SAS® FORUM
UNITED KINGDOM 2016
28th September

Macro Econometric IFRS9 and Stress Test models using Survival Analysis

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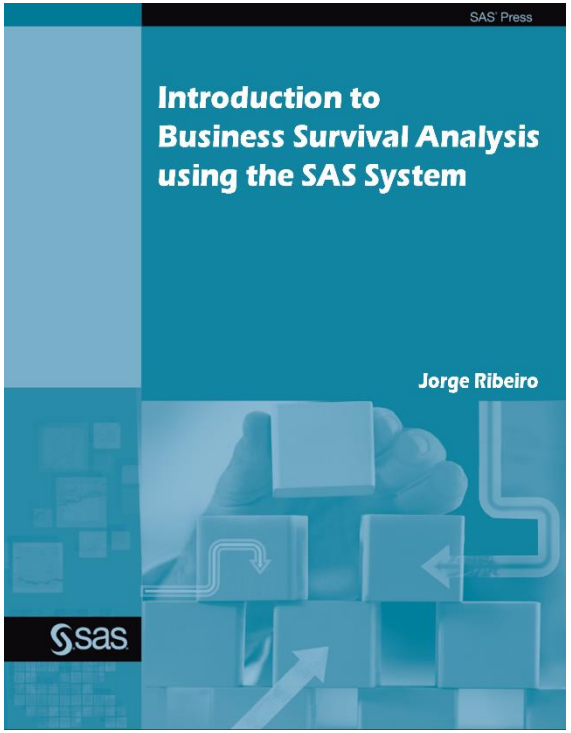
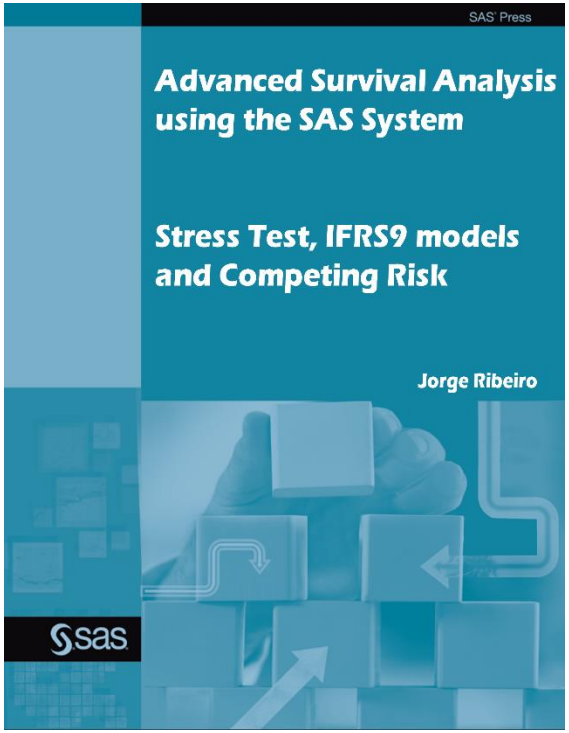
New SAS Books ❶

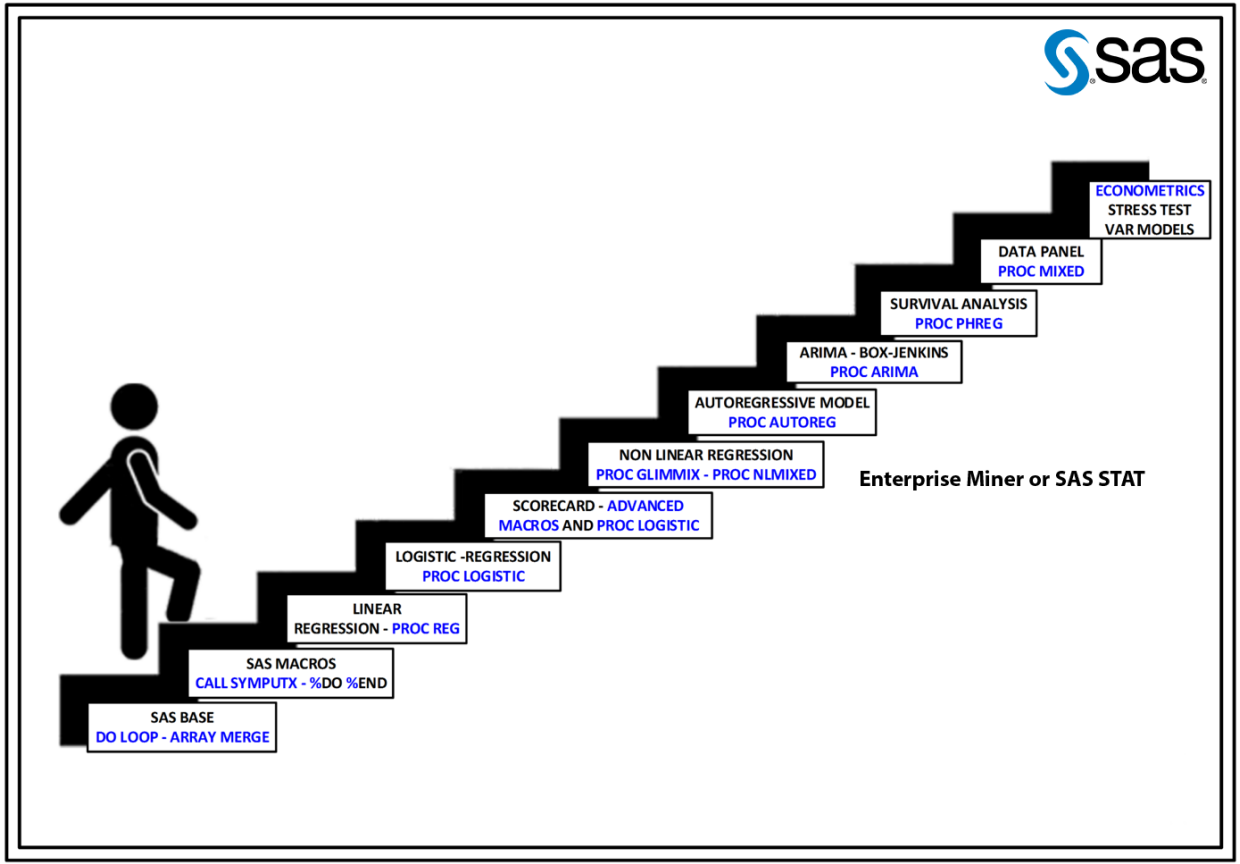


November 2016

❷



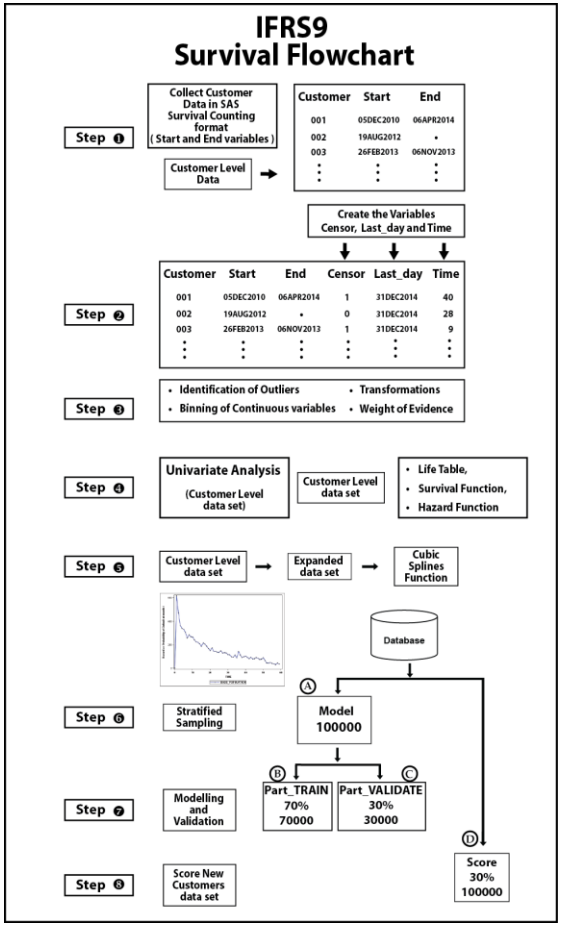
March 2017



Model – IFRS9

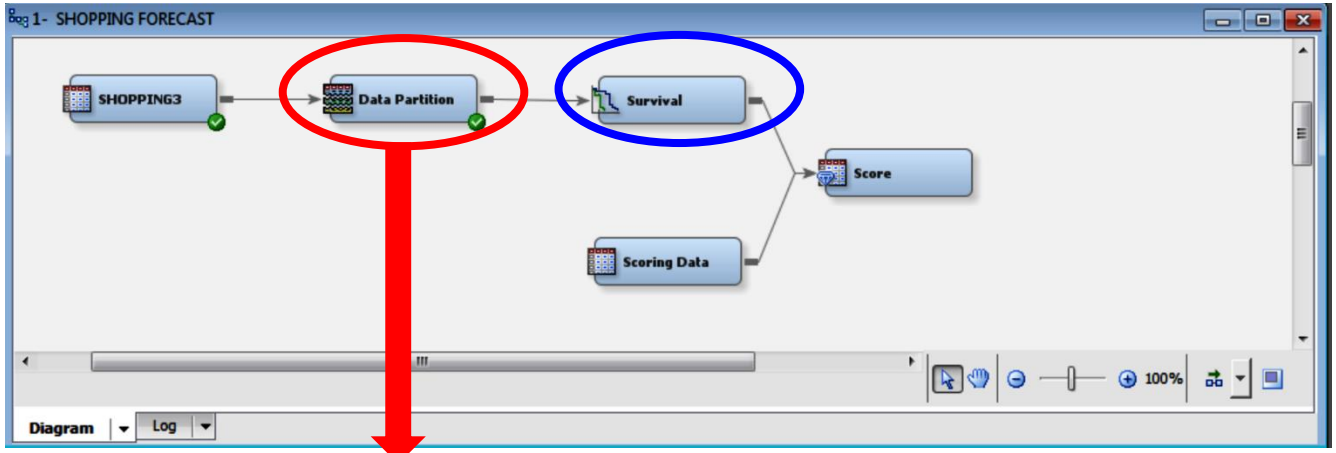
Steps Plan

“People are much more likely to get on a bus if they know where it is going”.

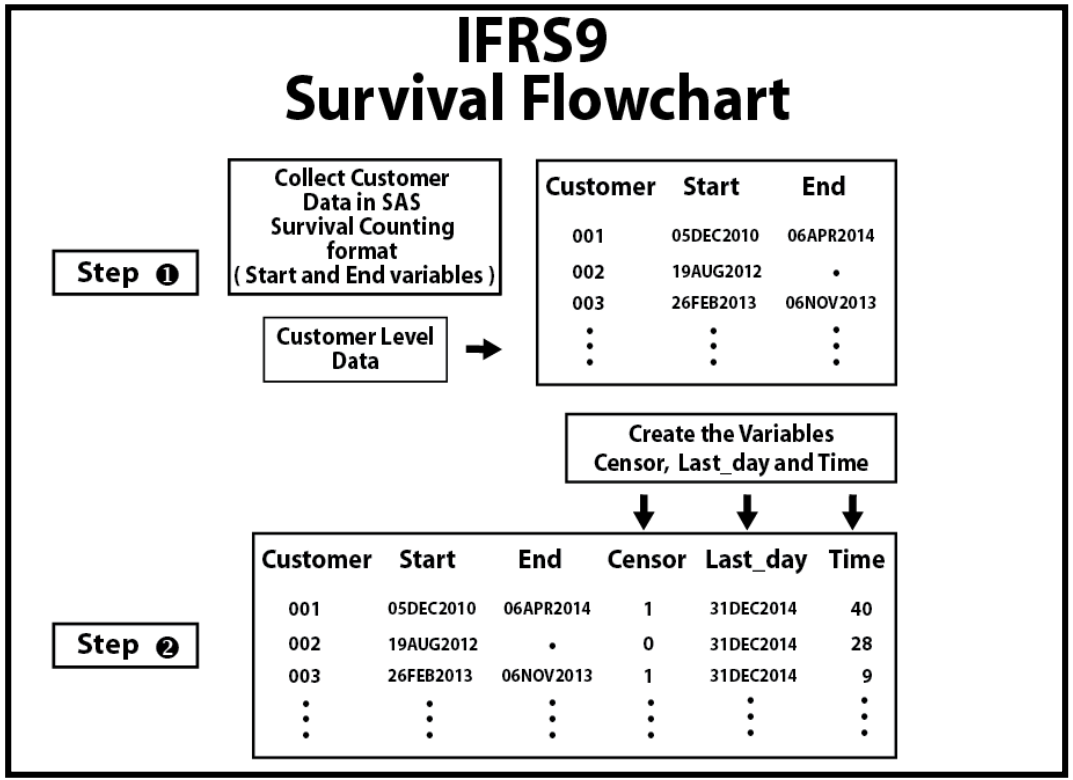


Enterprise Miner 14.1

Survival Analysis Node



Model 1 – IFRS9



Step ❸

- Identification of Outliers
- Binning of Continuous variables
- Transformations
- Weight of Evidence

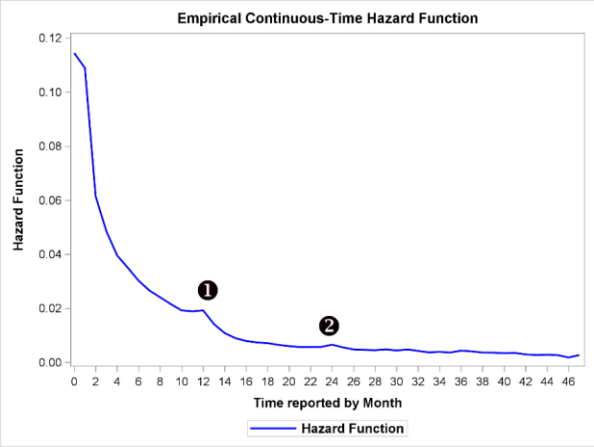
Step ❹

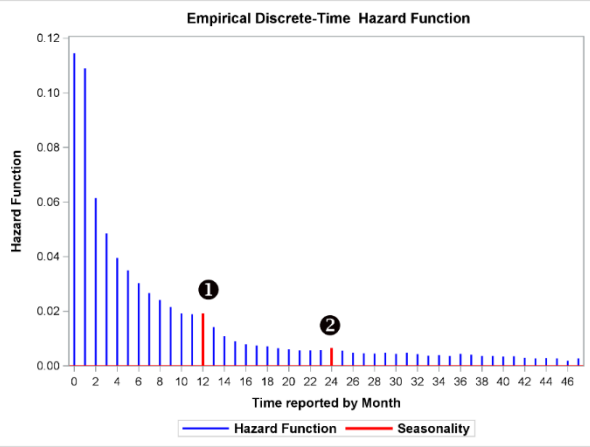
Univariate Analysis

(Customer Level data set)

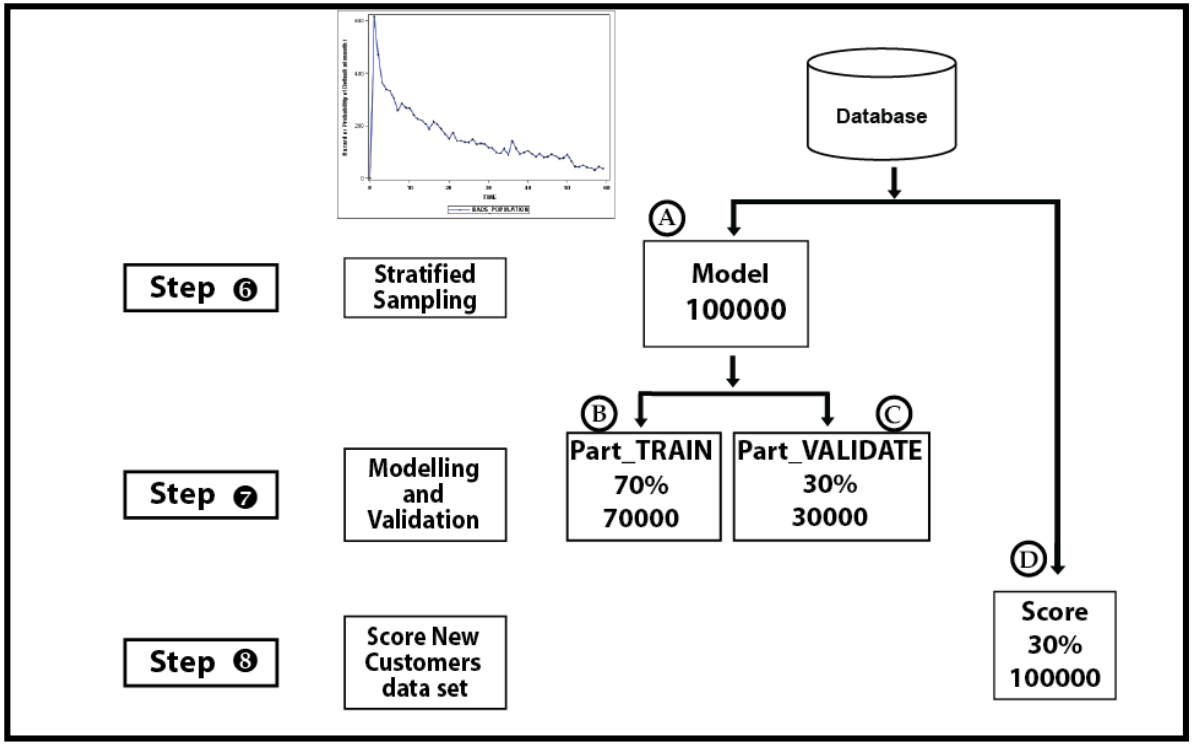
Customer Level data set

- Life Table,
- Survival Function,
- Hazard Function

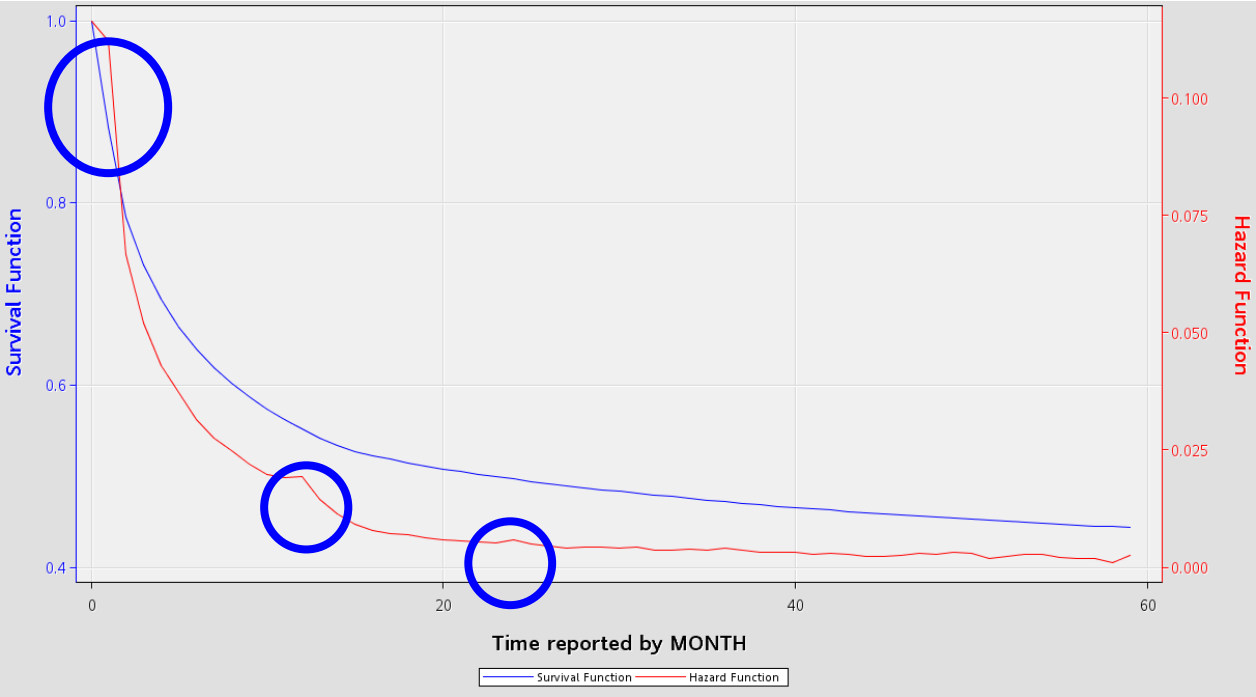




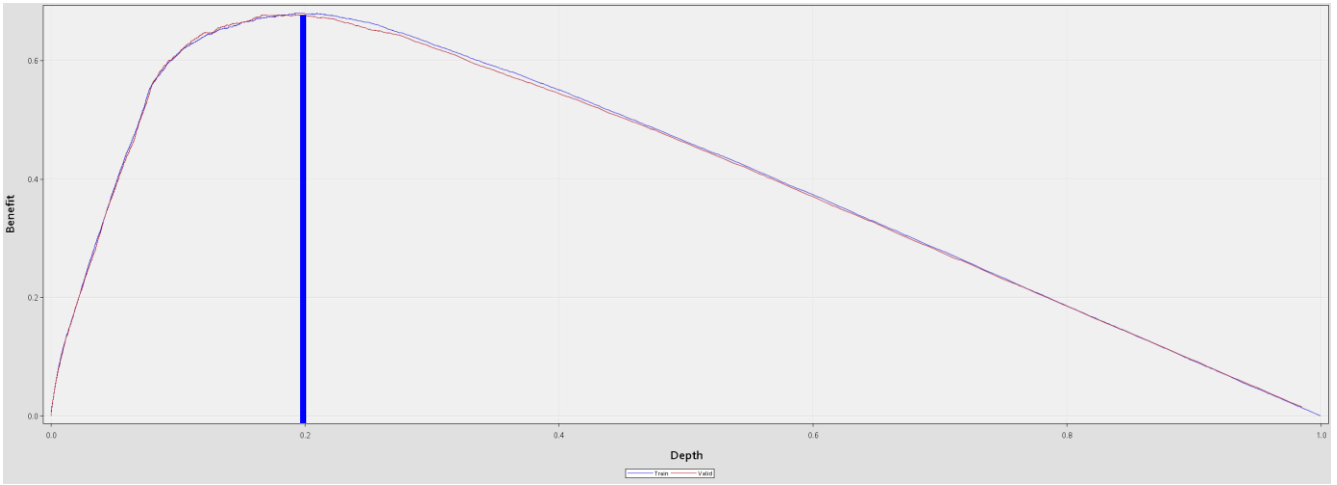
Model – IFRS9



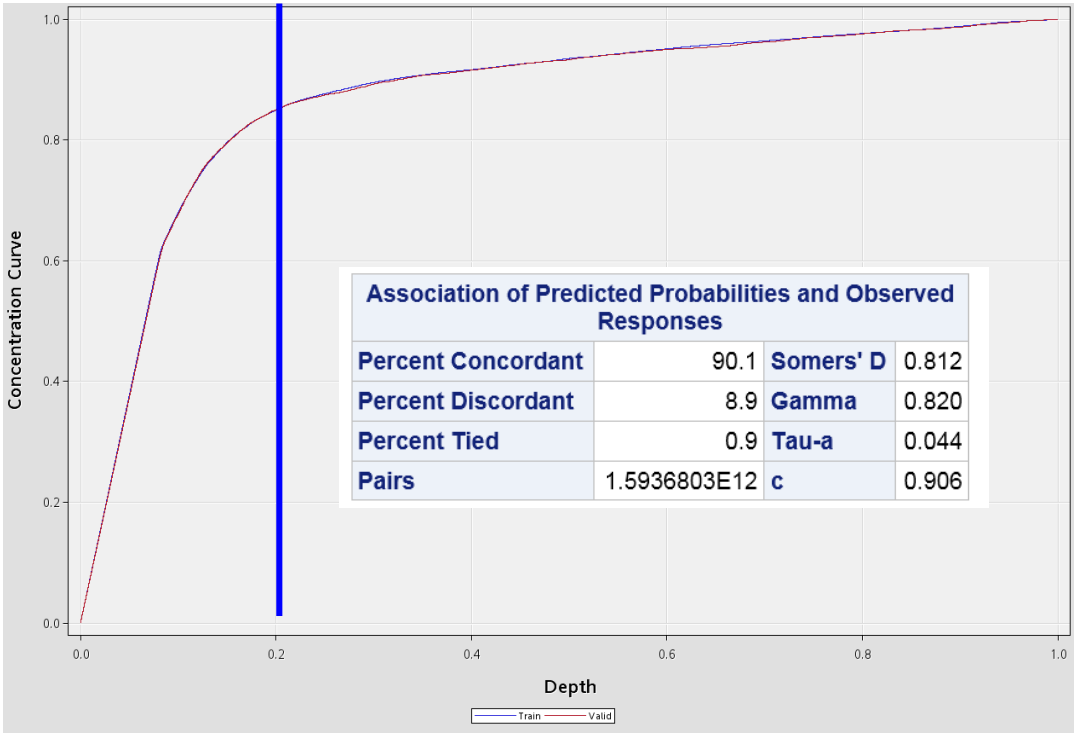
Final Model - Hazard Function



Final Model - Benefit graph

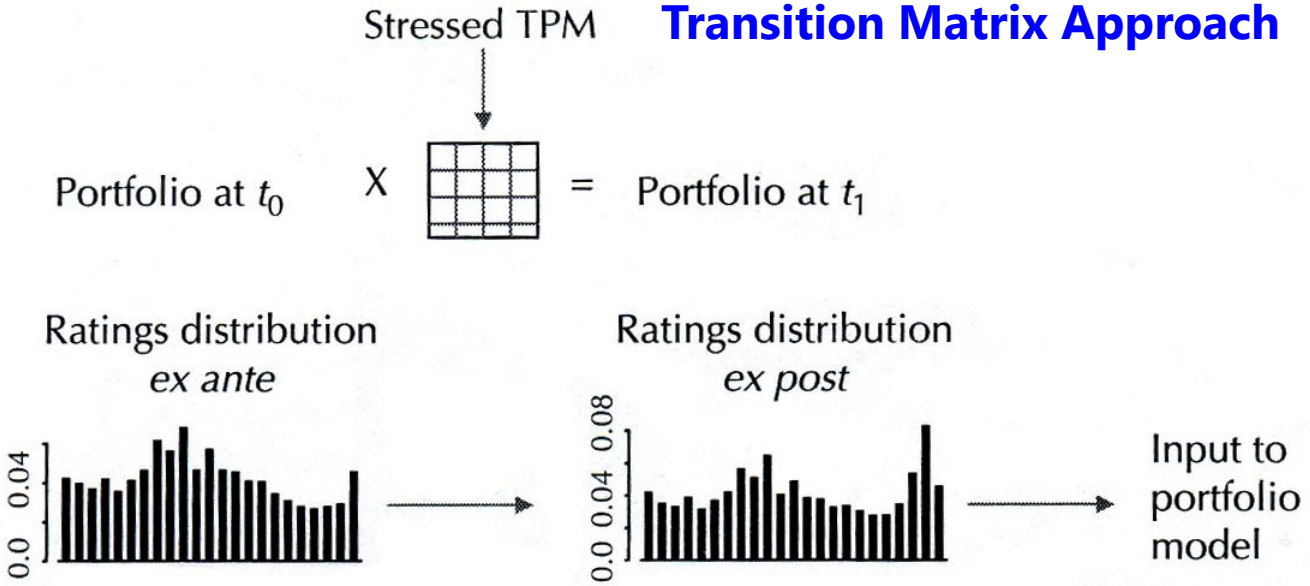


Final Model



Association of Predicted Probabilities and Observed Responses			
Percent Concordant	90.1	Somers' D	0.812
Percent Discordant	8.9	Gamma	0.820
Percent Tied	0.9	Tau-a	0.044
Pairs	1.5936803E12	c	0.906

Model 2 – Stress Test and Scenario Analysis



The central point of the procedure of Stress Testing In Basel II is the change in the risk parameters.

PD – LGD – EAD

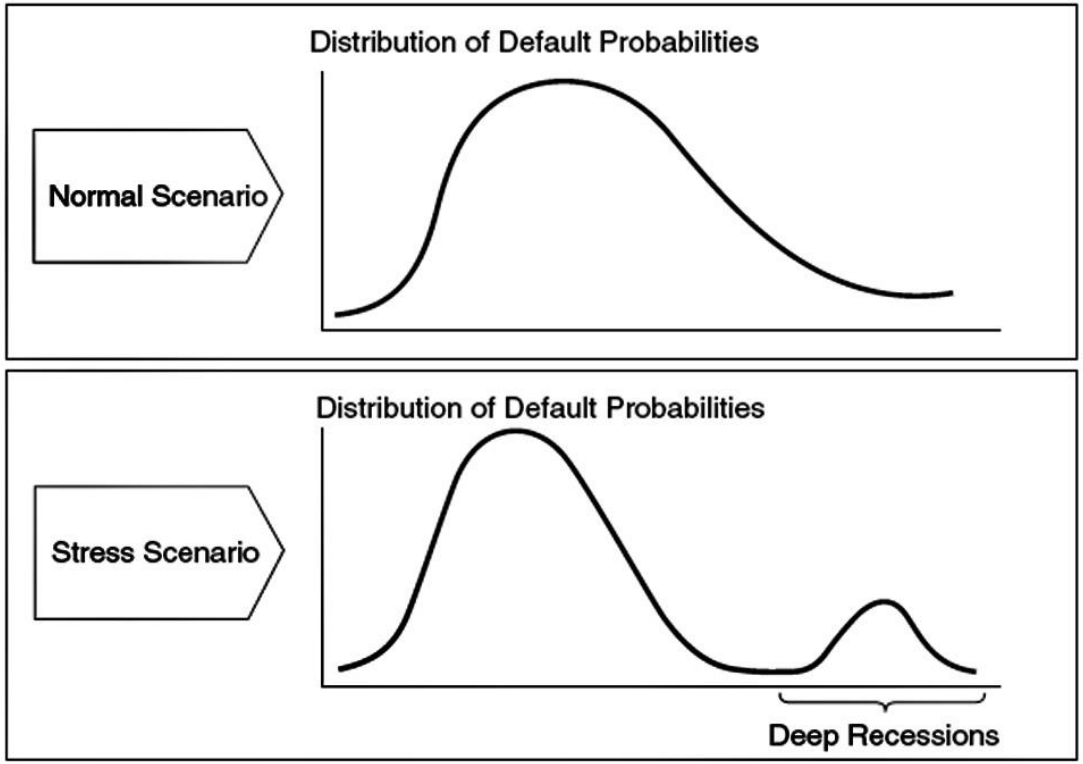
The easiest way to perform is the modification of the risk parameters test and belong to the class of the sensitivity analysis.

The more complex is based in macroeconomic variables using econometrics methods called risk factors.

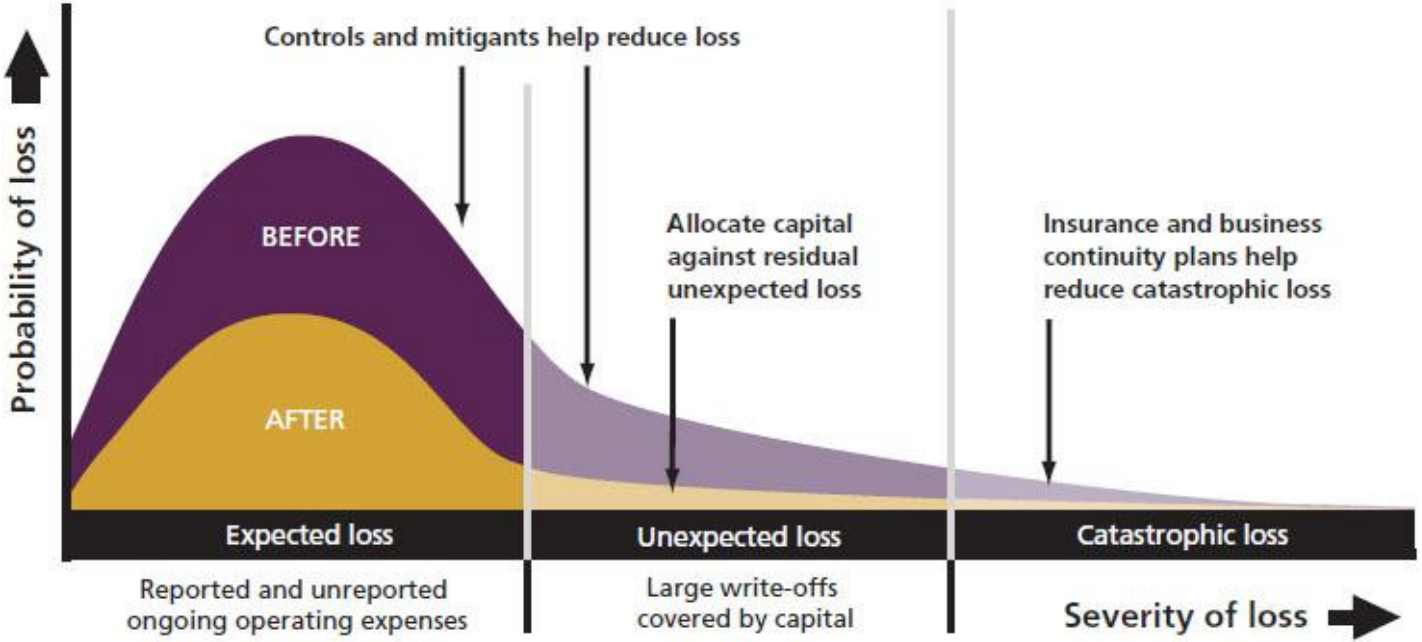
1. Obtain a time series of Macroeconomic variables and historical – PD.

2. Forecast of Macroeconomic variables using ARIMA or VAR (Vector Autoregressive) methods.

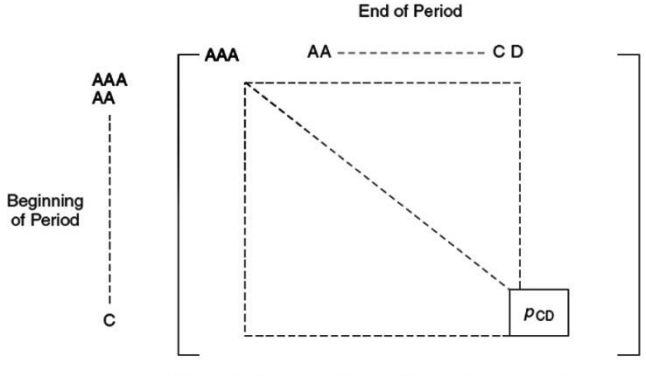
3. Simulate PD over many different possible macroeconomic states of the world to trace out the conditional PD.



Stress tests

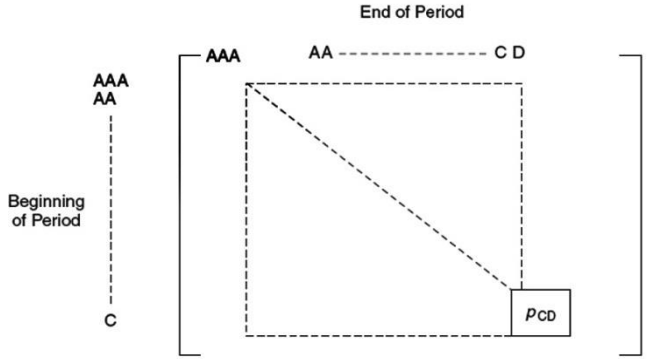


Transition Matrix Approach



Unconditional probabilities

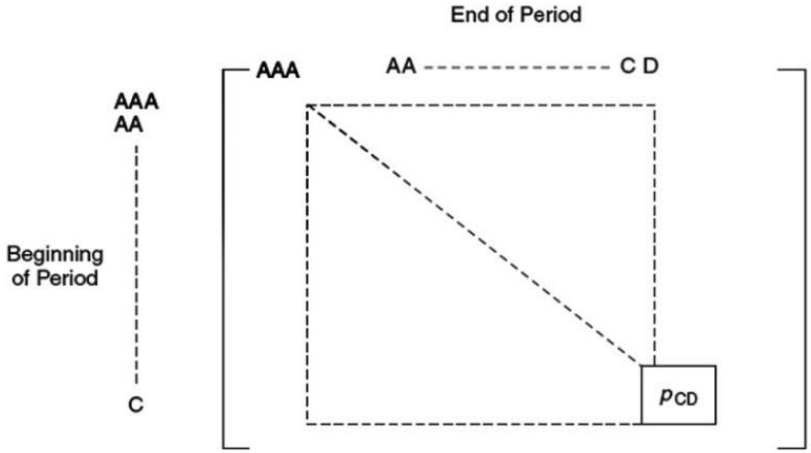
Obtained from historical Probabilities



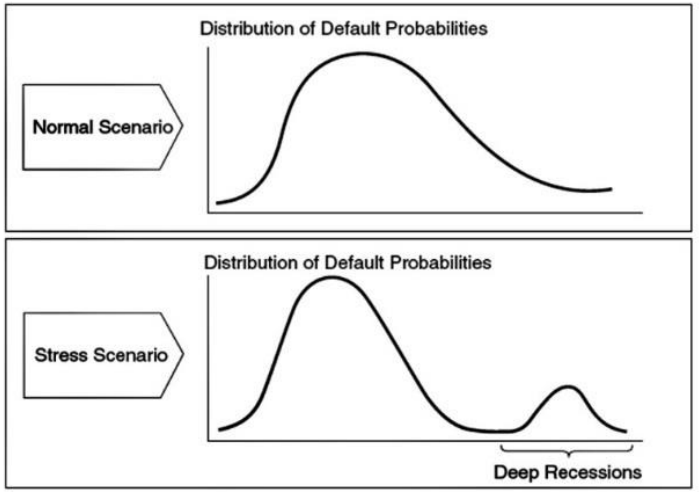
Conditional probabilities

Obtained from macroeconomics stress probabilities

Transition Matrix Approach



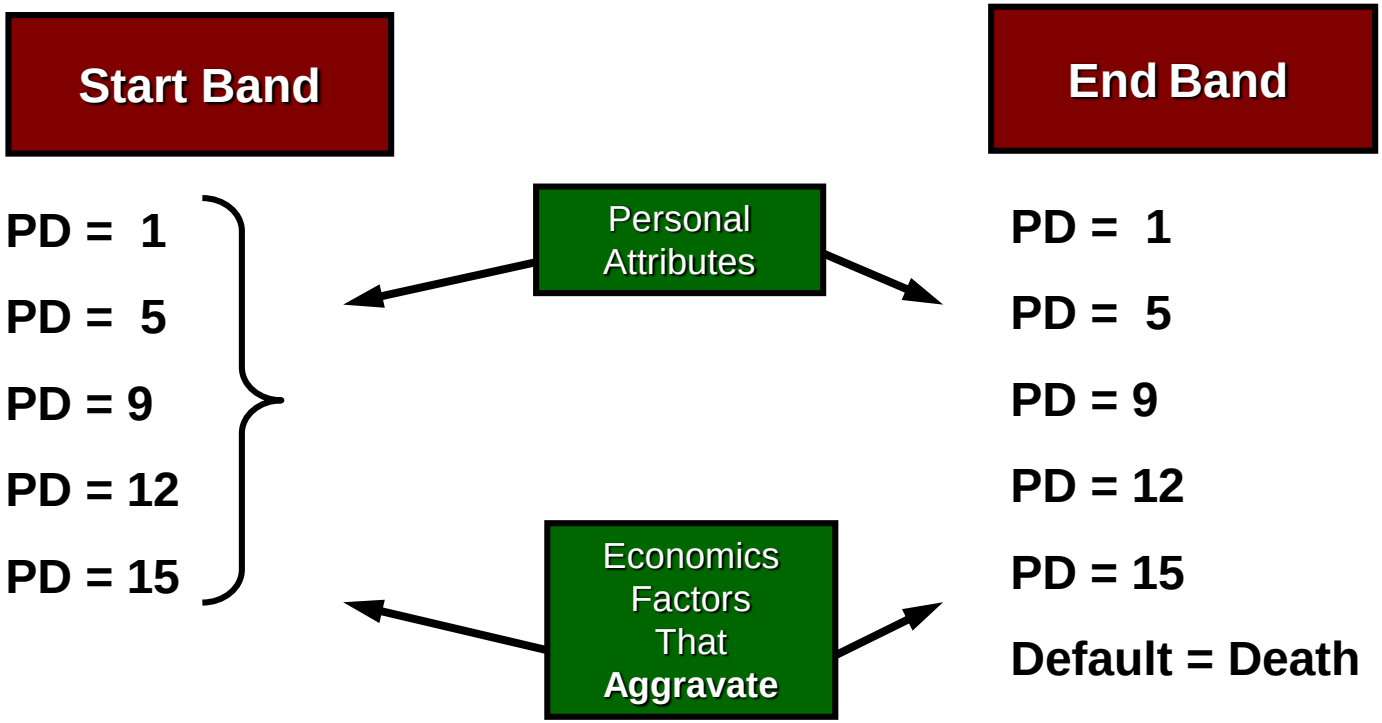
Historical (unconditional) transition matrix.



Stress tests

Band – Survival Model

The Focus is when the customer is going to Default given the Economics



Cox Proportional Hazards Model

$$h_i(t) = h_0(t)e^{\{\beta_1 X_{i1} + \ldots + \beta_k X_{ik}\}}$$

Baseline Hazard function – involves time but not predictor variables

Linear function of a set of predictor variables - does **not** involve time

Band – Survival Model

Step ❸

Modelling
PROC PHREG

```
PROC    PHREG DATA = MODEL COVSANDWICH(AGGREGATE);
CLASS   BAND;
MODEL  (START,END)*DEFAULT(0)= BAND  P1GDP UNEMPLOYMENT;
ID      CUSTOMER_ID;
HAZARDRATIO BAND          / DIFF=REF;
HAZARDRATIO P1GDP         / UNITS = 1 2 3 5;
HAZARDRATIO UNEMPLOYMENT  / UNITS = 1 2 3 5;
RUN;
```

PD_Band	Band
1 to 5	1
6 to 11	5
12 to 16	09
17 to 18	12
19 to 20	15

Customer Information

Economic variables

SAS Results

Output 1

The PHREG Procedure

Model Information	
Data Set	MODEL_2_ECON_VARIABLES
Dependent Variable	start
Dependent Variable	end
Censoring Variable	default
Censoring Value(s)	0
Ties Handling	BRESLOW

Output 2

Class Level Information					
Class	Value	Design Variables			
BAND	01	1	0	0	0
	05	0	1	0	0
	09	0	0	1	0
	12	0	0	0	1
	15	0	0	0	0

Output 3

Summary of the Number of Event and Censored Values			
Total	Event	Censored	Percent Censored
225974	1591	224383	99.30

Output 4

Model Fit Statistics		
Criterion	Without Covariates	With Covariates
-2 LOG L	29997.459	29402.838
AIC	29997.459	29414.838
SBC	29997.459	29447.071

Interpretation

For each 1 unit increase in the GDP, the Hazard of Default goes down by an estimated 16.7 %.

Output 5

Analysis of Maximum Likelihood Estimates

Parameter		DF	Parameter Estimate	Standard Error	StdErr Ratio	Chi-Square	Pr > ChiSq	Hazard Ratio	Label
BAND	01	1	-2.44279	0.18225	1.005	179.6585	<.0001	0.087	BAND 01
BAND	05	1	-2.19326	0.15439	1.006	201.8149	<.0001	0.112	BAND 05
BAND	09	1	-1.80172	0.14526	1.000	153.8457	<.0001	0.165	BAND 09
BAND	12	1	-1.36423	0.14663	1.003	86.5596	<.0001	0.256	BAND 12
P1GDP		1	-0.18257	0.01228	0.993	220.9088	<.0001	0.833	
Unemployment		1	0.22684	0.02464	1.013	84.7693	<.0001	1.255	

$$e^{-0.18257} = 0.833$$

$$100*(0.833-1) = -16.7\%$$

Interpretation

For each 1 unit increase in the GDP, the Hazard of Default goes down by an estimated 16.7 %.

Output 5

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Unemployment		1	0.22684	0.02464	1.013	84.7693	<.0001	1.255	

$$e^{0.22684} = 1.255$$

$$100 * (1.255 - 1) = 25.5\%$$

A customer in the Band 01 has a ONLY 8.7% the risk of Default (or - 91.3%) compared to a customer in the Band 15 (the reference Band).

Output 5

Analysis of Maximum Likelihood Estimates

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$$e^{-2.44279} = 0.087$$

$$100 * (0.087 - 1) = -91.3\%$$

$$\frac{\text{HAZARD RATIO (BAND} = 01)}{\text{HAZARD RATIO (BAND} = 15)} = 0.087$$

A customer in the Band 01 has a ONLY 8.7% the risk of Default (or - 91.3%) compared to a customer in the Band 15 (the reference Band).

Output 6

```
HAZARDRATIO BAND / DIFF=REF;
```

Hazard Ratios for BAND			
Description	Point Estimate	95% Wald Robust Confidence Limits	
BAND 01 vs 15	0.087	0.061	0.124
BAND 05 vs 15	0.112	0.082	0.151
BAND 09 vs 15	0.165	0.124	0.219
BAND 12 vs 15	0.256	0.192	0.341

$$\frac{\text{HAZARD RATIO (BAND = 01)}}{\text{HAZARD RATIO (BAND = 15)}} = 0.087$$

$$100 * (0.087 - 1) = -91.3\%$$

```
PROC    PHREG DATA = MODEL COVSANDWICH(AGGREGATE);
CLASS   BAND (PARAM=REF REF='15') ;
MODEL (START,END)*DEFAULT(0) = BAND P1GDP UNEMPLOYMENT;
ID      CUSTOMER_ID;
HAZARDRATIO P1GDP / UNITS = 1 2 3 5;
HAZARDRATIOUNEMPLOYMENT / UNITS = 1 2 3 5;
RUN;
```

Output 7

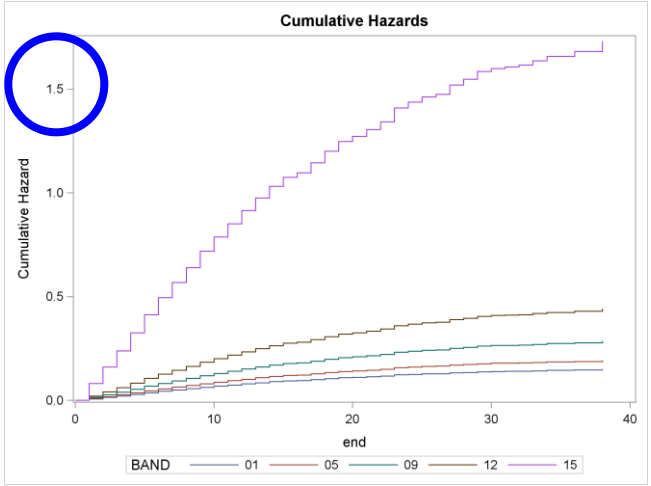
Hazard Ratios for P1GDP			
Description	Point Estimate	95% Wald Robust Confidence Limits	
P1GDP Unit=1	0.833	0.813	0.853
P1GDP Unit=2	0.694	0.661	0.728
P1GDP Unit=3	0.578	0.538	0.622
P1GDP Unit=5	0.401	0.356	0.453

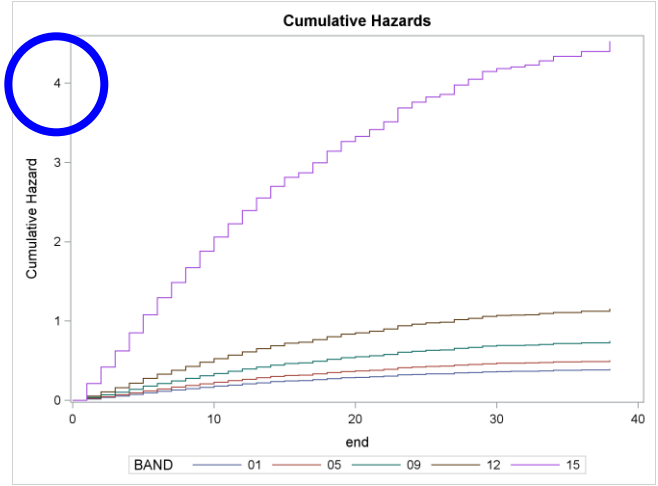
$100*(0.694-1) = -30.6\%$

$100*(0.578-1) = -42.2\%$

$100*(0.401-1) = -59.9\%$

Hazard Function





Scenario Analysis 1

P1GDP=**1.1**;

Unemployment = **6**;

Scenario Analysis 2

P1GDP=**0.8**;

Unemployment = **10**;

Forecast and Stressed PD

Step ❺

Compute the Survival function

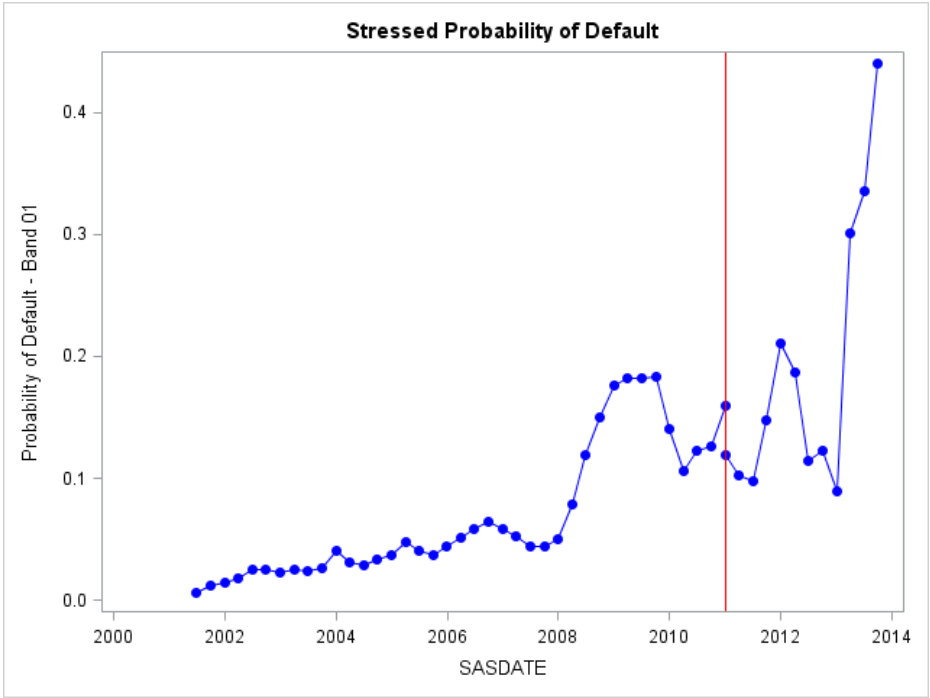
Obs	customer_id	TIME	BAND	P1GDP	Unemployment	PD_BAND01	PD_BAND05	SASDATE	Baseline	Survival_BY_hand	PD
1	811640	40	01	1.1	5.2	1	0	2011Q1	0.57750	0.88074	0.11926
2	811640	41	01	0.9	4.3	1	0	2011Q2	0.57388	0.89707	0.10293
3	811640	42	01	1.5	4.5	1	0	2011Q3	0.57038	0.90213	0.09787
4	811640	43	01	0.5	5.6	1	0	2011Q4	0.56699	0.85185	0.14815
5	811640	44	01	-0.2	6.7	1	0	2012Q1	0.56371	0.78960	0.21040
6	811640	45	01	1.2	7.2	1	0	2012Q2	0.56054	0.81307	0.18693
7	811640	46	01	0.8	4.5	1	0	2012Q3	0.55748	0.88532	0.11468
8	811640	47	01	1.8	5.6	1	0	2012Q4	0.55452	0.87685	0.12315
9	811640	48	01	4.3	6.1	1	0	2013Q1	0.55166	0.91021	0.08979
10	811640	49	01	-0.5	8.1	1	0	2013Q2	0.54889	0.69856	0.30144
11	811640	50	01	1.2	10.0	1	0	2013Q3	0.54622	0.66497	0.33503
12	811640	51	01	1.8	12.0	1	0	2013Q4	0.54364	0.55983	0.44017

Forecast and Stressed PD

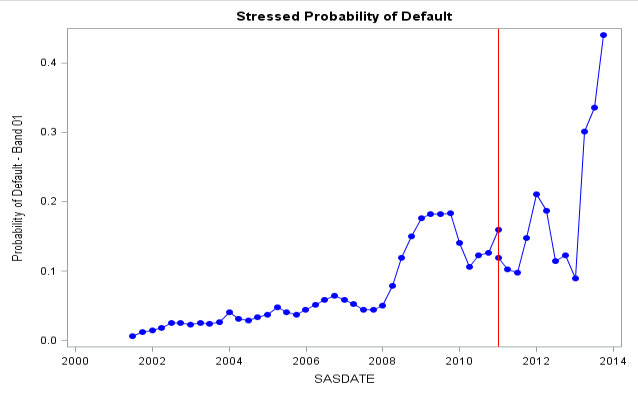
Step ⑥

Compute the Probability of Default for each customer

P1GDP	Unemployment	PD
1.1	5.2	0.11926
0.9	4.3	0.10293
1.5	4.5	0.09787
0.5	5.6	0.14815
-0.2	6.7	0.21040
1.2	7.2	0.18693
0.8	4.5	0.11468
1.8	5.6	0.12315
4.3	6.1	0.08979
-0.5	8.1	0.30144
1.2	10.0	0.33503
1.8	12.0	0.44017

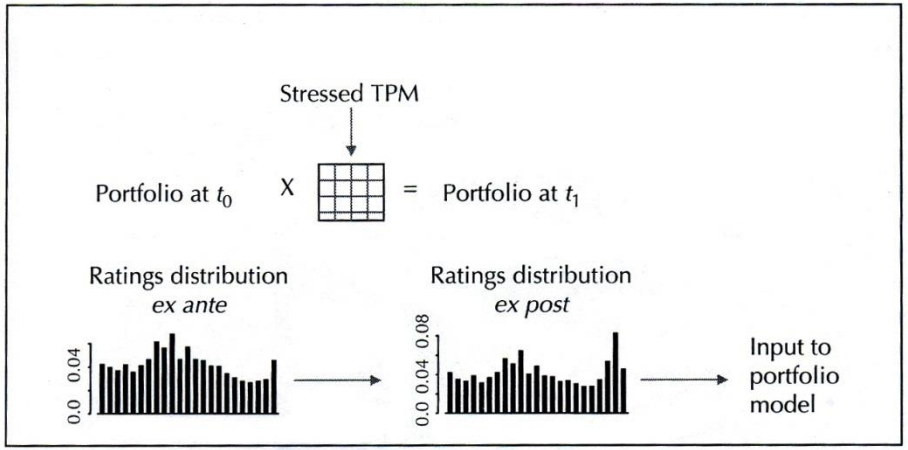


Forecast and Stressed PD



Step ❼

Compute the Conditional Probability of Default for each customer by scenario



Questions

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