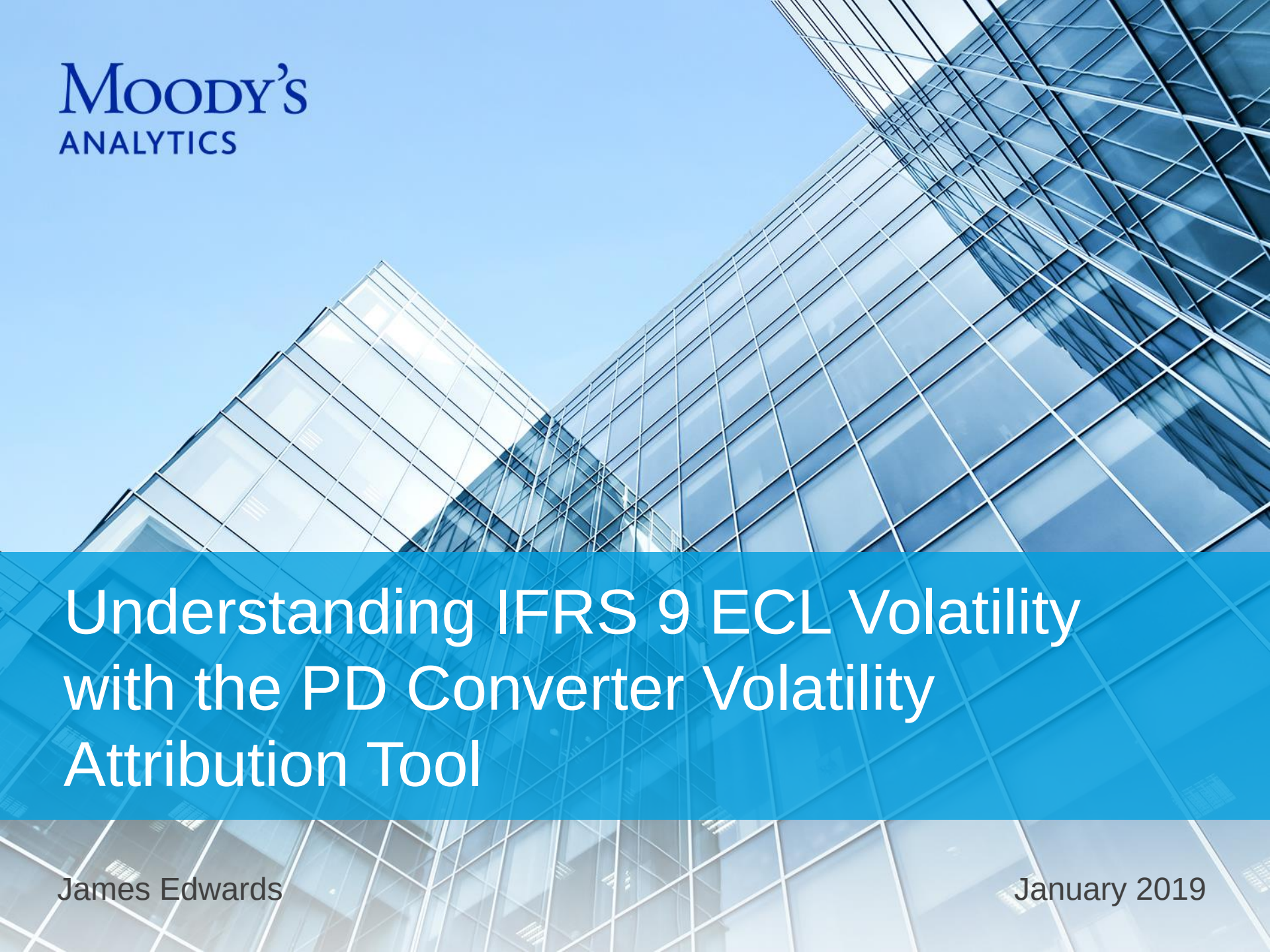

Understanding IFRS 9 ECL Volatility with the PD Converter Volatility Attribution Tool

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Scope of Today's Webinar

- The ImpairmentCalc software provides expected credit loss impairment calculations by taking user-defined asset classifications, credit risk measures, and IFRS 9 and CECL guidance to produce loss allowance.
- There are several models within ImpairmentCalc that can cause ECL and associated provisions to change from quarter to quarter.
- **Today we will focus on the role of the Rating to PIT PD Converter on ECL volatility.**

Agenda

1. Learning How to Interpret the Output of the Volatility Attribution Tool (~35 minutes)
2. Hands on Demo of Tool with Examples of Output (~15 minutes)
3. Q & A (~10 minutes)

1

Learning How to Interpret the Output of the Volatility Attribution Tool

A

Introduction and Overview of Tool

ImpairmentCalc Rating to PIT PD Converter

- The *Rating to PIT PD Converter* takes as input an agency rating or TTC PD and outputs a up-to-date and forward-looking PITPD for each instrument, based on:
  - Rating Grade
  - Country
  - Industry

- For more details about the methodology of the *Rating to PITPD Converter*, please refer to:
  - *Chen, Nan, Douglas Dwyer, and Sue Zhang, "Converting Agency Ratings to Point-In-Time PD Term Structure." Moody's Analytics White Paper, March 2017.*

Introducing the PIT PD Converter Volatility Attribution Tool

- The first major goal of the *PIT PD Converter Volatility Attribution Tool* is to report the changes in quarterly PITPD output across rating grades, countries, and industries

- The second and perhaps even more important goal is to give an understanding of the **factors** that have driven these changes in PD.

Breaking Down Quarterly PD Change into Factors

- The *Rating to PIT PD Converter* models the relationship between rating and PIT PD:
  - Using country and industry specific data when available
  - Augmenting this data from surrounding regions or broader industry when there is a relative lack of data
- This leads to the drivers of PITPD changes not always being obvious
- In order to provide a rich understanding of what is driving the change in PD output, the tool breaks down the total PD change in **three** different ways.

B

Description of PD Change Attribution Breakdowns

Breaking Down Quarterly and Yearly PD Change into Factors

» PD Change Breakdowns in the Tool:

1. **Model Component Attribution:** Within the modelling specification, which estimated terms are driving the change in PD?

2. **Geographical Attribution:** From what regions are the public firm data driving the change in PD coming from?

3. **Risk Factor Attribution:** What individual firm risk factors are driving the change in CreditEdge EDF that underlies the PD output?

Model Component Attribution

» PD output for a specific rating, country, and industry can be represented as:

$$PD_{Rating,C,I} = Base_{Rating,Region} + ICT_I + CCT_C$$

- **Base:** The base model includes an intercept term that allows the overall level of risk to vary based on the EDF data, and a slope term that models the relationship between risk and rating (again to fit the EDF data).
- **ICT:** the Industry Credit Trend term, which allows for more granular variation in risk within specific industries
- **CCT:** the Country Credit Trend, which allows for more granular variation in risk with specific countries

Model Component Attribution

- Due to this model specification, we can attribute the total change in PD for a country/industry/rating combination to the changes in the three factors. As an example:

$$PD_{Rating,C,I} = Base_{Rating,Region} + ICT_I + CCT_C$$

Total Change	Attribution to Change in Base Model	Attribution to Change in ICT	Attribution to Change in CCT
+0.08%	+0.04%	-0.02%	+0.06%

- Note that the sum of the three attributions on the right equal the total change on the left.

Model Component Attribution- Examples

2018Q2-2018Q3 Change for Baa3 Firms in Middle East Country Group
(Aggregated Across Industry)

		Default Probability			Model Component Attribution		
Country	Industry	Old PD	New PD	Change in PD	Base	Industry Credit Trend (ICT)	Country Credit Trend (CCT)
Bahrain		0.48%	0.58%	0.09%	0.09%	0.01%	-0.01%
Jordan		0.53%	0.70%	0.17%	0.09%	0.01%	0.07%
Kuwait		0.57%	0.70%	0.14%	0.09%	0.01%	0.03%
Oman		0.59%	0.68%	0.10%	0.09%	0.02%	-0.01%
Qatar		0.60%	0.68%	0.08%	0.09%	0.02%	-0.03%
Saudi Arabia		0.36%	0.51%	0.14%	0.08%	0.01%	0.05%
United Arab Emirates		0.54%	0.63%	0.09%	0.09%	0.01%	-0.01%

- Changes are typically spread across the three modelling components.
- Note that in the countries with largest changes (Jordan, Saudi Arabia), have relatively larger percentage of the change attributed to CCT.

Geographical Component Attribution

- PD output for a specific country draws as much as possible upon EDF data from that country. Because the data is finite, however, inference is drawn from broader country group, region, and world.

- We can therefore think of the output of the PD Converter for a specific country/industry/rating combination as a function of the EDF data from these four different geographic regions:

$$PD_{Rating,C,I} = f(Data_{Country}, Data_{CtryGroup}, Data_{Region}, Data_{World})$$

Geographical Component Attribution

$$PD_{Rating,C,I} = f(Data_{Country}, Data_{CtryGroup}, Data_{Region}, Data_{World})$$

» The **Geographical Attribution** attributes the change in PD to data across these four geographical areas:

1. **Country**: How would PD output have changed if we had used 2018Q2 data for Country X, but 2018Q1 data for all other geographical areas?
2. **Country Group**: How would PD output have *further* changed if we had used 2018Q2 data for Country X's Country Group, but 2018Q1 for all other geographical areas?
3. **Broad Region**: How would PD output have *further* changed if we had used 2018Q2 data for Country X's Broad Region, but 2018Q1 for all other geographical areas?
4. **Global**: How would PD output have *further* changed if we had used 2018Q2 data for the entire globe?

Geographical Component Attribution Example

	Date of Data for Country	Date of Data for Country Group (excluding Country)	Date of Data for Region (excluding Country Group)	Date of Data for World (excluding Region)	Recalibrated PD Convert Output	Change Attribution
2018 Q1 Output	2018 Q1	2018 Q1	2018 Q1	2018 Q1	0.44%	
Country Attribution	2018 Q2	2018 Q1	2018 Q1	2018 Q1	0.47%	+ 0.03%
Country Group Attribution	2018 Q2	2018 Q2	2018 Q1	2018 Q1	0.49%	+ 0.02%
Regional Attribution	2018 Q2	2018 Q2	2018 Q2	2018 Q1	0.50%	+ 0.01%
Global Attribution/ 2018 Q2 Output	2018 Q2	2018 Q2	2018 Q2	2018 Q2	0.49%	- 0.01%

- Note that he sum of the change attribution values is equal to the change between the 2018 Q1 Output (0.44%) and the 2018 Q2 Output (0.49%)

Geographical Component Attribution Example

2018Q2-2018Q3 Change for Baa3 Firms in Middle East Country Group
(Aggregated Across Industry)

		Default Probability			Geographical Attribution			
Country	Industry	Old PD	New PD	Change in PD	Country	Country Group	Broad Region	Global
Bahrain		0.48%	0.58%	0.09%	-0.02%	0.01%	0.06%	0.04%
Jordan		0.53%	0.70%	0.17%	0.06%	0.01%	0.06%	0.04%
Kuwait		0.57%	0.70%	0.14%	0.03%	0.01%	0.06%	0.04%
Oman		0.59%	0.68%	0.10%	-0.01%	0.01%	0.06%	0.04%
Qatar		0.60%	0.68%	0.08%	-0.04%	0.02%	0.06%	0.04%
Saudi Arabia		0.36%	0.51%	0.14%	0.04%	0.00%	0.06%	0.04%
United Arab Emirates		0.54%	0.63%	0.09%	-0.02%	0.01%	0.06%	0.04%

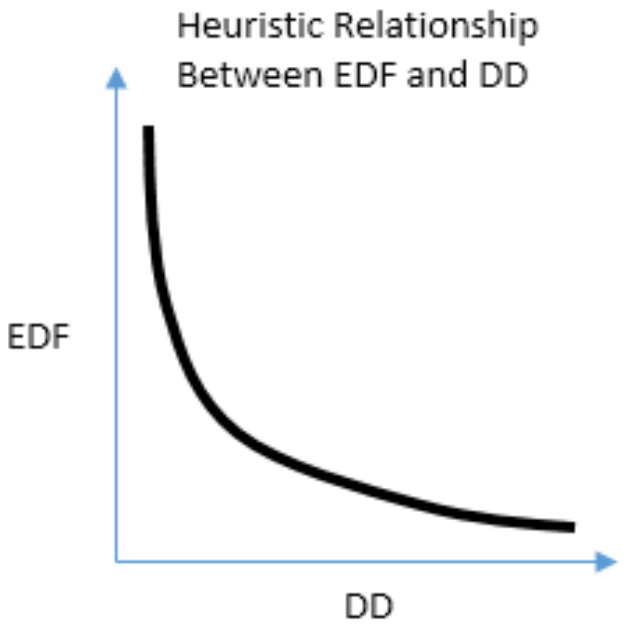
- The more data available in the country and the more the country effect varies from the broader country group or region, the larger the attribution to the country itself.

- Note that this breakdown is in many ways related to the Model Component Attribution, based on the geographical breakdowns in modelling

Risk Factor Attribution

- The PD Converter is calibrated on CreditEdge EDF data. CreditEdge EDF is a Merton-type structural model of default probability. EDF for a specific firm is a function of the "Distance to Default", or how many standard deviations Asset Value must fall to reach the default point.

$$EDF_i = f(DD_i)$$



Risk Factor Attribution

» Distance-to-Default can be roughly split in two parts:

1. **The Inverse of Leverage**: How far in absolute terms asset value can fall before it reaches the default point (the default point being a function of debt).

2. **Asset Volatility**: A measure of the average size of asset value shocks

$$EDF_i = f(DD_i) \approx f\left(\frac{1/Leverage_i}{Asset\ Volatility_i}\right)$$

Risk Factor Attribution

- Since Leverage in this instance is defined as Default Point divided by Equity Value:

$$EDF_i \approx f\left(\frac{1/Leverage_i}{Asset\ Volatility_i}\right) \approx f\left(\frac{\frac{Equity\ Value_i}{Default\ Point_i}}{Asset\ Volatility_i}\right)$$

- For Risk Factor Attribution, we will attribute the total change in PD converter output to changes in these three risk drivers of the underlying EDF.

Risk Factor Attribution

- Interpreting each Risk Factor:
  - **Equity Value:** Indicates broader credit conditions in a country or region by reflecting how investors are valuing the ownership of firms
    - Equity values are derived from firm's daily stock prices
  - **Default Point:** Indicates broader credit conditions in a country or region by reflecting how leveraged the average firm in the industry is
    - The default point is a function of the firm's liabilities from their financial statements, and incorporates the cost of borrowing
  - **Asset Volatility:** Indicates broader credit conditions in a country or region by reflecting how much uncertainty or risk there is in firm valuation
    - Asset volatilities are derived from the recent volatility in equity value of the underlying firms

Risk Factor Attribution Example

» Similar to the Geographical Attribution, we recalculate PD Converter output through a mixture of last period risk factor values and new period risk factor values.

	Date of Data for Equity Values	Date of Data for Default Point	Date of Data for Asset Volatility	Recalibrated PD Convert Output	Change Attribution
2018 Q1 Output	2018 Q1	2018 Q1	2018 Q1	0.44%	
Equity Value Attribution	2018 Q2	2018 Q1	2018 Q1	0.49%	+ 0.05%
Default Point Attribution	2018 Q1	2018 Q2	2018 Q1	0.43%	- 0.01%
Asset Volatility Attribution	2018 Q1	2018 Q1	2018 Q2	0.45%	+ 0.01%
2018 Q2 Output	2018 Q2	2018 Q2	2018 Q2	0.49%	

» Note that unlike Geographical Attribution, we do not perform this exercise sequentially. This is due to interactions between the risk factors in the EDF calculation. These interactions also mean the sum of the partial PD changes in this exercise will not always equal the total change in PD. In the tool, for ease of interpretation we allocate the residual change to preserve the equal summation.

Risk Factor Attribution Example

2018Q2-2018Q3 Change for Baa3 Firms in Middle East Country Group
(Aggregated Across Industry)

		Default Probability			Risk Factor Attribution		
Country	Industry	Old PD	New PD	Change in PD	Equity Value	Default Point	Asset Volatility
Bahrain		0.48%	0.58%	0.09%	0.02%	0.00%	0.07%
Jordan		0.53%	0.70%	0.17%	0.05%	0.04%	0.09%
Kuwait		0.57%	0.70%	0.14%	0.01%	0.00%	0.12%
Oman		0.59%	0.68%	0.10%	0.03%	-0.02%	0.09%
Qatar		0.60%	0.68%	0.08%	0.02%	-0.01%	0.07%
Saudi Arabia		0.36%	0.51%	0.14%	0.05%	0.02%	0.07%
United Arab Emirates		0.54%	0.63%	0.09%	0.05%	0.00%	0.05%

- All three factors affect PD output, but typically the strongest is change in Equity Value (although for the Middle East in this period an increase in Asset Volatility was a major driver of PD increase).

- On a country-wide level, this intuitively makes sense as, quarter-on-quarter, we would not expect to see extreme changes in Default Points and Asset Volatilities except in special cases.

Full Example

2018Q2-2018Q3 Change for Baa3 Firms (Aggregated Across Industry)

		Default Probability			Model Component Attribution			Geographical Attribution				Risk Factor Attribution		
Country	Industry	Old PD	New PD	Change in PD	Base	ICT	CCT	Country	Country Group	Broad Region	Global	Equity Value	Default Point	Asset Volatility
Turkey		0.70%	1.12%	0.42%	0.11%	0.05%	0.26%	0.22%	0.02%	0.11%	0.06%	0.21%	0.12%	0.09%

- We see that there was a 0.42% increase in Turkey's average Baa3 PITPD between 2018 Q2 and 2018 Q3
- On a Model Component Level, more than half of this was attributable to the CCT, indicating that that the risk is being driven by changes in Turkey and/or the South Asia country group.
- On a Geographical Level we see that the country is the largest driver of the PD change.
- Finally, in the Risk Factor Attribution, we see that change in the equity values of firms is the strongest risk driver.

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Additional Content in Tool

Number of Firms in Data by Country and Industry

- The tool displays the number of firms in each Country, Industry, Country Group, and Region
- This data gives users a sense of the depth of data in a particular region.
- Note that countries with no observations in the CreditEdge universe are shown in italics in this and other tabs.

		Total Number of Firms			Number of Rated Firms		
Country	Industry	Country (Total)	Country Group (Total)	Broad Region (Total)	Country (Rated)	Country Group (Rated)	Broad Region (Rated)
Bahrain		32	728	20220	5	69	645
Jordan		168	728	20220	2	69	645
Kuwait		151	728	20220	13	69	645
Oman		70	728	20220	8	69	645
Qatar		43	728	20220	9	69	645
Saudi Arabia		174	728	20220	15	69	645
United Arab Emirates		90	728	20220	17	69	645

Geographical Breakdown of CCT and ICT

- The CCT term is calculated as a weighted average of data from an individual country and its country group. The more data in the country, the higher weight on that country. The tool provides the percentage weights on country and country group for CCT.

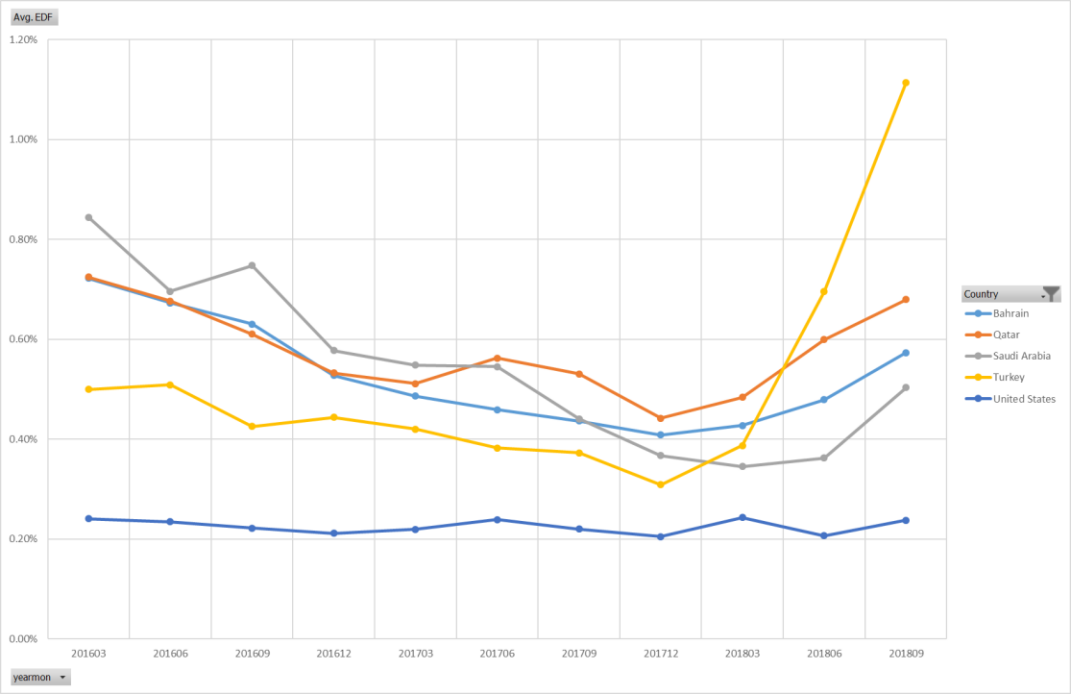
- The ICT term is likewise calculated as the weighted average of data from the country group and region (within the relative industry). The tool also provides this breakdown, additionally breaking out the percentage of data from the country with the country group.

		CCT Makeup		ICT Makeup		
Country	**Industry**	**CCT (Country)**	**CCT (CG)**	**ICT (Country)**	**ICT (CG)**	**ICT (Region)**
Bahrain		63%	37%	1%	28%	71%
Jordan		92%	8%	7%	22%	71%
Kuwait		91%	9%	6%	23%	71%
Oman		80%	20%	3%	26%	71%
Qatar		70%	30%	2%	28%	71%
Saudi Arabia		92%	8%	7%	22%	71%
United Arab Emirates		84%	16%	3%	26%	71%

Historical Trend of PD Output

- Finally, the tool provides graphical output of the average PD output for each country over the last 12 quarters.

- Users can change the rating to be graphed, and compare across countries. They can also pick out the specific industries to be graphed.



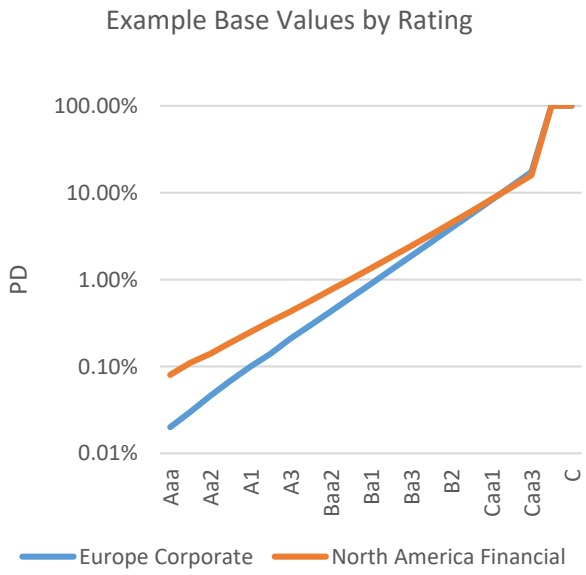
D

Appendices

Understanding the Model Component Attribution

$$PD_{Rating,C,I} = Base_{Rating,Region} + ICT_I + CCT_C$$

1. **Base Model:** Calibrates the relationship between rating and point-in-time PD on a broad geographical and industry basis
   - Overall Level of PD is allowed to vary by broad region (NA, Europe, Japan, and Rest of World) and broad industry (corporates, financials)
   - Slope of PD vs Rating relationship is allow to vary globally by broad industry (corporates, financials)



Understanding the Model Component Attribution

$$PD_{Rating,C,I} = Base_{Rating,Region} + ICT_I + CCT_C$$

2. **Industry Credit Trend:** Measures the state of each of the 61 industries in the business cycle, by comparing average EDFs of firms in that industry against their 3 year moving average

   - Because of the fine industry granularity, the ICT is calculated on the country group level (rather than varying by individual country within the country group).

   - Due to ICT being fixed within country group, when looking at PD changes aggregated on country level, ICT can indicate overall (non-industry specific) change in country group credit-conditions.

Understanding the Model Component Attribution

$$PD_{Rating,C,I} = Base_{Rating,Region} + ICT_I + CCT_C$$

3. **Country Credit Trend:** Measures the state of each of country relative to the business cycle, by comparing average EDFs of firms in that industry against their three-year moving average

   - Where the number of firms with EDFs in the country is low, additional data from the wider country group is used in calculating CCT. The more firms in the country, the higher the weight on the country EDF data (see slide 30 for more information).

Understanding Risk Factor Attribution

» We split the change in EDF for each firm into the change in these 3 risk components:

1. **Equity Value Change:** Reflects the change in Equity Value for the firm, which increase Asset Value and, as an effect, reduces leverage.
   - This indicates broader credit conditions in a country or region by reflecting how investors are valuing the ownership of firms (equity values are derived from firm's daily stock prices).
   - The higher firms are valued, the more buffer they have against negative shocks, and the lower the likelihood of default.
   - An **increase in Equity Value** will result in a **decrease in the firm's EDF**.

Understanding Risk Factor Attribution

» We split the change in EDF for each firm into the change in these 3 risk components:

2. **Default Point Change:** Reflects the change in Default Point for the firm, which increase the leverage of the firm:
   - This indicates broader credit conditions in a country or region by reflecting how leveraged the average firm in the industry is (the default point is a function of the firm's liabilities from their financial statements).
   - Because interest rates and borrowing costs are included in the default point, this also illustrates changes in the cost of debt servicing.
   - An **increase in the Default Point** will result in **an increase in the firm's EDF**.

Understanding Risk Factor Attribution

» We split the change in EDF for each firm into the change in these 3 risk components:

3. **Asset Volatility Change:** Reflects the change in the expectation of asset volatility for an individual firm in the next year.
   - This indicates broader credit conditions in a country or region by reflecting how much uncertainty or risk there is in firm valuation (these asset volatilities are derived from the recent volatility in equity value of the underlying firms).
   - Since negative shocks in asset value is what leads to defaults, and this is important for predicting default risk in a country or industry.
   - An **increase in the firm's Asset Volatility** will result in an **increase in the firm's EDF**.

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