

mguchiQ

Model Building Tutorial 4

Multiple Products

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Overview

The objective of this document is to elaborate on the model building process by creating a model that has two products.

In addition to the **Life** product specified previously we will also specify an **Annuity** product that pays a monthly annuity that escalates over time.

The **Instance Variables** required for the **Annuity** product are:

Name	Description
AgeAtInception	Policy holder age at inception, in years
DurationInforce	Number of months the policy is in force
Gender	Whether the policy holder is male or female
Smoker	Whether the policy holder is a smoker or not
Annuity	The monthly annuity payable to the policy holder
AnnuityEscalation	The amount by which the annuity escalates annually.

The **Single Variables** required for the **Annuity** product are:

Name	Description
Expense	The monthly expense incurred to maintain each policy

The **Series Variables** required for the **Annuity** product are:

Name	Description	Index By
Inflation	Forecast inflation rates, for each future time period	Time
Yield	Forecast yield curve, to be used to present value future cash flows	Time

The **Table Variables** required for the **Annuity** product are:

Name	Description	Index By
Qx	Life table, giving the probability of survival for a given policy holder age. We will use a table with 4 columns – the columns representing a combination of gender (male / female) and smoker status (smoker / non-smoker)	Policy Holder Age

Spreadsheet Structure

The spreadsheet structure is as before with the following changes within each sheet:

Model Sheet

There is no change to the **Model** sheet when defining multiple products.

Products Sheet

When declaring multiple products it is often useful to derive actual products from a common **base** product. This **base** product can define all of the variables that are common to all of the products in our model that will inherit from it. We will define a base product called **Global** and derive our **Life** and **Annuity** products from this **Global** product.

We have added some more information on the **Products** sheet to enable us to define the relationship between products:

- **Abstract.** Specifies whether the product is a 'real' product (such as a life policy) or an 'abstract' product (such as Global). Abstract products are not 'real' products, i.e. we cannot have an instance of an abstract product – they are used for convenience when creating our product hierarchy. Products are NOT abstract by default.
- **InheritsFrom.** Specifies which other product a product inherits from. This allows us to specify the relationships between products in our product hierarchy.

We will specify our **Global** product as follows:

- **Name:**

The screenshot shows the 'Global' product definition in the 'Products' sheet. The 'Name' dropdown is set to 'Global'. The 'MaxT' cell (B2) contains the value '948'. The 'Abstract' cell (C2) contains the value 'TRUE'. The 'Inherits From' cell (D2) is empty. The 'Life' and 'Annuity' products are listed in rows 3 and 4, both inheriting from 'Global'.

	A	B	C	D	E	F
1	Product	MaxT	Abstract	Inherits From		
2	Global	948	TRUE			
3	Life			Global		
4	Annuity			Global		
5						
6						

- **MaxT:** By specifying **MaxT** at the **Global** level will mean that any product that inherits from **Global** will use this **MaxT**. Note that we need to prefix **MaxT** with the product name in order to differentiate this **MaxT** definition from any other product **MaxT** definition, thus the name **Global_MaxT**:

The screenshot shows the 'Global_MaxT' formula in the 'Products' sheet. The 'Name' dropdown is set to 'Global_MaxT'. The formula bar shows the formula '=MAX(1,(101-Global_CurrentAge)*12)'. The 'MaxT' cell (B2) contains the value '948'. The 'Abstract' cell (C2) contains the value 'TRUE'. The 'Inherits From' cell (D2) is empty. The 'Life' and 'Annuity' products are listed in rows 3 and 4, both inheriting from 'Global'.

	A	B	C	D	E	F	G	H
1	Product	MaxT	Abstract	Inherits From				
2	Global	948	TRUE					
3	Life			Global				
4	Annuity			Global				
5								
6								

- **Abstract:** We specify that the product is abstract by entering TRUE into a cell named **Abstract** prefixed by the product name, thus the name **Global_Abstract**:

The screenshot shows the 'Global_Abstract' formula in the 'Products' sheet. The 'Name' dropdown is set to 'Global_Abstract'. The formula bar shows the value 'TRUE'. The 'MaxT' cell (B2) contains the value '948'. The 'Abstract' cell (C2) contains the value 'TRUE'. The 'Inherits From' cell (D2) is empty. The 'Life' and 'Annuity' products are listed in rows 3 and 4, both inheriting from 'Global'.

	A	B	C	D	E	F	G
1	Product	MaxT	Abstract	Inherits From			
2	Global	948	TRUE				
3	Life			Global			
4	Annuity			Global			
5							
6							

We will specify our **Annuity** product as follows:

- **Name:**

	A	B	C	D	E	F	G
1	Product	MaxT	Abstract	Inherits From			
2	Global	948	TRUE				
3	Life			Global			
4	Annuity			Global			
5							
6							

- **MaxT:** It is unnecessary to specify **MaxT** as it will be inherited from the **Global** product.
- **Abstract:** It is unnecessary to specify that the product is not abstract as this is the default.
- **InheritsFrom:** We will specify that the **Annuity** product inherits from the **Global** product. This is achieved by entering the name of the product we are inheriting from (**Global**) in a cell named **InheritsFrom** prefixed by the product name, thus the name **Life_InheritsFrom**.

	A	B	C	D	E	F	G
1	Product	MaxT	Abstract	Inherits From			
2	Global	948	TRUE				
3	Life			Global			
4	Annuity			Global			
5							
6							

Constants Sheet

Constants are specified as before, but must be preceded by the name of the product they belong to:

Global_cSmoker

1

	A	B	C	D	E	F	G
1	Name	Value					
2	cSmoker	1					
3	cNonSmoker	0					
4	cMale	1					
5	cFemale	0					
6							

Constants

Instanc ...

Instance Variables Sheet

Instance Variables are specified as before, but must be preceded by the name of the product they belong to:

Global_AgeAtInception 21

	A	B	C	D
1		Name	Value	
2		AgeAtInception (years)	21.00	
3		DurationInforce (months)	12.00	
4	Global	Gender (1=Male, 0=Female)	1.00	
5		Smoker (1=Smoker, 0=NonSmoker)	1.00	
6		CurrentAge (years)	22.00	
7		QxIndex	4.00	
8				
9	Life	SumAssured	500,000.00	
10		Premium	44.60	
11				
12	Annuity	Annuity	1,000.00	
13		AnnuityEscalation	5%	
14				

InstanceVariables

Annuity_AnnuityEscalation 5%

	A	B	C	D
1		Name	Value	
2		AgeAtInception (years)	21.00	
3		DurationInforce (months)	12.00	
4	Global	Gender (1=Male, 0=Female)	1.00	
5		Smoker (1=Smoker, 0=NonSmoker)	1.00	
6		CurrentAge (years)	22.00	
7		QxIndex	4.00	
8				
9	Life	SumAssured	500,000.00	
10		Premium	44.60	
11				
12	Annuity	Annuity	1,000.00	
13		AnnuityEscalation	5%	
14				

InstanceVariables

Derived Instance Variables are specified as before, but must be preceded by the name of the product they belong to. Remember that all variables names referenced in formulae must include a product prefix as well:

Global_CurrentAge =FLOOR(Global_AgeAtInception+(Global_DurationInforce/12),1)

	A	B	C	D	E	F
1		Name	Value			
2		AgeAtInception (years)	21.00			
3		DurationInforce (months)	12.00			
4	Global	Gender (1=Male, 0=Female)	1.00			
5		Smoker (1=Smoker, 0=NonSmoker)	1.00			
6		CurrentAge (years)	22.00			
7		QxIndex	4.00			
8						
9	Life	SumAssured	500,000.00			
10		Premium	44.60			
11						
12	Annuity	Annuity	1,000.00			
13		AnnuityEscalation	5%			
14						

InstanceVariables SingleVariables Serie ...

Single Variables Sheet

Single Variables are specified as before, but must be preceded by the name of the product they belong to:

The screenshot shows a spreadsheet interface. At the top, a dropdown menu is set to 'Global_Expense' and a value of '5' is entered. Below this, a table is visible with columns B, C, D, F, G, H, and I. Row 1 is labeled 'Base'. Row 2 has headers 'Name' and 'Value'. Row 3 shows 'Expense' with a value of '5.00'. At the bottom, a tab labeled 'SingleVariables' is highlighted.

	B	C	D	F	G	H	I
1	Base						
2	Name	Value					
3	Expense	5.00					
4							
5							

Series Variables Sheet

Series Variables are specified as before, but must be preceded by the name of the product they belong to:

The screenshot shows a spreadsheet interface. At the top, a dropdown menu is set to 'Life_LapseRate' and a value of '0.215' is entered. Below this, a table is visible with columns A, B, G, J, W, X, Y, and Z. Row 1 is labeled 'Base'. Row 2 has headers 'Inflation', 'Yield', and 'LapseRate'. Rows 3 through 8 show a series of values for 'Inflation' (1 to 6), 'Yield' (5.00% to 6.00%), and 'LapseRate' (0.215). At the bottom, a tab labeled 'SeriesVariables' is highlighted.

	A	B	G	J	W	X	Y	Z
1	Base							
2	i	Inflation	Yield	LapseRate				
3	1	5.00%	6.00%	0.215				
4	2	5.00%	6.00%	0.215				
5	3	5.00%	6.00%	0.215				
6	4	5.00%	6.00%	0.215				
7	5	5.00%	6.00%	0.215				
8	6	5.00%	6.00%	0.215				

Derived Series Variables are specified as before, but must be preceded by the name of the product they belong to. Remember that all variables names referenced in formulae must include a product prefix as well:

The screenshot shows a spreadsheet interface. At the top, a dropdown menu is set to 'Life_LapseRateFactor' and a formula is entered: '=1-POWER(1-INDEX(Life_LapseRate,A3),1/12)'. Below this, a table is visible with columns A, B, G, J, K, W, X, Y, Z, and AA. Row 1 is labeled 'Base'. Row 2 has headers 'Inflation', 'Yield', 'LapseRate', and 'LapseRateFactor'. Rows 3 through 8 show a series of values for 'Inflation' (1 to 6), 'Yield' (5.00% to 6.00%), 'LapseRate' (0.215), and 'LapseRateFactor' (0.01997). At the bottom, a tab labeled 'SeriesVariables' is highlighted.

	A	B	G	J	K	W	X	Y	Z	AA
1	Base									
2	i	Inflation	Yield	LapseRate	LapseRateFactor					
3	1	5.00%	6.00%	0.215	0.01997					
4	2	5.00%	6.00%	0.215	0.01997					
5	3	5.00%	6.00%	0.215	0.01997					
6	4	5.00%	6.00%	0.215	0.01997					
7	5	5.00%	6.00%	0.215	0.01997					
8	6	5.00%	6.00%	0.215	0.01997					

Table Variables Sheet

Table Variables are specified as before, but must be preceded by the name of the product they belong to:

Global_Qx

		Qx			
		Female		Male	
i		Non Smoker	Smoker	Non Smoker	Smoker
1		0.000249640	0.000020806	0.000274604	0.000022887
2		0.000249640	0.000020806	0.000274604	0.000022887
3		0.000249640	0.000020806	0.000274604	0.000022887
4		0.000249640	0.000020806	0.000274604	0.000022887
5		0.000249640	0.000020806	0.000274604	0.000022887

TableVariables

Derived Table Variables are specified as before, but must be preceded by the name of the product they belong to. Remember that all variables names referenced in formulae must include a product prefix as well:

Global_QxFactor

$$=(1-POWER(1-INDEX(Global_Qx,A4,1),1/12))$$

		QxFactor			
		Female		Male	
		Non Smoker	Smoker	Non Smoker	Smoker
1	x	0.000274604	0.000022887	0.000020806	0.000001734
2		0.000274604	0.000022887	0.000020806	0.000001734
3		0.000274604	0.000022887	0.000020806	0.000001734
4		0.000274604	0.000022887	0.000020806	0.000001734
5		0.000274604	0.000022887	0.000020806	0.000001734

TableVariables

Functions Sheet

We will define the functions required to calculate **Best Estimate Liability (BEL)** for our **Annuity** product as follows:

Function	Formula
Age(t)	FLOOR(AgeAtInception+((DurationInforce+t)/12))
PolicyAge(t)	FLOOR((DurationInforce+t)/12)
Deaths(t)	PolicyHoldersInforce(t) * QxFactor[Age(t),QxIndex]
PolicyHoldersInforce(t)	IF(t=1, 1, PolicyHoldersInforce(t-1) - Deaths(t-1))
EscalatedAnnuity(t)	Annuity * POWER(1+AnnuityEscalation,PolicyAge(t))
AnnuitiesPaid(t)	PolicyHoldersInforce(t) * EscalatedAnnuity(t)
ExpensesPaid(t)	PolicyHoldersInforce(t) * EscalatedExpense[t]
NetCF(t)	- ExpensesPaid(t) - AnnuitiesPaid(t)
BEL(t)	IF(t=MaxT, NetCF(t), NetCF(t) + (BEL(t+1) * DiscountFactor[t]))

Functions are specified as before, but must be preceded by the name of the product they belong to. Remember that all variables and other function names referenced in formulae must include a product prefix as well:

Global_Age : $\text{=FLOOR}(\text{Global_AgeAtInception} + ((\text{Global_DurationInforce} + \text{A3}) / 12), 1)$

	A	B	C	D	E	F	G	H	I	J	K
1		Global									
2	t	Age		PolicyHoldersInforce	Lapses	Deaths	DeathBenefitsPaid	PremiumsReceived	ExpensesPaid	NetCF	BEL
3	1	22		1.0000000	0.0124899	0.0000020	0.98	44.60	5.00	38.62	654.7
4	2	22		0.9875081	0.0123339	0.0000019	0.97	44.04	4.96	38.11	613.1
5	3	22		0.9751723	0.0121798	0.0000019	0.96	43.49	4.92	37.62	572.2
6	4	22		0.9629906	0.0120277	0.0000019	0.95	42.95	4.87	37.13	532.0
7	5	22		0.9509611	0.0118774	0.0000019	0.94	42.41	4.83	36.64	492.5
8	6	22		0.9390818	0.0117290	0.0000018	0.92	41.88	4.79	36.17	453.6

TableVariables Functions FunctionProp ...

Annuity_AnnuitiesPaid : $\text{=INDEX}(\text{Annuity_PolicyHoldersInforce}, \text{A3}) * \text{INDEX}(\text{Annuity_EscalatedAnnuity}, \text{A3})$

	K	L	M	N	O	P	Q	R	S	T	U
1											
2		BEL		PolicyAge	Deaths	PolicyHoldersInforce	EscalatedAnnuity	ExpensesPaid	AnnuitiesPaid	NetCF	BEL
3	654.74		1	0.0000020	1.0000000	1,050.00	5.00	1,050.00	- 1,055.00	- 676,494.48	
4	613.13		1	0.0000020	0.9999980	1,050.00	5.02	1,050.00	- 1,055.02	- 678,727.22	
5	572.24		1	0.0000020	0.9999961	1,050.00	5.04	1,050.00	- 1,055.04	- 680,970.80	
6	532.03		1	0.0000020	0.9999941	1,050.00	5.06	1,049.99	- 1,055.06	- 683,225.29	
7	492.50		1	0.0000020	0.9999921	1,050.00	5.08	1,049.99	- 1,055.07	- 685,490.73	
8	453.65		1	0.0000020	0.9999902	1,050.00	5.10	1,049.99	- 1,055.09	- 687,767.18	

TableVariables Functions FunctionProperties Condi ...

Function Properties Sheet

Function Properties are entered as before except a product prefix must be used:

	A	B	C	D	E	F
1		Only Positive Difference				
2	Life_BEL	TRUE				
3	Annuity_BEL	TRUE				
4						
5						

Scenarios Sheet

There is no change to the **Scenarios** sheet as scenarios are not product specific.

Scenarios Adjustments are entered as before except a product prefix must be used:

	O	P	Q	R	S	T	U	V	W
1									
2		ShockExpense	ShockLapseDown	ShockLapseUp	ShockYieldUp	ShockYieldDown			
3		0.07	0.1075	0.3225	0.0006	0.0006			
4		0.07	0.1075	0.3225	0.0006	0.0006			
5		0.07	0.1075	0.3225	0.0006	0.0006			
6		0.07	0.1075	0.3225	0.0006	0.0006			
7		0.07	0.1075	0.3225	0.0006	0.0006			
8		0.07	0.1075	0.3225	0.0006	0.0006			

Conditions Sheet

Conditions are entered as before except a product prefix must be used:

	A	B	C	D	E	F	G
1	Name	Condition					
2	Juniors	TRUE					
3	MiddleAged	FALSE					
4	Seniors	FALSE					