Fall Conference
November 7-8, 2023

Nov 7, 2023

Mark Slattery

SAS Institute Inc.

www.iacpm.org

Welcome & Introduction

- Welcome to my home
  - Born and raised; less than 12 miles south of downtown
- Distinct neighborhoods / sides
  - Southside (me) – glass half empty; 0-162
  - Northside (the ‘other’ me) – glass half full; 161-1
- Quick survey to start with more to come. . .

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It is one or the other. . .you must choose a side. . .

Or maybe it is not simply one or the other. . .

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How is the Forward View of Default Risk Changing?

- What do current market conditions tell us about future default risk?
  - Point in time vs through the cycle
- Newer ways to look at default risk
  - What data is needed?
  - What gaps exists?
  - Breakdown in factor relationships
- Implications for stress testing
- Role of Risk Management, what to do to be prepared?

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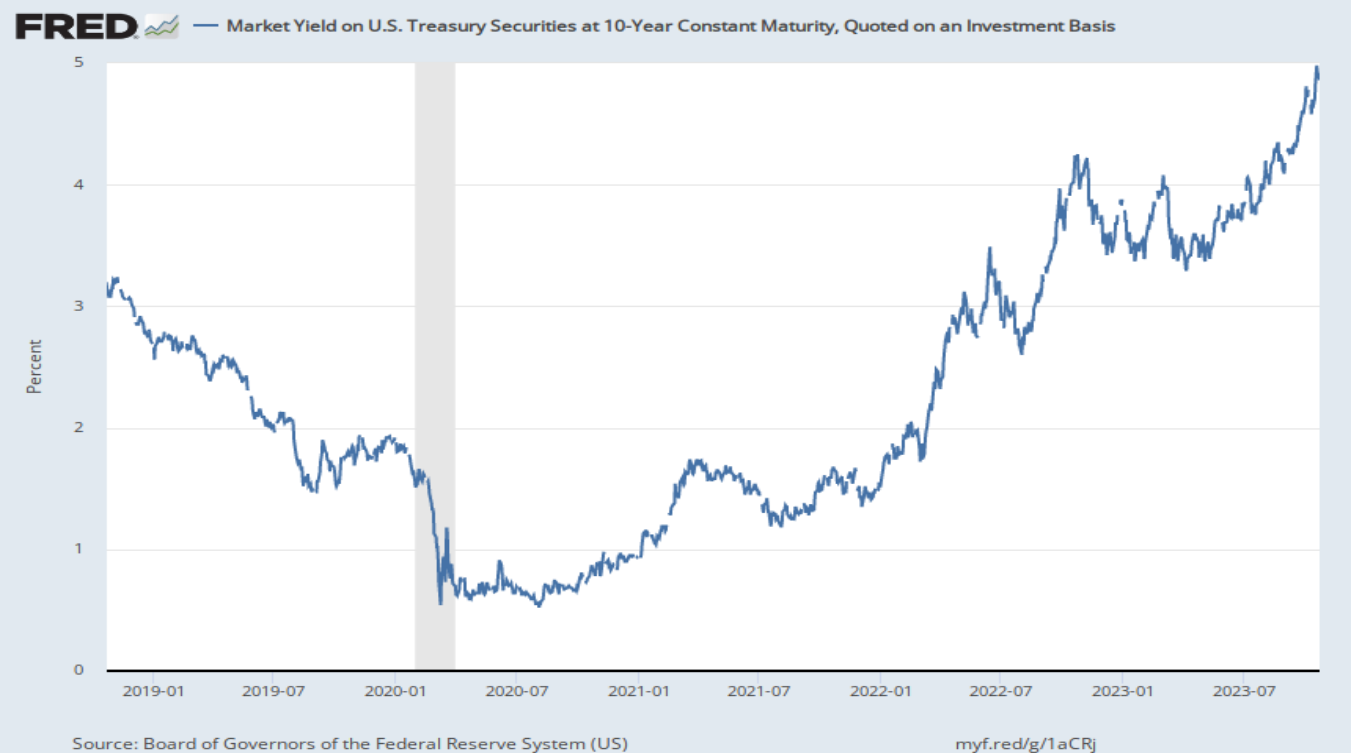
Market Yield on 10-Year UST Constant Maturity



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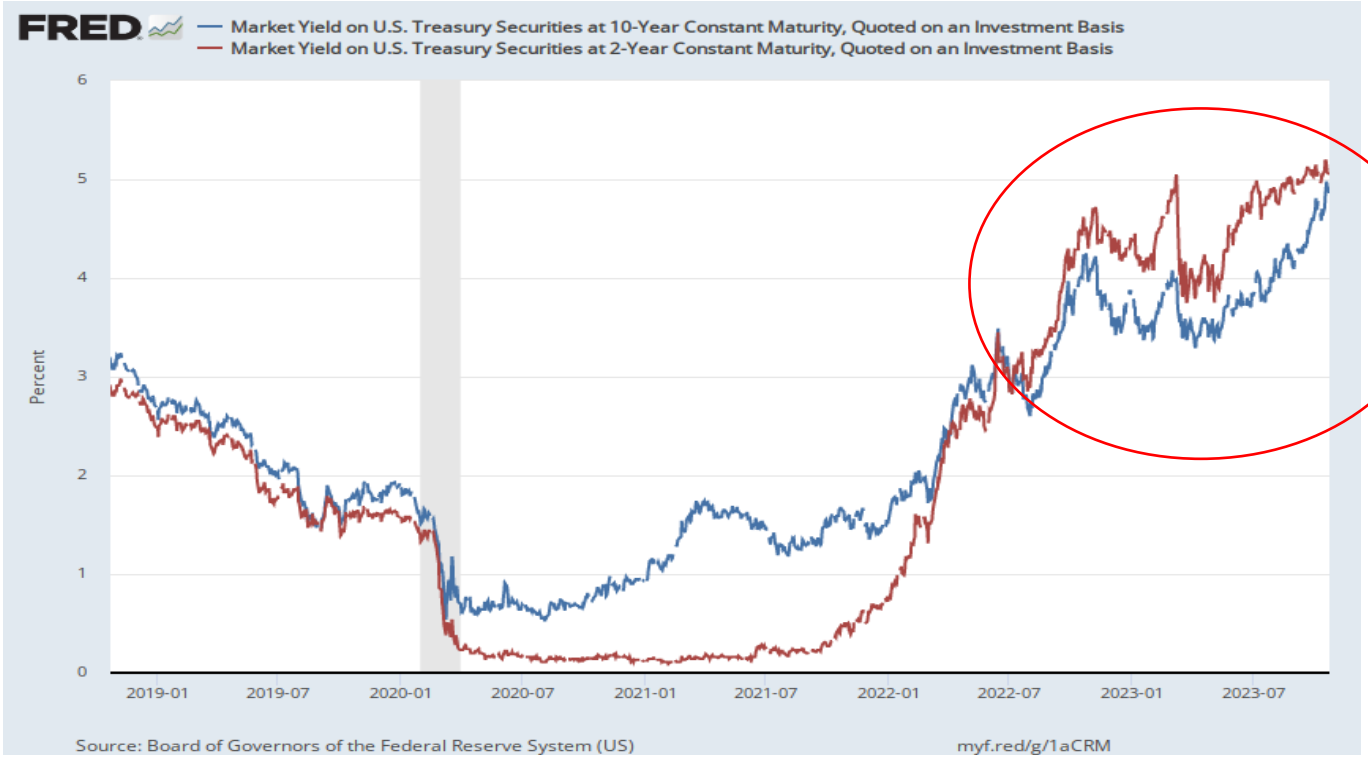
Market Yield on 10-Year vs 2-Year UST Constant Maturities



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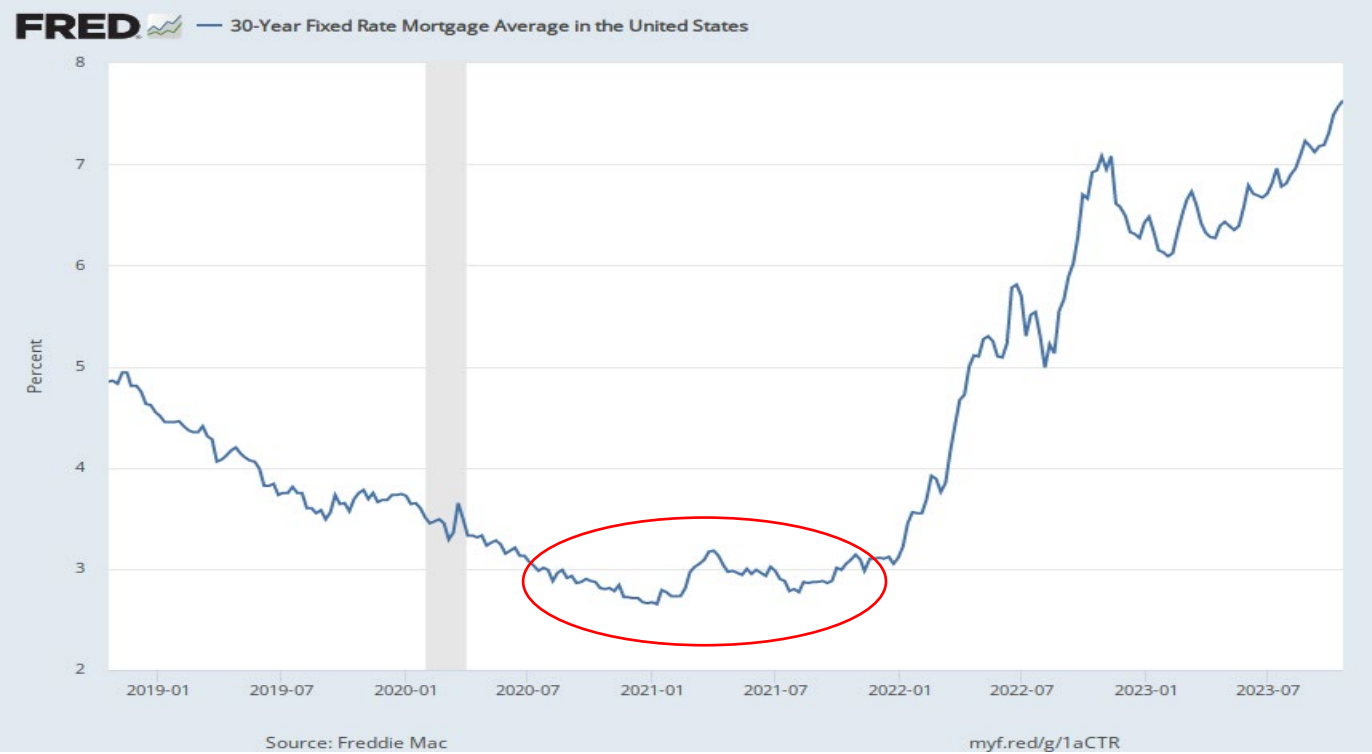
30-Year FRM Rate



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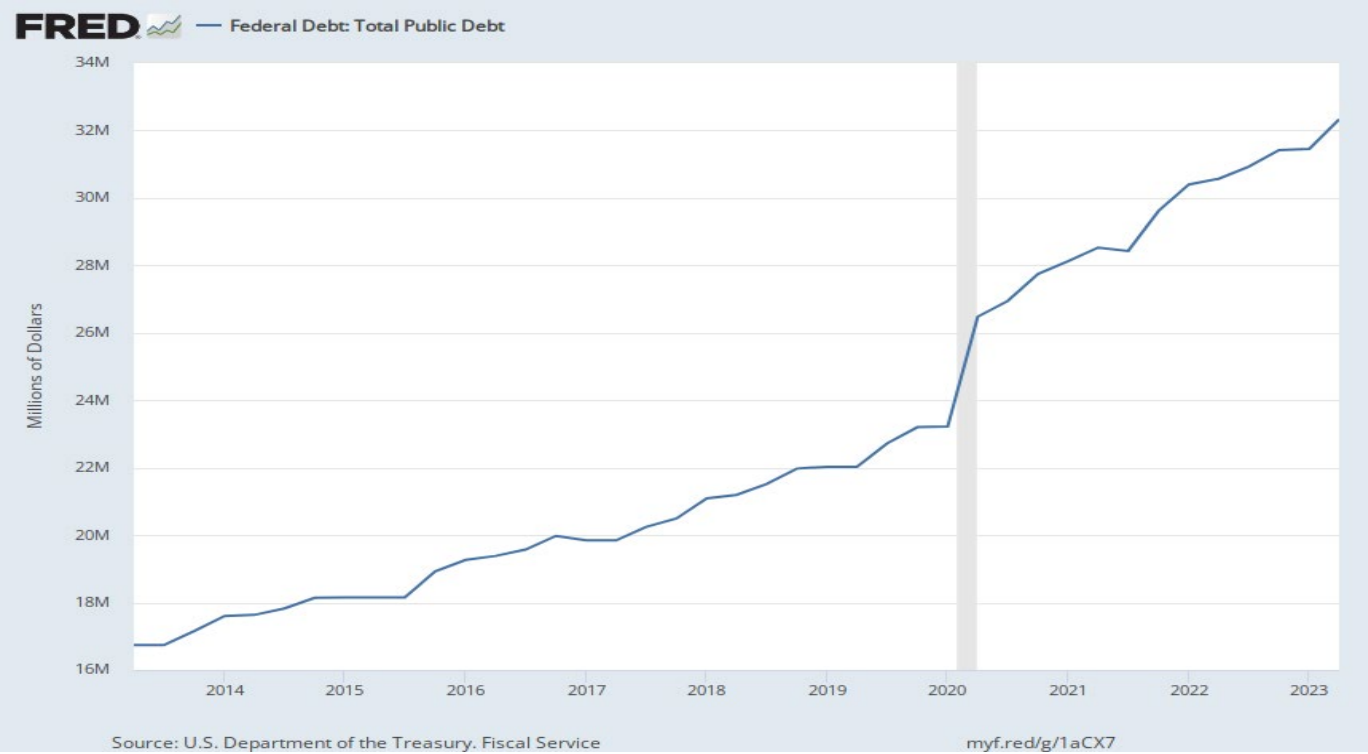
Total Public Debt



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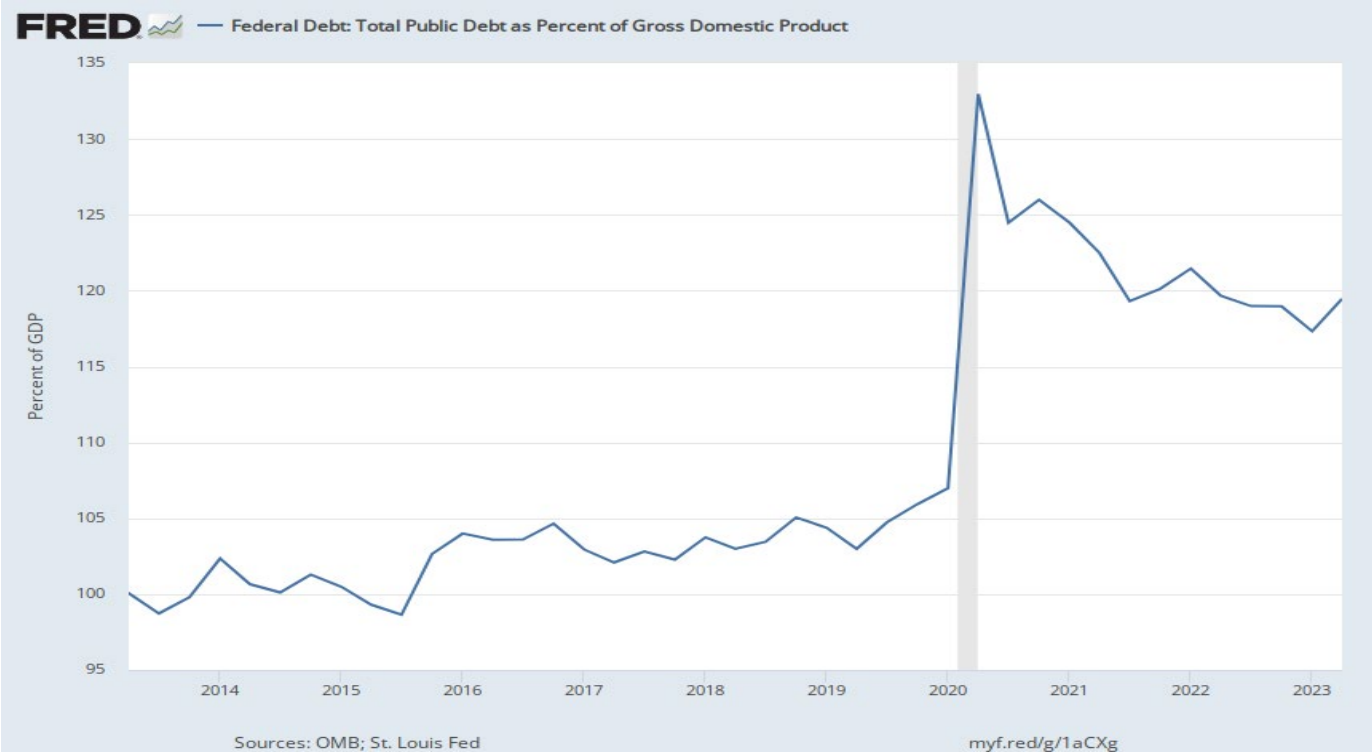
Total Public Debt as a Percent of GDP



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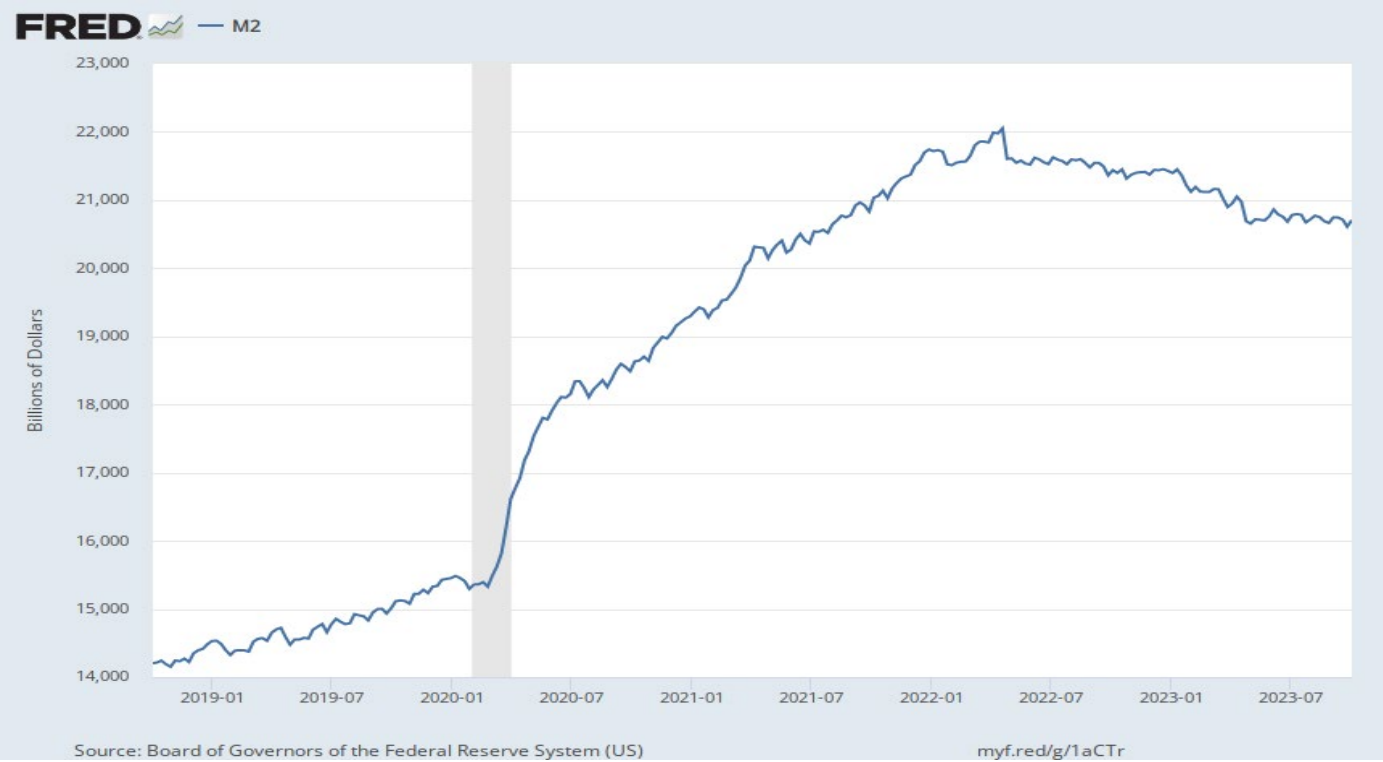
M2



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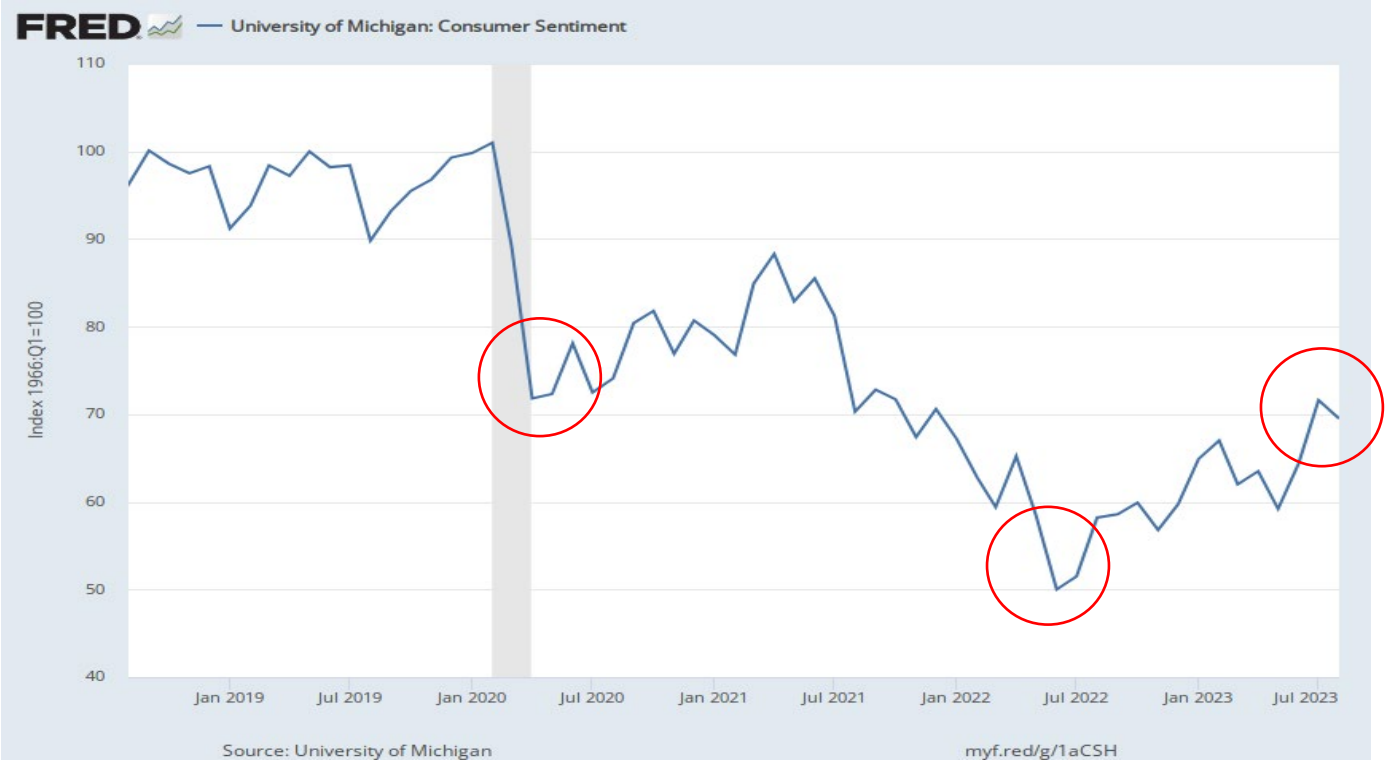
University of Michigan Consumer Sentiment



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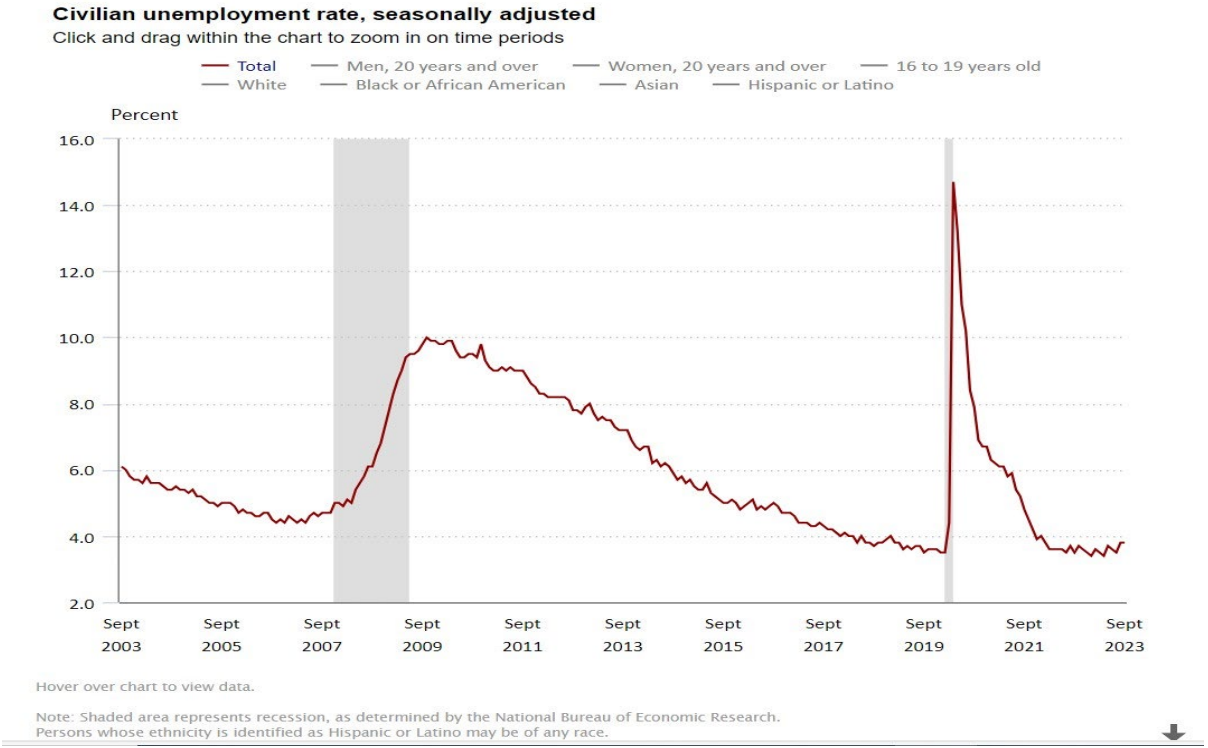
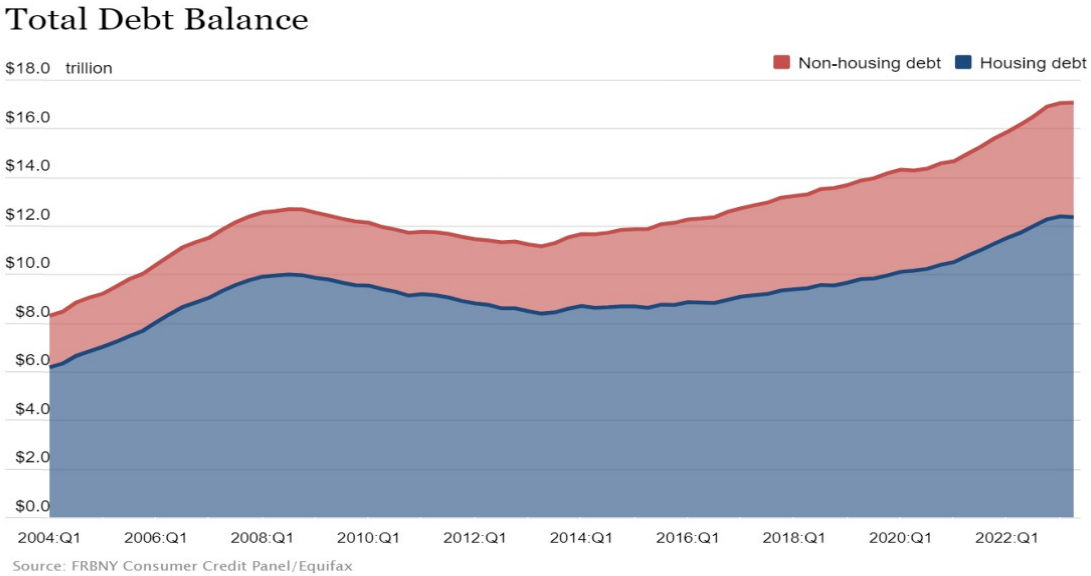
Civilian Unemployment Rate



Total (Consumer) Debt Balance(s)



Mortgage balances shown on consumer credit reports were largely unchanged from the previous quarter, during the second quarter of 2023 and stood at $12.01 trillion at the end of June. Balances on home equity lines of credit (HELOC) were essentially flat as well; the outstanding HELOC balance stands at $340 billion. Credit card balances increased by $45 billion, a 4.6% quarterly increase, and now stand at $1.03 trillion. Auto loan balances increased by $20 billion, continuing the upward trajectory that has been in place since 2011.

Headline

More U.S. companies have gone bankrupt in 2023 so far than all of 2022 or 2021

There have been more U.S. corporate bankruptcies so far in 2023 than in all of 2022 or 2021, as companies continue to struggle with high interest rates and a tight labor market.

S&P Global Market Intelligence has recorded 459 filings as of Aug. 31, which compares with 373 for all of 2022 and 408 for all of 2021. That's still well below the 639 recorded in 2020, when the pandemic forced many companies into Chapter 11.

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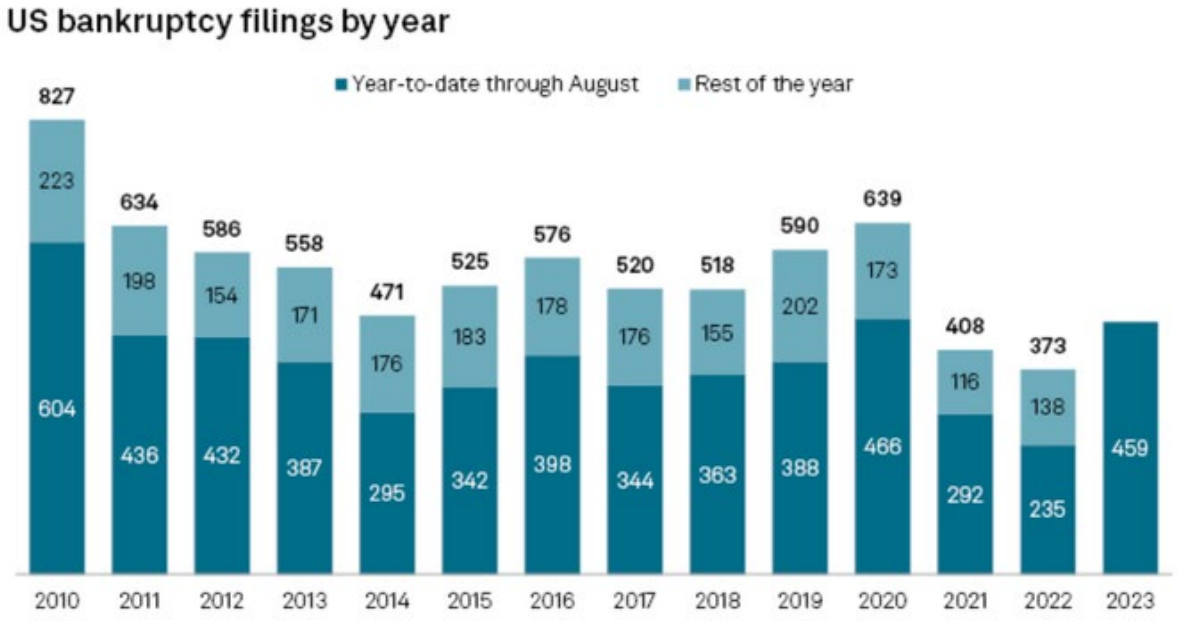
US Bankruptcy Filings by Year



SOURCE: S&P GLOBAL MARKET INTELLIGENCE

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Headline #2

Kamakura Solutions www.Kamakuraco.com

November 2, 2023

Expected Cumulative Defaults Up Sharply

Through the first nine months of 2023, we have seen a surge in defaults. One of the hardest hit sectors is healthcare. A recent S&P release stated that the sector ‘s default risk jumped, while most others fell during the third quarter. The KRIS® default universe mirrors that headline with 24 defaults in our coverage universe year to date.

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Risk Realization

Overview of the current risk environment

Default Risk	Interest Rate Risk	Market/Liquidity Risk
Debt service coverage	Inflation	Required market interventions
Higher borrowing costs	Fastest pace of interest rate hike in two decades	Mark to market risk
Increased difficulty in rolling over debt	Commitment of CB to price stability	Changing risk factor relationships
Zombie companies		FX risk

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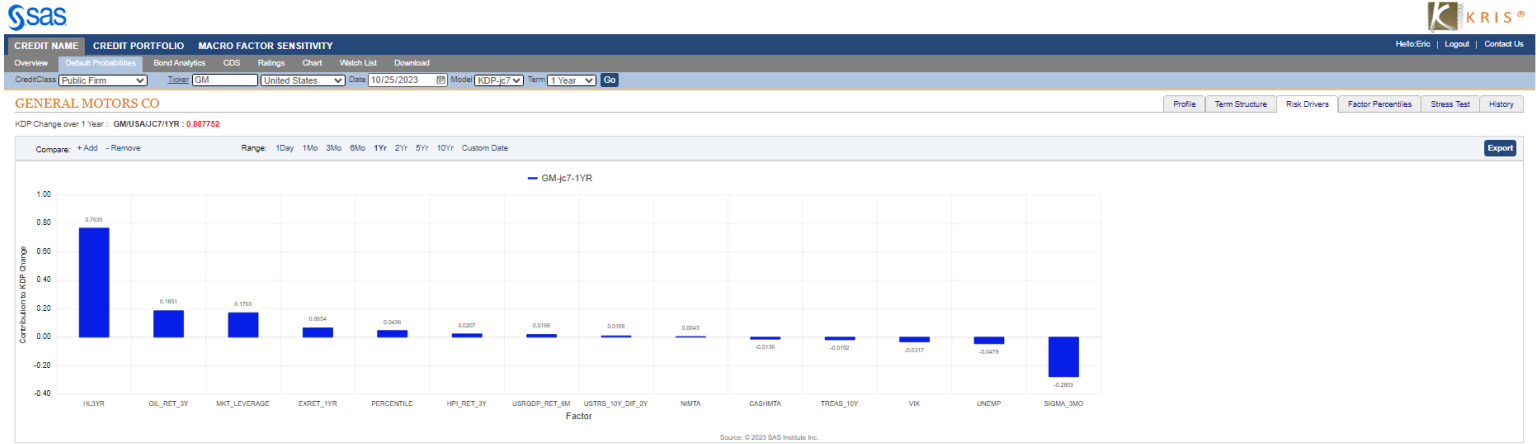
Default Probability Model

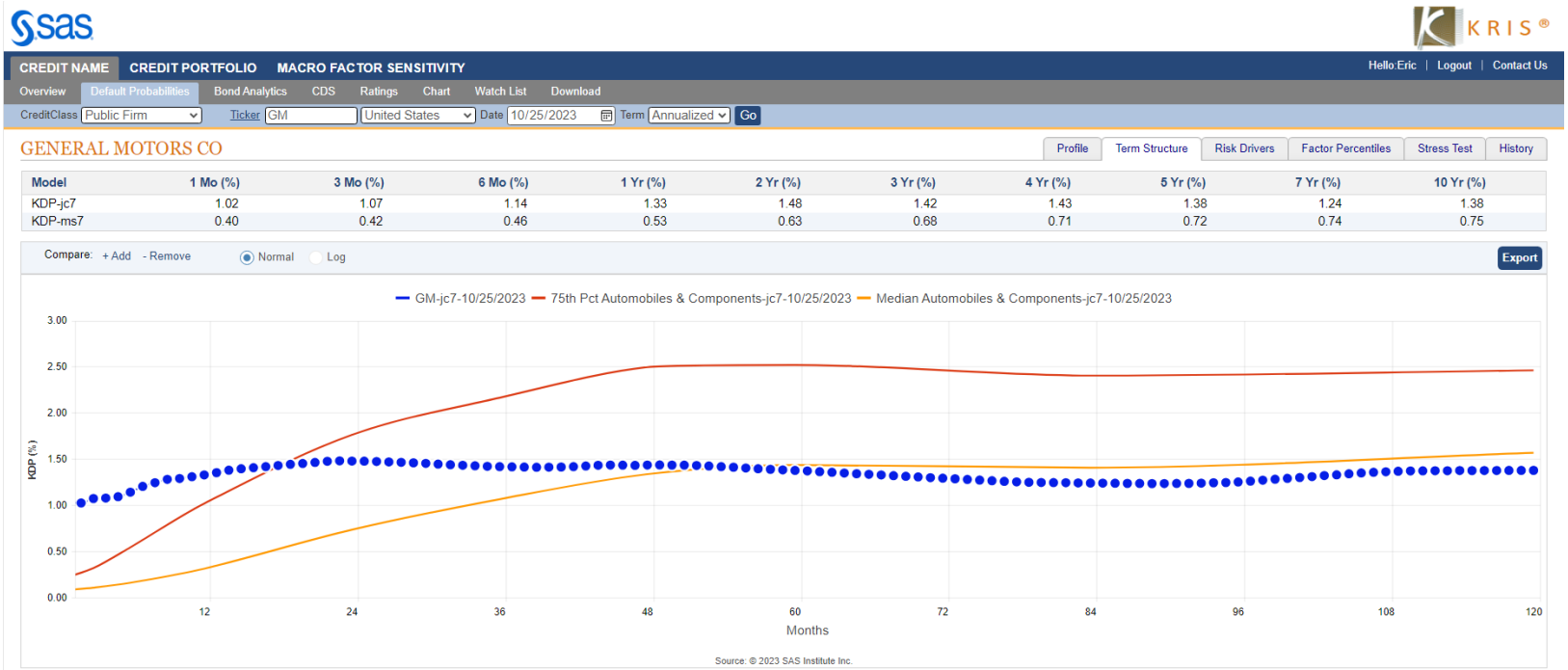
Company specific and Macro Factors – illustrate the impact



Factor	Description
CASHMTA	Cash over market value of total assets
EXRET_1YR	Excess return of stock price relative to the market local index
HL3YR	3 Year high low ratio (current stock price-low) / (high-low)
HPI_RET_3Y	Home Price Index 3 year return
MKT_LEVERAGE	Total Liabilities / (Market Cap + Total Liabilities)
NI_TA	Net income over total assets
NIMTA	Net income over the market value of total assets
PERCENTILE	Percentile of absolute stock price relative to market peers
RET_OIL_3Y	Oil price return over 3 years
RSIZ	Log of company market cap relative to market cap of S&P 500
SECTOR	MSCI GIC Sector
SIGMA_3MO	The stock price volatility over the previous 3 month
TREAS_10Y	10 Year Treasury Yield
UNEMP	US unemployment rate
UNEMP_1Y	Change in US unemployment rate over 1 year
USRGDP_RET_6M	US Real GDP 6 month return
USTRS_10Y_DIF_2Y	Difference of 10 year and 2 year UST yields
VIX	S&P 500 volatility index value

Term Structure of Default Probabilities

One model framework to capture PIT and TTC



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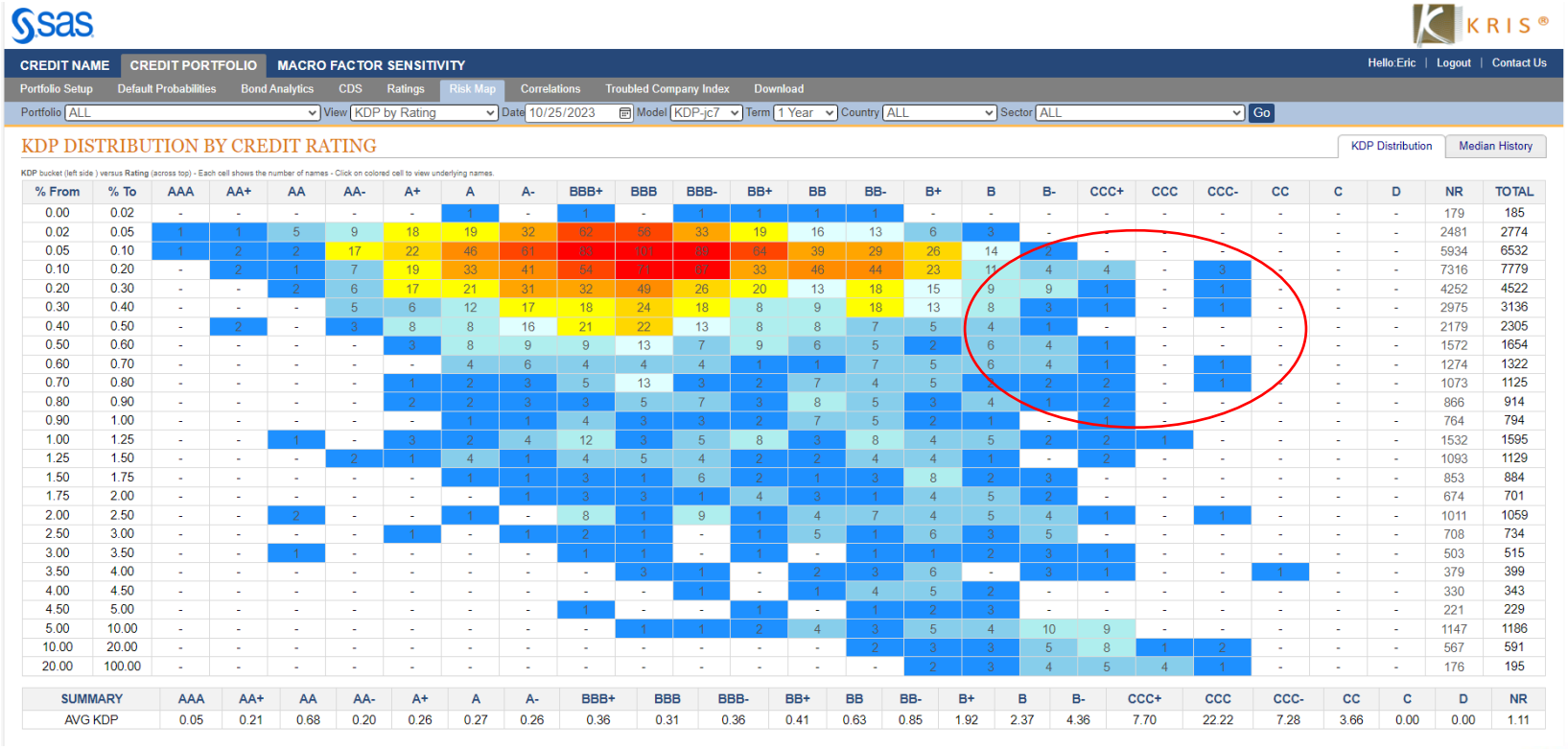
Default Probabilities

Beyond Ratings – a clear focus on default



sas

KRIS®

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Portfolio: ALL | View: KDP by Rating | Date: 10/25/2023 | Model: KDP-jc7 | Term: 1 Year | Country: ALL | Sector: ALL | Go

KDP DISTRIBUTION BY CREDIT RATING

KDP Distribution | Median History

KDP bucket (left side) versus Rating (across top) - Each cell shows the number of names - Click on colored cell to view underlying names.

% From	% To	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	CC	C	D	NR	TOTAL
0.00	0.02	-	-	-	-	-	1	-	1	-	1	1	1	1	-	-	-	-	-	-	-	-	-	179	185
0.02	0.05	1	1	5	9	18	19	32	62	56	33	19	16	13	6	3	-	-	-	-	-	-	-	2481	2774
0.05	0.10	1	2	2	17	22	46	61	88	101	89	64	39	29	26	14	2	-	-	-	-	-	-	5934	6532
0.10	0.20	-	2	1	7	19	33	41	54	71	67	33	46	44	23	11	4	4	-	3	-	-	-	7316	7779
0.20	0.30	-	-	2	6	17	21	31	32	49	26	20	13	18	15	9	9	1	-	1	-	-	-	4252	4522
0.30	0.40	-	-	-	5	6	12	17	18	24	18	8	9	18	13	8	3	1	-	1	-	-	-	2975	3136
0.40	0.50	-	2	-	3	8	8	16	21	22	13	8	8	7	5	4	1	-	-	-	-	-	-	2179	2305
0.50	0.60	-	-	-	-	3	8	9	9	13	7	9	6	5	2	6	4	1	-	-	-	-	-	1572	1654
0.60	0.70	-	-	-	-	-	4	6	4	4	4	1	1	7	5	6	4	1	-	1	-	-	-	1274	1322
0.70	0.80	-	-	-	-	1	2	3	5	13	3	2	7	4	5	2	2	2	-	1	-	-	-	1073	1125
0.80	0.90	-	-	-	-	2	2	3	3	5	7	3	8	5	3	4	1	2	-	-	-	-	-	866	914
0.90	1.00	-	-	-	-	-	1	1	4	3	3	2	7	5	2	1	-	1	-	-	-	-	-	764	794
1.00	1.25	-	-	1	-	3	2	4	12	3	5	8	3	8	4	5	2	2	1	-	-	-	-	1532	1595
1.25	1.50	-	-	-	2	1	4	1	4	5	4	2	2	4	4	1	-	2	-	-	-	-	-	1093	1129
1.50	1.75	-	-	-	-	-	1	1	3	1	6	2	1	3	8	2	3	-	-	-	-	-	-	853	884
1.75	2.00	-	-	-	-	-	-	1	3	3	1	4	3	1	4	5	2	-	-	-	-	-	-	674	701
2.00	2.50	-	-	2	-	-	1	-	8	1	9	1	4	7	4	5	4	1	-	1	-	-	-	1011	1059
2.50	3.00	-	-	-	-	1	-	1	2	1	-	1	5	1	6	3	5	-	-	-	-	-	-	708	734
3.00	3.50	-	-	1	-	-	-	-	1	1	-	1	-	1	1	2	3	1	-	-	-	-	-	503	515
3.50	4.00	-	-	-	-	-	-	-	-	3	1	-	2	3	6	-	3	1	-	-	1	-	-	379	399
4.00	4.50	-	-	-	-	-	-	-	-	-	1	-	1	4	5	2	-	-	-	-	-	-	-	330	343
4.50	5.00	-	-	-	-	-	-	-	1	-	-	1	-	1	2	3	-	-	-	-	-	-	-	221	229
5.00	10.00	-	-	-	-	-	-	-	-	1	1	2	4	3	5	4	10	9	-	-	-	-	-	1147	1186
10.00	20.00	-	-	-	-	-	-	-	-	-	-	-	-	2	3	3	5	8	1	2	-	-	-	567	591
20.00	100.00	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	5	4	1	-	-	-	176	195

SUMMARY	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	CC	C	D	NR
AVG KDP	0.05	0.21	0.68	0.20	0.26	0.27	0.26	0.36	0.31	0.36	0.41	0.63	0.85	1.92	2.37	4.36	7.70	22.22	7.28	3.66	0.00	0.00	1.11

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Default Probabilities

Relative to peers

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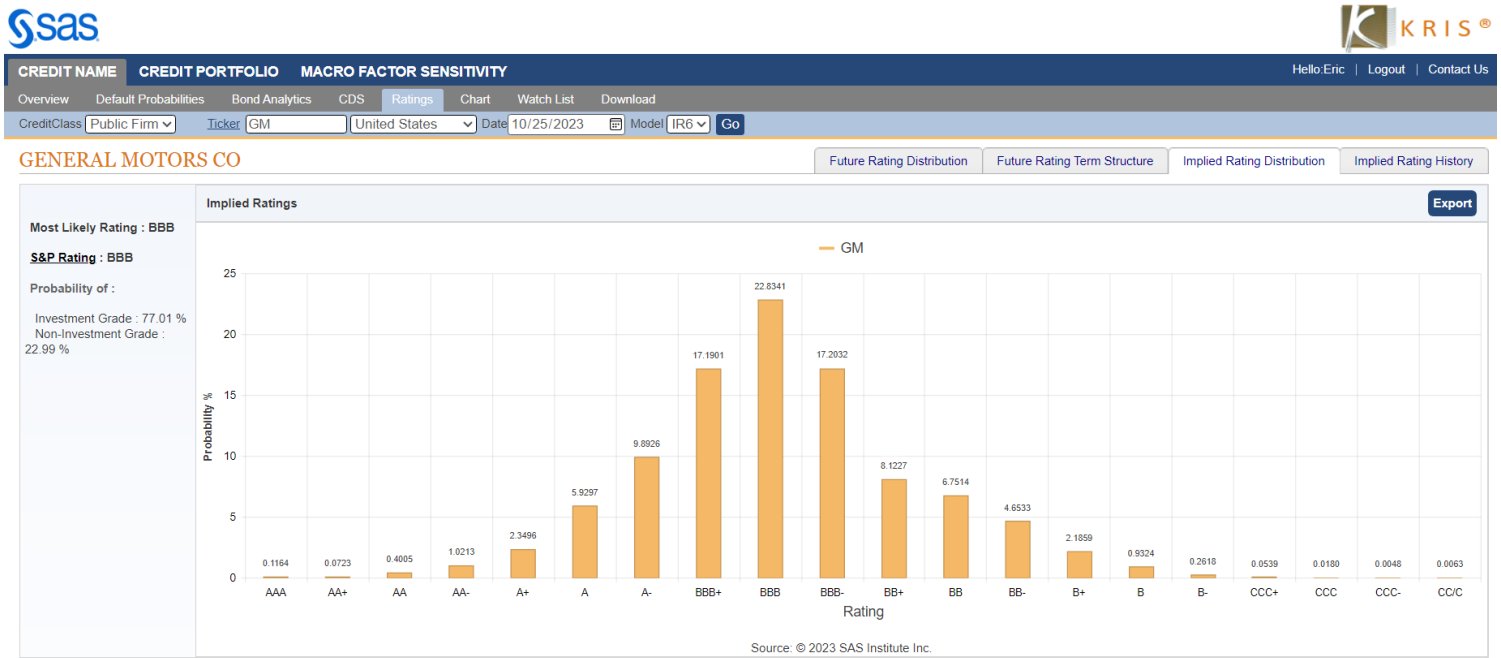
Default Probabilities in context

Using Default Probability factors to infer most likely rating



Distribution	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	CC/C
Probability	0.1	0.1	0.4	1.0	2.3	5.9	9.9	17.2	22.8	17.2	8.1	6.8	4.7	2.2	0.9	0.3	0.1	0.0	0.0	0.0
Cumulative	0.1	0.2	0.6	1.6	4.0	9.9	19.8	37.0	59.8	77.0	85.1	91.9	96.5	98.7	99.7	99.9	100.0	100.0	100.0	100.0

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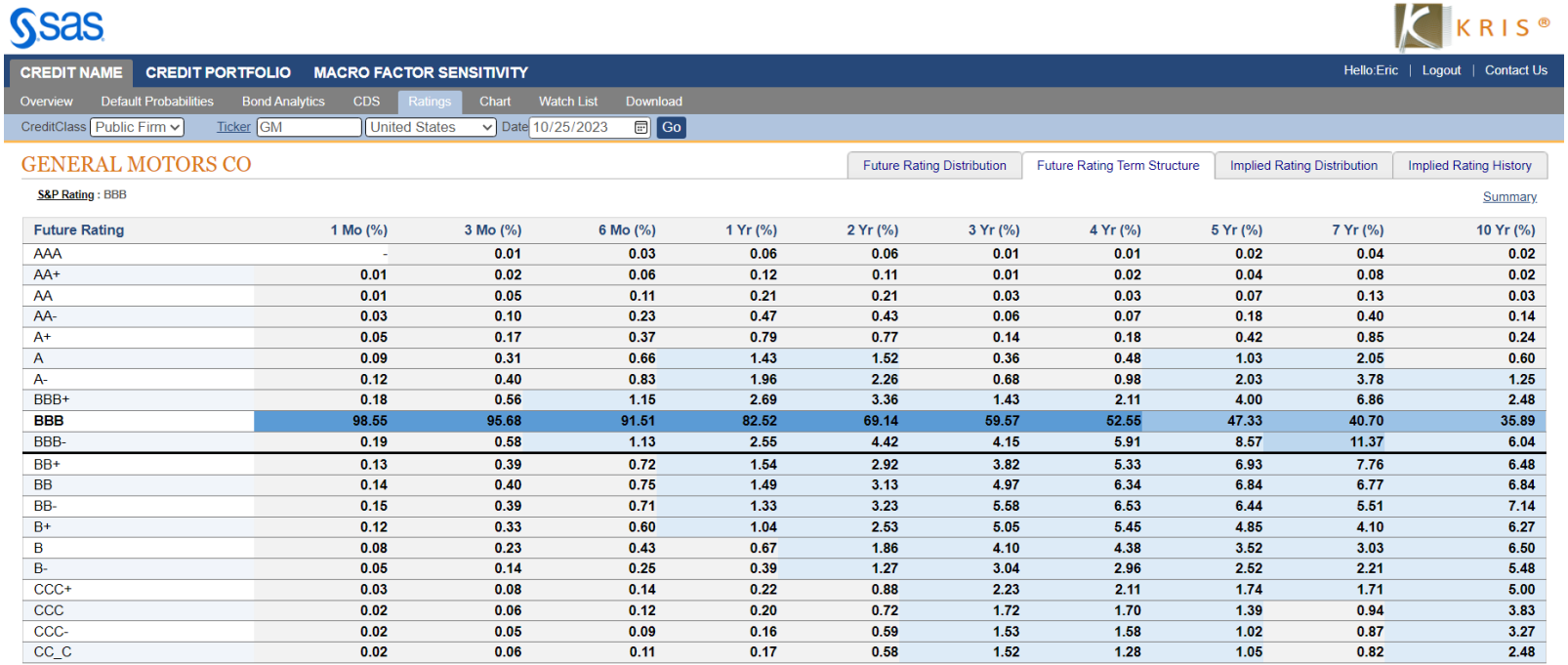
Default Probabilities in context

Using Default Probability factors to infer likely rating change



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CreditClass: Public Firm | Ticker: GM | United States | Date: 10/25/2023 | Go

GENERAL MOTORS CO

Future Rating Distribution | Future Rating Term Structure | Implied Rating Distribution | Implied Rating History

S&P Rating : BBB

Summary

Future Rating	1 Mo (%)	3 Mo (%)	6 Mo (%)	1 Yr (%)	2 Yr (%)	3 Yr (%)	4 Yr (%)	5 Yr (%)	7 Yr (%)	10 Yr (%)
AAA	-	0.01	0.03	0.06	0.06	0.01	0.01	0.02	0.04	0.02
AA+	0.01	0.02	0.06	0.12	0.11	0.01	0.02	0.04	0.08	0.02
AA	0.01	0.05	0.11	0.21	0.21	0.03	0.03	0.07	0.13	0.03
AA-	0.03	0.10	0.23	0.47	0.43	0.06	0.07	0.18	0.40	0.14
A+	0.05	0.17	0.37	0.79	0.77	0.14	0.18	0.42	0.85	0.24
A	0.09	0.31	0.66	1.43	1.52	0.36	0.48	1.03	2.05	0.60
A-	0.12	0.40	0.83	1.96	2.26	0.68	0.98	2.03	3.78	1.25
BBB+	0.18	0.56	1.15	2.69	3.36	1.43	2.11	4.00	6.86	2.48
BBB	98.55	95.68	91.51	82.52	69.14	59.57	52.55	47.33	40.70	35.89
BBB-	0.19	0.58	1.13	2.55	4.42	4.15	5.91	8.57	11.37	6.04
BB+	0.13	0.39	0.72	1.54	2.92	3.82	5.33	6.93	7.76	6.48
BB	0.14	0.40	0.75	1.49	3.13	4.97	6.34	6.84	6.77	6.84
BB-	0.15	0.39	0.71	1.33	3.23	5.58	6.53	6.44	5.51	7.14
B+	0.12	0.33	0.60	1.04	2.53	5.05	5.45	4.85	4.10	6.27
B	0.08	0.23	0.43	0.67	1.86	4.10	4.38	3.52	3.03	6.50
B-	0.05	0.14	0.25	0.39	1.27	3.04	2.96	2.52	2.21	5.48
CCC+	0.03	0.08	0.14	0.22	0.88	2.23	2.11	1.74	1.71	5.00
CCC	0.02	0.06	0.12	0.20	0.72	1.72	1.70	1.39	0.94	3.83
CCC-	0.02	0.05	0.09	0.16	0.59	1.53	1.58	1.02	0.87	3.27
CC_C	0.02	0.06	0.11	0.17	0.58	1.52	1.28	1.05	0.82	2.48

“New” Risks

- Rising interest rates (i.e., unrealized losses / extension risk)
  - ‘Regime Change’ – for 40 years rates have been falling (US 10-year peaked at 16% in 1981 reaching 0.5% during the pandemic)
- Liquidity (funding / deposit) and Refinance Risks
  - Contagion risk(s), especially for Banks
- Cyber-currencies
- Unanticipated disruptions in labor markets
- Geopolitical concerns – Ukraine, Israel/Gaza, China/Taiwan

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What Changes are Likely to be Permanent?

Supply Chain Re-engineering (residual fallout from pandemic)

Work-life (residual fallout from pandemic)

- Remote work – how will it effect business intelligence
- Productivity

Fiscal Policies

- Government policies benefitting certain segments or companies over others

Leverage

- Will both the private and public sector (continue to) operate with higher levels of debt?
- Gen Z spending more this Holiday Season?

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What Does this Mean?

- Time to revisit your credit risk tools
  - Validate material models if you have not recently done so
  - Are there new risk drivers?
  - Do your models need recalibrating?
  - Are you looking at the term structure?
  - Back to basics
    - Know your customers
    - Know your customers' customers
    - Follow the Cash

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Strategies for Regime Shift Detection and Early Warning Indicators

Prudent Risk Modeling

- Back-test models frequently and rigorously
- Attribution analysis to detect deviations from the model assumptions
- Create narrative for the deviations

Regime Detection

- Use of ML for regime detection from HF data
- Contagion monitoring

Early Warning Systems

- Triggers
- Business rules
- Predictive models
- Process automation

Alternative Data

- Text data analytics (sentiment, consistency, etc.)
- Supply chain mapping
- Unstructured data

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Tools to Address the Challenges

Credit Models

- Term-based default models
- Sector-based tools
- High frequency updates

Integrated Balance Sheet View

- Holistic perspective on balance sheet risk
- Competing risk paradigm more important than ever

Risk Management Automation

- Reduce unnecessary manual intervention
- Automation in data quality, feature engineering, model deployment, and model performance monitoring

Technology

- Modularity & API-first design
- Best of breed design
- Cloud computing
- Low code / no code

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Baseline Scenario 2023

Table 3.A. Supervisory baseline scenario: Domestic variables, Q1:2023–Q1:2026

Percent, unless otherwise indicated

Date	Real GDP growth	Nominal GDP growth	Real disposable income growth	Nominal disposable income growth	Unemployment rate	CPI inflation rate	3-month Treasury rate	5-year Treasury yield	10-year Treasury yield	BBB corporate yield	Mortgage rate	Prime rate	Level			
													Dow Jones Total Stock Market Index	House Price Index	Commercial Real Estate Price Index	Market Volatility Index
Q1 2023	-0.5	2.9	1.8	5.1	3.9	3.2	4.7	4.0	3.9	5.9	6.2	7.4	38,521	301	361	30.7
Q2 2023	-0.9	2.1	0.7	3.5	4.3	2.9	4.8	4.0	3.8	5.8	5.9	7.6	38,521	303	364	29.0
Q3 2023	0.0	2.6	1.5	4.0	4.6	2.7	4.6	3.9	3.7	5.6	5.6	7.4	38,521	304	366	27.2
Q4 2023	0.9	3.4	2.0	4.3	4.8	2.4	4.4	3.7	3.6	5.5	5.4	7.2	38,521	306	369	28.4
Q1 2024	1.5	3.9	2.4	4.6	4.9	2.2	4.0	3.6	3.5	5.4	5.2	6.8	38,521	307	372	28.5
Q2 2024	1.9	4.1	2.4	4.5	4.9	2.1	3.7	3.5	3.4	5.3	5.0	6.5	38,521	309	375	28.6
Q3 2024	2.2	4.3	2.4	4.3	4.8	2.2	3.3	3.4	3.3	5.3	4.9	6.2	38,521	310	377	28.4
Q4 2024	2.3	4.4	2.4	4.4	4.7	2.1	3.1	3.3	3.3	5.2	4.9	6.0	38,521	312	380	28.4
Q1 2025	2.2	4.4	2.1	4.2	4.6	2.2	3.0	3.2	3.3	5.2	4.8	5.9	38,521	314	383	28.5
Q2 2025	2.1	3.9	2.0	4.1	4.6	2.2	3.0	3.1	3.3	5.2	4.8	5.9	38,521	315	386	28.5
Q3 2025	2.1	3.8	2.0	4.0	4.6	2.2	3.0	3.0	3.3	5.2	4.8	5.9	38,521	317	389	28.5
Q4 2025	2.1	3.8	2.0	4.0	4.6	2.2	3.0	3.0	3.2	5.2	4.8	5.9	38,521	318	392	28.5
Q1 2026	2.0	3.9	2.0	4.0	4.6	2.2	3.0	2.9	3.2	5.2	4.8	5.9	38,521	320	395	28.4

Note: Refer to Notes Regarding Scenario Variables for more information on the definitions and sources of historical observations of the variables in the table.

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Severely Adverse Scenario 2023

Table 4.A. Supervisory severely adverse scenario: Domestic variables, Q1:2023–Q1:2026

Percent, unless otherwise indicated

Date	Real GDP growth	Nominal GDP growth	Real disposable income growth	Nominal disposable income growth	Unemployment rate	CPI inflation rate	3-month Treasury rate	5-year Treasury yield	10-year Treasury yield	BBB corporate yield	Mortgage rate	Prime rate	Level			
													Dow Jones Total Stock Market Index	House Price Index	Commercial Real Estate Price Index	Market Volatility Index
Q1 2023	-12.5	-10.1	-7.9	-5.8	5.6	2.3	1.7	1.2	1.1	5.8	4.0	4.7	24,338	249	348	70.0
Q2 2023	-6.7	-5.3	-3.0	-1.8	6.8	1.5	1.0	0.9	0.8	6.3	3.7	4.0	22,132	229	337	75.0
Q3 2023	-8.0	-7.0	-3.4	-2.4	8.1	1.3	0.1	0.8	0.8	6.5	3.8	3.1	21,502	213	323	65.4
Q4 2023	-5.9	-4.9	-2.1	-0.9	9.2	1.3	0.1	0.8	0.8	6.6	3.8	3.1	21,186	202	301	58.0
Q1 2024	-1.8	-0.7	0.3	1.6	9.7	1.4	0.1	0.9	0.9	6.4	3.8	3.1	21,817	194	277	52.1
Q2 2024	0.6	1.9	1.5	2.8	9.9	1.4	0.1	0.9	1.0	6.1	3.7	3.1	22,762	190	255	47.4
Q3 2024	0.9	2.2	1.7	2.9	10.0	1.4	0.1	1.0	1.1	5.8	3.5	3.1	24,023	186	234	43.6
Q4 2024	6.3	7.6	5.3	6.6	9.5	1.5	0.1	1.0	1.2	5.5	3.4	3.1	25,599	191	215	40.6
Q1 2025	5.9	7.2	5.3	6.7	9.0	1.5	0.1	1.0	1.3	5.1	3.3	3.1	27,490	196	218	38.2
Q2 2025	5.6	6.4	5.1	6.5	8.6	1.5	0.1	1.0	1.3	4.8	3.2	3.1	29,381	202	220	36.2
Q3 2025	5.3	6.3	4.8	6.3	8.2	1.6	0.1	1.0	1.4	4.5	3.1	3.1	32,217	207	223	34.7
Q4 2025	5.0	6.1	4.5	6.0	7.8	1.6	0.1	1.0	1.5	4.1	3.1	3.1	35,369	212	226	33.4
Q1 2026	4.7	6.0	4.2	5.7	7.5	1.6	0.1	1.1	1.5	3.8	3.1	3.1	38,521	216	228	32.4

Note: Refer to Notes Regarding Scenario Variables for more information on the definitions and sources of historical observations of the variables in the table.

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Regulatory History Revisited?

From the Office of Thrift Supervision ("OTS"), Thrift Bulletin 13, "Responsibilities of the Board of Directors and Management with Regard to Interest Rate Risk"

- +/- 100, 200, 300, 400 basis point interest rate shocks for NII and EVE
- Effective date: 01/26/1989
- **Rescinded** date: 12/01/1998, rescinded by TB 13a

OTS TB 13a, "Management of Interest Risk and Investment and Derivative Activities"

- Effective date: 12/01/1998
- **Rescinded** date: 3/31/2012, **rescinded** by OCC Bulletin 2012-5

OCC Bulletin 2012-5 (January 12, 2012), "Interest Rate Risk Management: FAQs on 2010 Interagency Advisory on Interest Rate Risk Management"

- "*The OCC expects all national banks and federal savings associations to manage their IRR exposures using processes and systems commensurate with their earnings and capital levels; complexity; business model; risk profile; and scope of operations*."

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Interest Rate Risk and Credit Spread Risk

- Started with prescribed scenarios for IRRBB (for runoff and static balance sheets).
- Then . . . SOTs were introduced.
  - Supervisory Outlier Tests are used to assess the impact of interest rate risk arising from non-trading book activities (IRRBB) on an institution's economic value of equity (EVE) and net interest income (NII) under different shock scenarios.
- Now and per Deloitte regarding CSRBB measurement – *"Banks should develop and use their own methodologies for the assessment and monitoring of CSRBB, which should be adequate for the complexity of the bank itself."*

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Reverse Stress Testing

Reverse stress testing is a type of stress testing that starts from the identification of a pre-defined outcome of business failure or non-viability, and then explores scenarios and circumstances that might cause this to occur. It is used as a risk management tool to increase the institution's awareness of its vulnerabilities and possible risk concentrations. It is different from regular or forward stress testing that starts with the identification of a set of scenarios and explores their ultimate outcome.

Some of the benefits of reverse stress testing are:

- It can help identify and assess the tail risks that could threaten the viability of a financial institution’s business model.
- It can increase the institution’s awareness of its vulnerabilities and possible risk concentrations.
- It can overcome disaster myopia and the possibility that a false sense of security might arise from regular stress testing.
- It can improve contingency planning and risk management arrangements.
- It can help develop mitigating actions and enhance risk assessment.

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Reverse Stress Testing, cont.

Some of the challenges of reverse stress testing are:

- It requires a clear definition of the outcome of business failure or non-viability, which may vary depending on the type and size of the institution, the regulatory framework, and the market conditions.
- It involves a high degree of uncertainty and subjectivity, as there is no unique way to identify the scenarios and circumstances that could lead to the failure outcome. Different methods and assumptions may yield different results.
- It requires a comprehensive and consistent data set that covers all the relevant risk factors, exposures, and interdependencies across the institution. Data quality and availability may pose significant challenges, especially for complex and diversified institutions.
- It demands a high level of expertise and judgment from the staff involved in the process, as well as effective communication and coordination among different departments and functions. It also requires senior management support and oversight to ensure the credibility and usefulness of the results.
- It may face some resistance or complacency from the institution, as it may reveal some uncomfortable truths or challenge some established beliefs or practices. It may also be perceived as too pessimistic or unrealistic by some stakeholders.
- These challenges can be addressed by adopting a systematic and structured approach to reverse stress testing, following the best practices and guidelines from regulators and industry experts.

Reverse Stress Testing, cont.

Reverse stress testing is performed by following a general methodology that consists of four main steps:

Step 1: Define the outcome of business failure or non-viability. This could be based on regulatory capital ratios, liquidity ratios, solvency ratios, or other indicators of financial distress.

Step 2: Identify the scenarios and circumstances that could lead to the outcome of business failure or non-viability. This could be done by using quantitative models, qualitative analysis, or a combination of both.

Step 3: Assess the plausibility and severity of the scenarios and circumstances identified in step 2. This could be done by using historical data, expert judgment, market indicators, or other sources of information.

Step 4: Report and communicate the results of the reverse stress testing to senior management, board of directors, and regulators. This could include the main assumptions, limitations, and implications of the reverse stress testing exercise.

Scenario vs Simulation Analysis?

Scenario analysis – from a process perspective, this exercise is predicated on a deterministic forecast of the future state, (e.g., an instantaneous +100 basis point shock to underlying interest rates; an instantaneous -100 basis point shock to underlying interest rates; an instantaneous +xxx basis point shock to the short end of the underlying yield curve combined with an instantaneous –xxx basis point shock to the long end of the underlying yield curve; etc.).

- Realistic?
- Will x number of deterministic scenarios provide the analytical insights needed to manage risk?

(Monte Carlo) Simulation analysis – from a process perspective, this exercise is predicated on an objective forecast that effectively includes hundreds or thousands of ‘what if’ analyses that enable the risk manager to model different combinations of key inputs and, therefore, produce a distribution of income and valuation results.

- Unattainable?
- Too complicated to configure?
- Difficult to explain?

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(More) Survey Questions for you

- How many participants are testing their models?
  - If so, how often?
  - Is AI a consideration / (part of the existing) framework?
  - Is there a focus on tails and risk factor correlations?
- Is stress testing / reverse stress testing part of your production runs?
  - If so, are the runs predicated on variable shifts and / or top of the house model ‘stresses’ (i.e., 125% vs 80% of the model; ‘duration’ like assessment)?
  - Is the end state a multi-period, credit-adjusted, (Monte Carlo-based) simulation based on a dynamic balance sheet (i.e., true, unadulterated integrated balance sheet management)?

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Recap

- Challenging market conditions
- Not necessarily Cubs vs White Sox
  - Not necessarily half full versus half empty
- Models need to be reviewed / challenged
  - Alternative frameworks are available
- Impact of reverse stress testing scenarios should be quantified / assessed
  - Migration to non-deterministic scenarios

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Questions for me. . .

Appendix

- 4 Key Risk Management Questions
- Default Probability Term Structure
- Selected References
- Best Practice Simulation and Scenario Generation
- (More) SAS KRIS Screen Shots

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Question 1

What happens to the market capitalization and net income of the firm if any of these risk factors change: home prices, foreign exchange rates, commercial real estate prices, stock index levels, interest rates, commodity prices?

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Question 2

Using an insider's knowledge of the assets and liabilities of the firm, both "on balance sheet" and "off balance sheet," what is the best estimate, monthly for the next ten years, of the probability that the firm will fail in each of these 120 monthly periods?

Question 3

Using only information available to an outsider, what is the best estimate of the probability of the failure of the firm in both the short run and the long run?

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Question 4

If the firm can answer Questions 1, 2, and 3, what hedging position is necessary to ensure that the macro factor sensitivity of the firm and default probability of the firm reach the target levels set by the Board of Directors?

Default Probability Term Structure

120 conditional forecasts – factors coefficients relative values across terms

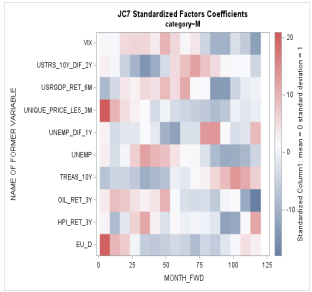
Standardized coefficients

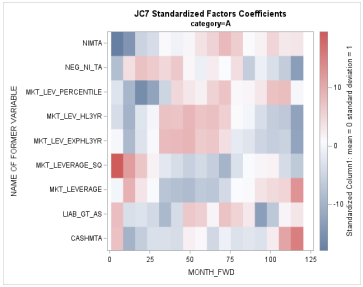
Weights differ for each conditional monthly forecast

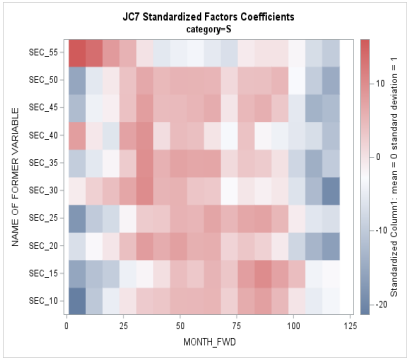
Forecasts combined to construct term structure

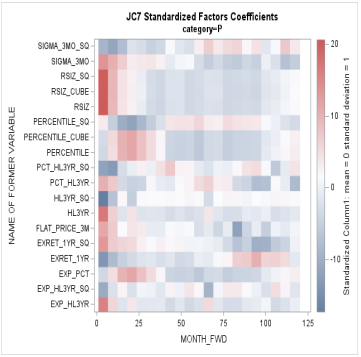
Implications

- Distinguish short, medium and long-term impacts
- Another dimension to the measure of credit risk (is short-term higher than long-term DP?)









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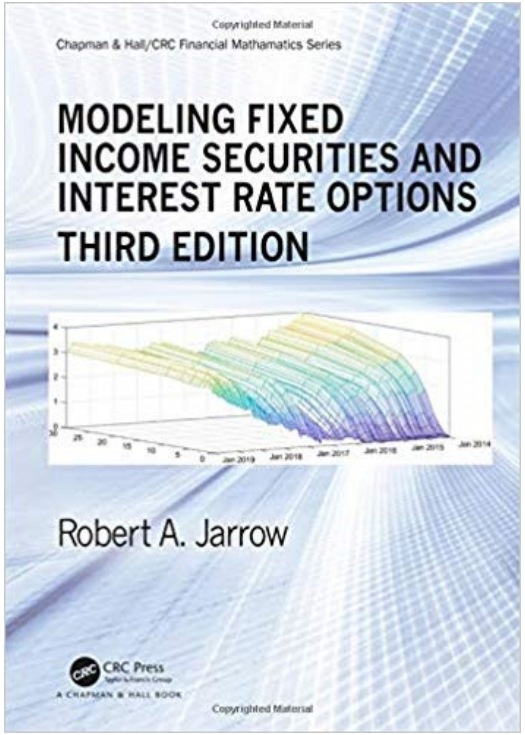
Econometrica, Vol. 60, No. 1 (January, 1992), 77–105

BOND PRICING AND THE TERM STRUCTURE OF INTEREST RATES: A NEW METHODOLOGY FOR CONTINGENT CLAIMS VALUATION[1]

BY DAVID HEATH, ROBERT JARROW, AND ANDREW MORTON[2]

This paper presents a unifying theory for valuing contingent claims under a stochastic term structure of interest rates. The methodology, based on the equivalent martingale measure technique, takes as given an initial forward rate curve and a family of potential stochastic processes for its subsequent movements. A no arbitrage condition restricts this family of processes yielding valuation formulae for interest rate sensitive contingent claims which do not explicitly depend on the market prices of risk. Examples are provided to illustrate the key results.



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Journal of International Money and Finance
Volume 10, Issue 3, September 1991, Pages 310-329

Pricing foreign currency options under stochastic interest rates

Kaushik I. Amin, Robert A. Jarrow

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Abstract

In this paper, we build a general framework to price contingent claims on foreign currencies using the Heath *et al.* (1987) model of the term structure. Closed form solutions are obtained for European options on currencies and currency futures assuming that the volatility functions determining the term structure are deterministic. As such, this paper provides an example of a bond price process (for both the domestic and foreign economies) consistent with Grabbe's (1983) formulation of the same problem.

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Best Practice Simulation and Scenario Generation

Scenario generation should not be a simple simulation based on a variance-covariance matrix of user-selected risk factors.

Instead, using no-arbitrage constraints from a long series of research papers by SAS and Cornell University's Prof. Robert Jarrow, SAS scenario generation and simulations perfectly price all traded inputs to the simulation using that same Monte Carlo simulation.

A typical simulation is a correlated multi-national simulation that produces risk-free yield curves in key counties, the relevant foreign exchanges rates, and key traded macro-economic factors.

As a result, using the Monte Carlo output (typically 500,000 scenarios) will perfectly price (for example)

- The initial US Treasury curve
- The initial UK Gilt curve
- The initial JGB curve
- The initial prices of key traded macro factors like oil, stock price indices, commercial real estate indices, home price indices, volatility indices, and many other commodities.

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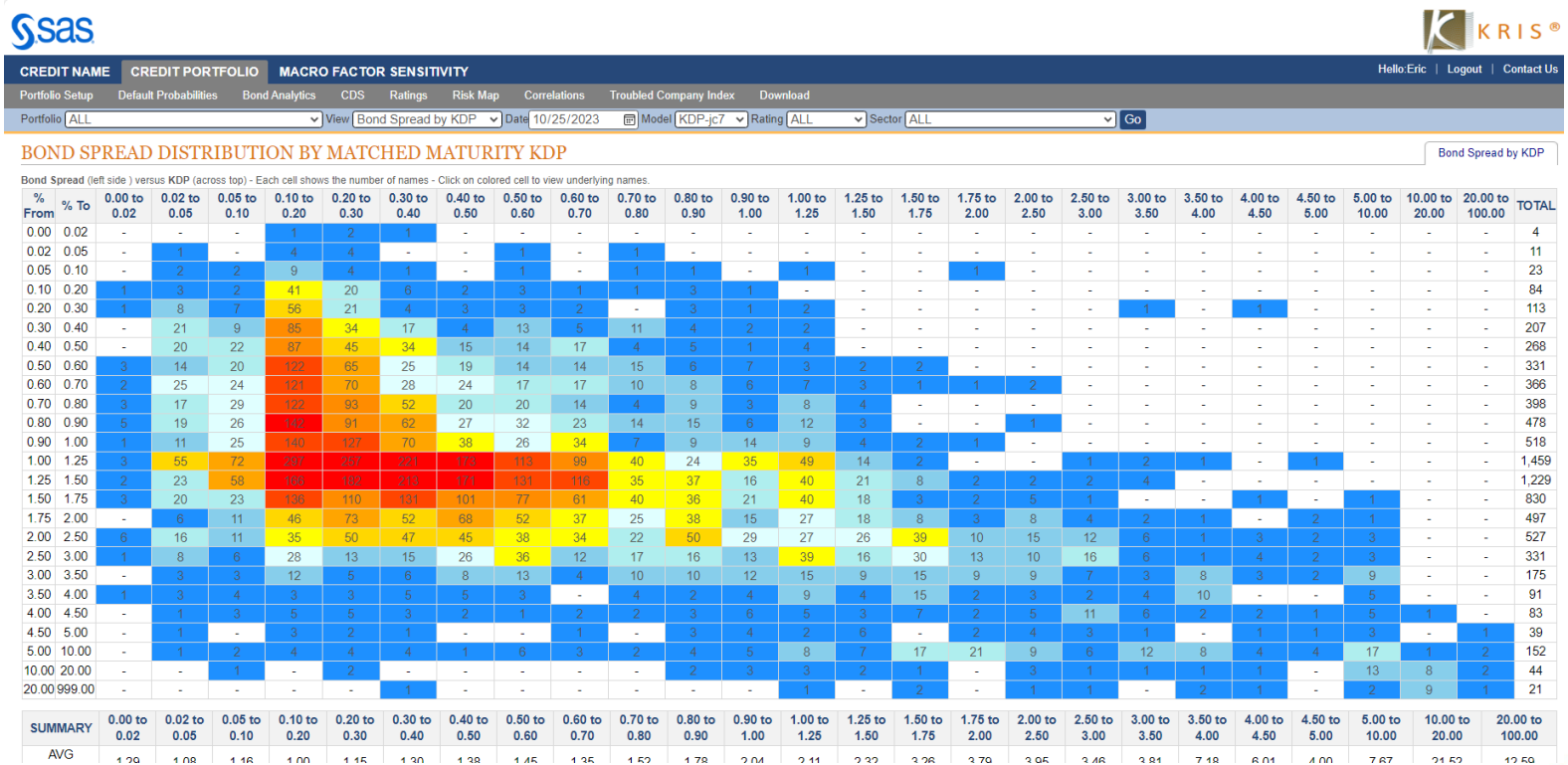
Default Probabilities

Untangle default risk from bond spreads



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Portfolio: ALL | View: Bond Spread by KDP | Date: 10/25/2023 | Model: KDP-jc7 | Rating: ALL | Sector: ALL | Go

BOND SPREAD DISTRIBUTION BY MATCHED MATURITY KDP

Bond Spread by KDP

Bond Spread (left side) versus **KDP** (across top) - Each cell shows the number of names - Click on colored cell to view underlying names.

% From	% To	0.00 to 0.02	0.02 to 0.05	0.05 to 0.10	0.10 to 0.20	0.20 to 0.30	0.30 to 0.40	0.40 to 0.50	0.50 to 0.60	0.60 to 0.70	0.70 to 0.80	0.80 to 0.90	0.90 to 1.00	1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.50	2.50 to 3.00	3.00 to 3.50	3.50 to 4.00	4.00 to 4.50	4.50 to 5.00	5.00 to 10.00	10.00 to 20.00	20.00 to 100.00	TOTAL
0.00	0.02	-	-	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
0.02	0.05	-	1	-	4	4	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
0.05	0.10	-	2	2	9	4	1	-	1	-	1	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-	23
0.10	0.20	1	3	2	41	20	6	2	3	1	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	84
0.20	0.30	1	8	7	56	21	4	3	3	2	-	3	1	2	-	-	-	-	-	1	-	1	-	-	-	-	113
0.30	0.40	-	21	9	85	34	17	4	13	5	11	4	2	2	-	-	-	-	-	-	-	-	-	-	-	-	207
0.40	0.50	-	20	22	87	45	34	15	14	17	4	5	1	4	-	-	-	-	-	-	-	-	-	-	-	-	268
0.50	0.60	3	14	20	122	65	25	19	14	14	15	6	7	3	2	2	-	-	-	-	-	-	-	-	-	-	331
0.60	0.70	2	25	24	121	70	28	24	17	17	10	8	6	7	3	1	1	2	-	-	-	-	-	-	-	-	366
0.70	0.80	3	17	29	122	93	52	20	20	14	4	9	3	8	4	-	-	-	-	-	-	-	-	-	-	-	398
0.80	0.90	5	19	26	142	91	62	27	32	23	14	15	6	12	3	-	-	1	-	-	-	-	-	-	-	-	478
0.90	1.00	1	11	25	140	127	70	38	26	34	7	9	14	9	4	2	1	-	-	-	-	-	-	-	-	-	518
1.00	1.25	3	55	72	287	267	221	173	113	99	40	24	35	49	14	2	-	-	1	2	1	-	1	-	-	-	1,459
1.25	1.50	2	23	58	186	192	213	171	131	116	35	37	16	40	21	8	2	2	2	4	-	-	-	-	-	-	1,229
1.50	1.75	3	20	23	136	110	131	101	77	61	40	36	21	40	18	3	2	5	1	-	-	1	-	1	-	-	830
1.75	2.00	-	6	11	46	73	52	68	52	37	25	38	15	27	18	8	3	8	4	2	1	-	2	1	-	-	497
2.00	2.50	6	16	11	35	50	47	45	38	34	22	50	29	27	26	39	10	15	12	6	1	3	2	3	-	-	527
2.50	3.00	1	8	6	28	13	15	26	36	12	17	16	13	39	16	30	13	10	16	6	1	4	2	3	-	-	331
3.00	3.50	-	3	3	12	5	6	8	13	4	10	10	12	15	9	15	9	9	7	3	8	3	2	9	-	-	175
3.50	4.00	1	3	4	3	3	5	5	3	-	4	2	4	9	4	15	2	3	2	4	10	-	-	5	-	-	91
4.00	4.50	-	1	3	5	5	3	2	1	2	2	3	6	5	3	7	2	5	11	6	2	2	1	5	1	-	83
4.50	5.00	-	1	-	3	2	1	-	-	1	-	3	4	2	6	-	2	4	3	1	-	1	1	3	-	1	39
5.00	10.00	-	1	2	4	4	4	1	6	3	2	4	5	8	7	17	21	9	6	12	8	4	4	17	1	2	152
10.00	20.00	-	-	1	-	2	-	-	-	-	-	2	3	3	2	1	-	3	1	1	1	1	-	13	8	2	44
20.00	999.00	-	-	-	-	-	1	-	-	-	-	-	-	1	-	2	-	1	1	-	2	1	-	2	9	1	21

SUMMARY	0.00 to 0.02	0.02 to 0.05	0.05 to 0.10	0.10 to 0.20	0.20 to 0.30	0.30 to 0.40	0.40 to 0.50	0.50 to 0.60	0.60 to 0.70	0.70 to 0.80	0.80 to 0.90	0.90 to 1.00	1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.50	2.50 to 3.00	3.00 to 3.50	3.50 to 4.00	4.00 to 4.50	4.50 to 5.00	5.00 to 10.00	10.00 to 20.00	20.00 to 100.00
AVG	1.29	1.08	1.16	1.00	1.15	1.30	1.38	1.45	1.35	1.52	1.78	2.04	2.11	2.32	3.26	3.79	3.95	3.46	3.81	7.18	6.01	4.00	7.67	21.52	12.59

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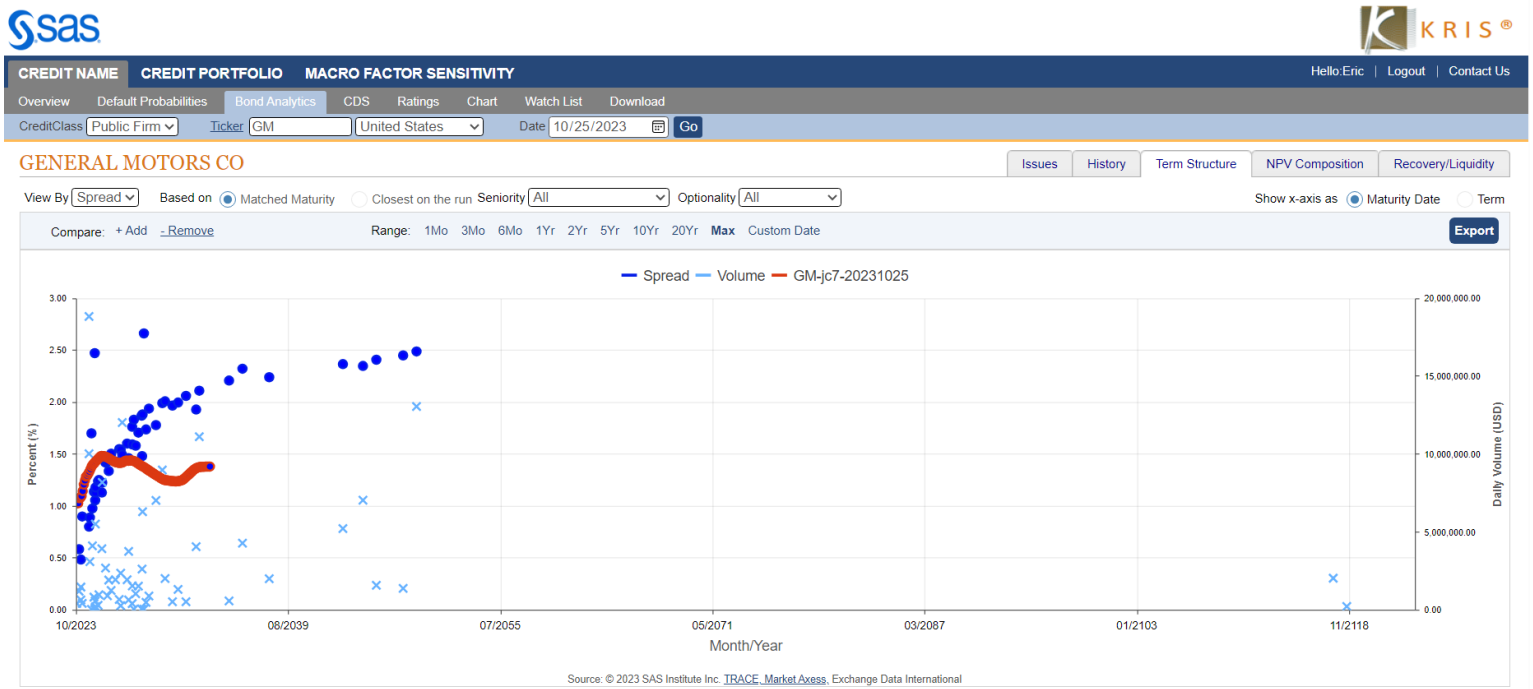
Default Probabilities in context

Bonds Prices and Spreads



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Expected Cumulative Defaults

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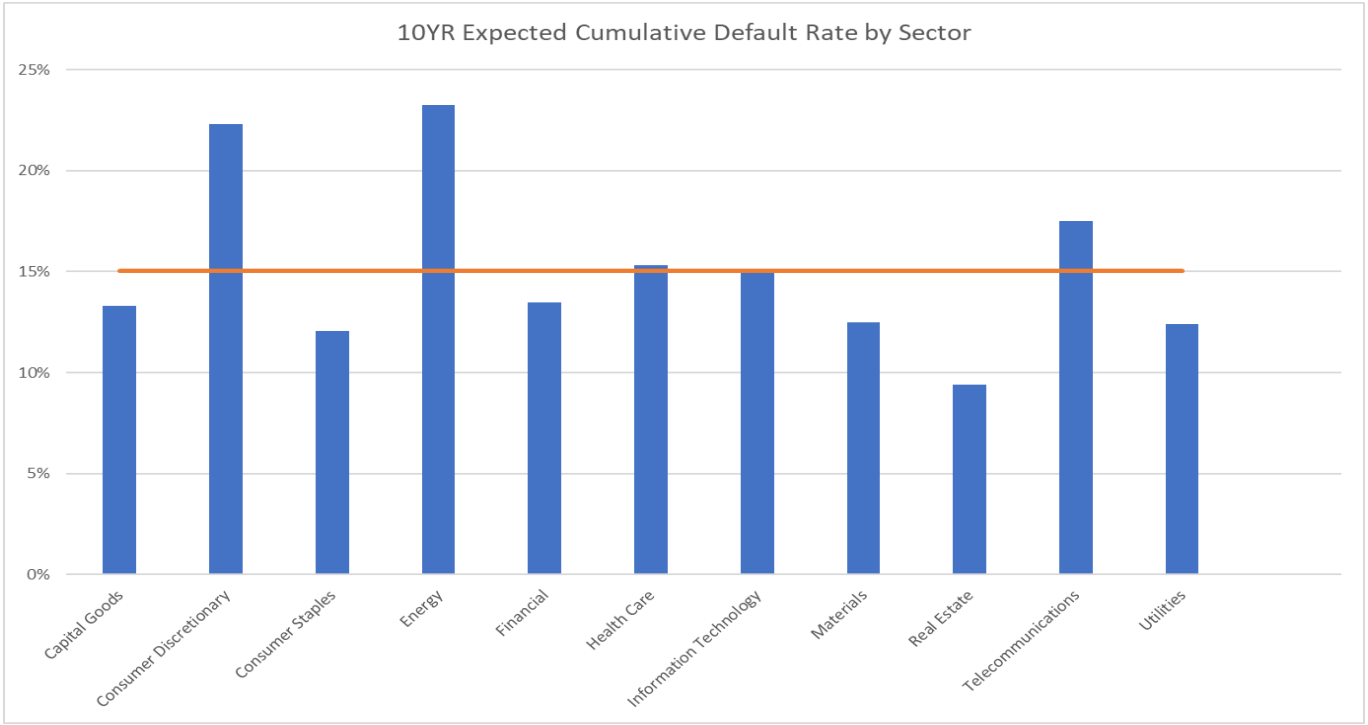
Expected Cumulative Default Rate by Sector Oct 2023



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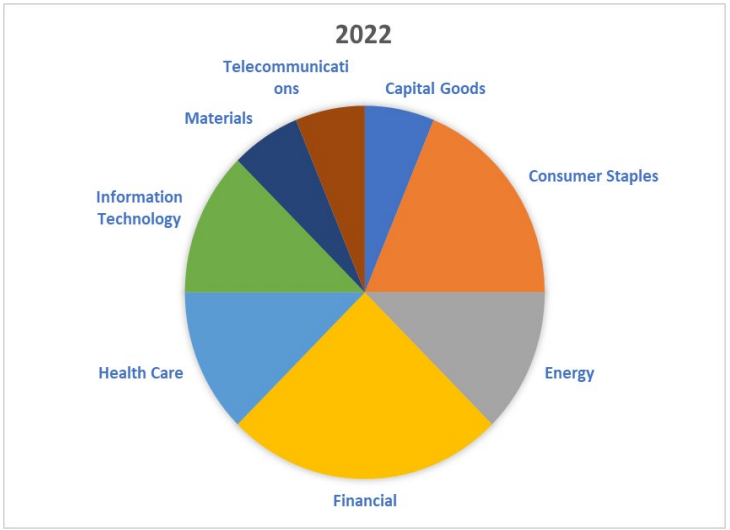
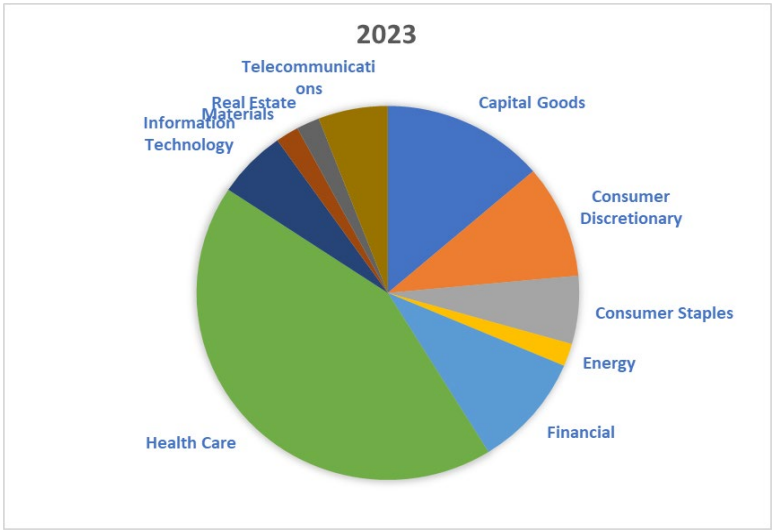
Number of U.S. Defaults by Sector, Q1-Q3 2022 Versus Q1-Q3 2023





What has happened to longer term defaults?