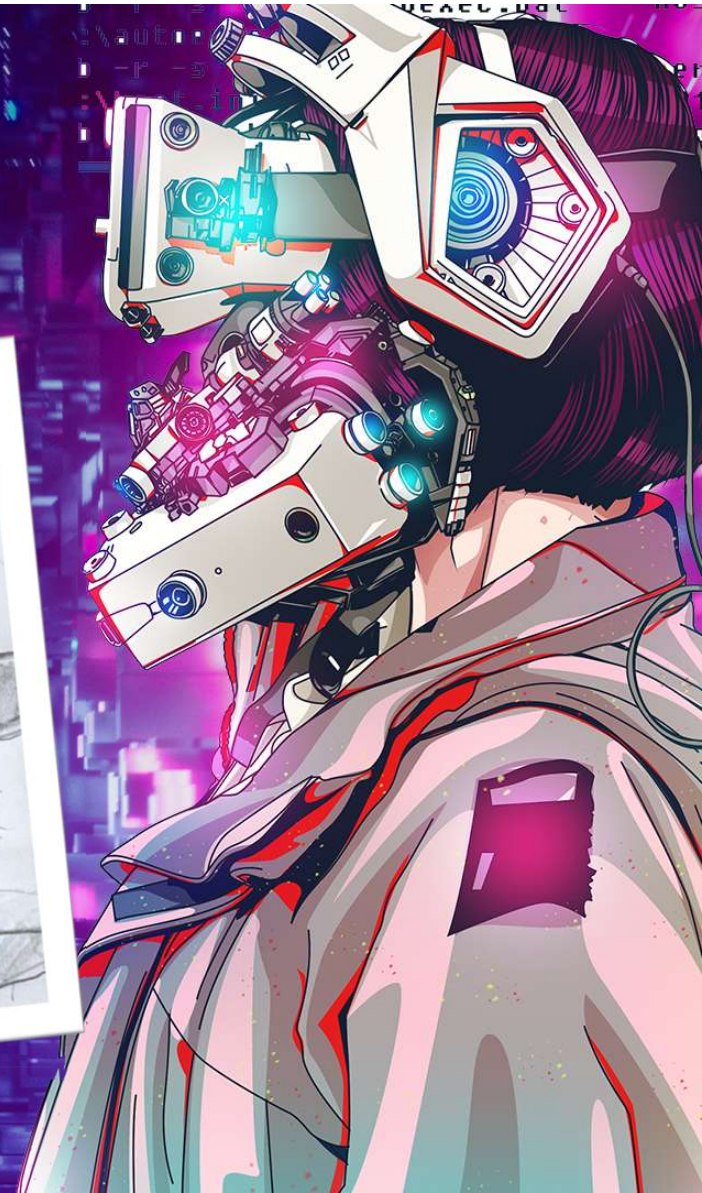
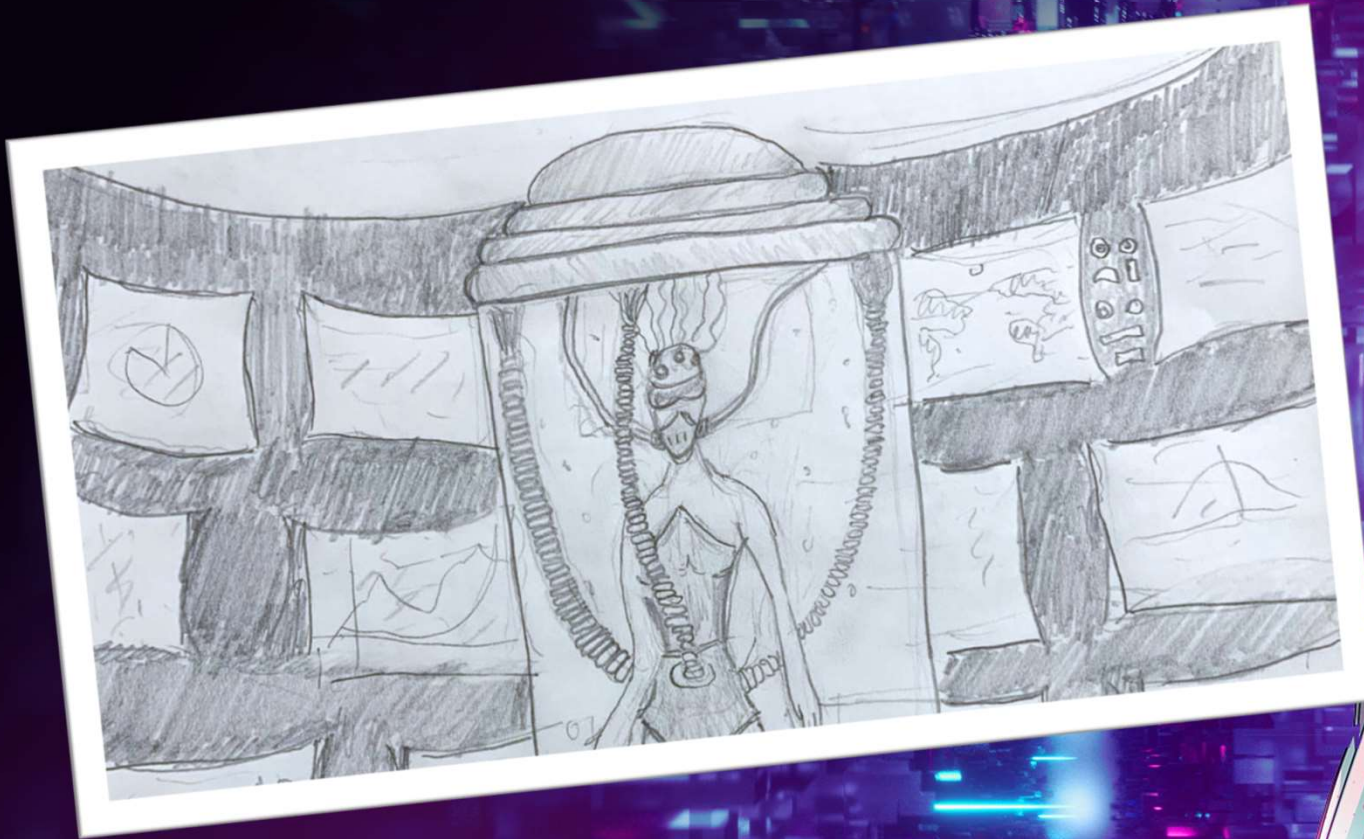
1. Integrating visualizer to calculator
2. Role of automation
3. Newsworthiness

The background of the image is a dynamic, abstract composition. It features numerous horizontal light trails in shades of blue, teal, and orange, suggesting high-speed motion or data flow. In the lower right foreground, there is a curved, metallic-looking structure that resembles a futuristic road or a large-scale architectural element. The overall color palette is dominated by cool blues and teals, with warm orange and yellow highlights from the light trails.

TO THE FUTURE



2021 Speculative Contest WINNER



ASOP 56- “MODEL”

A simplified representation of relationships among real world variables, entities, or events using statistical, financial, economic, mathematical, non-quantitative, or scientific concepts and equations. A model consists of three components: an **information input component**, which delivers data and assumptions to the model; a **processing component**, which transforms input into output; and a **results component**, which translates the output into useful business information.

MOODY'S ANALYTICS



Shameless Plugs

More Resources

Society of Actuaries:

- **Modelling Section**
 - [Models that Make The Cut](#)
- **Actuary of the Future Section**
 - [Speculative Fiction Contests](#)
- **Technology Section**
 - [Resources Page](#)

Actuarial Standards of Practice

- [ASOP 56](#)

Moody's Analytics White Papers

- [Proxy Functions](#)
- [Narrative Scenarios](#)

Other Resource

- [Wearables and the Internet of Things \(IFOA\)](#)
- [Data Narratives](#)

© 2021 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 CREDIT RATINGS AFFILIATES ARE THEIR 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 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 APPLICABLE MOODY'S RATING SYMBOLS AND DEFINITIONS PUBLICATION FOR INFORMATION ON THE TYPES OF CONTRACTUAL FINANCIAL OBLIGATIONS ADDRESSED BY MOODY'S 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) any 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. have, prior to assignment of any credit rating, agreed to pay to Moody's Investors Service, Inc. for credit ratings opinions and services rendered by it fees ranging from \$1,000 to approximately \$5,000,000. 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 who 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.moodyys.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 61 003 399 657 AFSL 336969 and/or Moody's Analytics Australia Pty Ltd ABN 94 105 136 972 AFSL 383569 (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. 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 G.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 registered with the Japan Financial Services Agency and their registration numbers are FSA Commissioner (Ratings) No. 2 and 3 respectively.

MJKK or 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 JPY550,000,000.

MJKK and MSFJ also maintain policies and procedures to address Japanese regulatory requirements.