4-2018

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Citation
GOH, Clarence. Excel and simulation for accountants. (2018). *Journal of Corporate Accounting and Finance*. 29, (2), 133-138.
Available at: https://ink.library.smu.edu.sg/soa_research/1773

Published in Journal of Corporate Accounting and Finance,
Vol 29, Issue 2, April 2018, Pages 133–138
DOI 10.1002/jcaf.22328

Excel and Simulation for Accountants

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Simulation is an extremely useful decision-making tool for accountants. While many companies have invested heavily in developing sophisticated software to help them run simulations, simulations can also be run on tools such as Excel. In this article, I will use a simple example to demonstrate how an accountant could use Excel to run simulations.

EXCEL AND SIMULATION FOR ACCOUNTANTS

In Formula One, where races are often won or lost by margins of fractions of a second, the skill of the driver is as important as the race strategy devised by team strategists. While luck certainly plays an important part in the success of any race strategy, many other factors such as fuel load, tire degradation, driver ability, and weather conditions can also influence race outcomes.

To help them devise winning race strategies, F1 teams are increasingly turning to sophisticated simulators which can run thousands of race simulations while changing variables in each simulated race. By running numerous simulations, race strategists gain insights into likely race outcomes when different combinations of variable inputs are implemented, thus helping them devise the race strategy that would give them the greatest chance of success in the actual race.

Simulation is an extremely useful decision-making tool not only in F1 but also for accountants. While many companies have invested heavily in developing sophisticated software to help them run simulations, simulations can also be run on tools such as Excel. In this article, I will use a simple example to demonstrate how an accountant could use Excel to run simulations.

CONDUCTING SIMULATION IN EXCEL

Simulation is a mathematical technique for solving a problem by performing a large number of trial runs (called simulations) and inferring a solution from the collective results of the trial runs. In simulation, uncertainty in a business situation is explicitly incorporated into a model via random variables.

In this example, we will look at Baker Limited, a fictitious insurance company which provides a health insurance plan to its customers. In particular, we examine how Baker can use a simulation model to determine how much money it should accrue in the coming year (2017) to pay for customer insurance claims.

It is now December 31, 2016. As of December 2016, Baker has 15,222 customers who each pay $200 per month in premiums. Average insurance claim per customer in the month was $185. Although Baker does not expect to raise premiums in 2017, it expects the number of customers signed on to the health insurance plan to increase by an average of 2% per month, and for average claims per customer to increase by an average of 1% per month. Exhibit 1 summarizes these expected trends related to the insurance plan in 2017:

Any claims made by customers of the health insurance plan are paid out by Baker from premiums collected from other customers on the plan. Should premiums collected from customers be insufficient to pay claims, Baker would then have to pay these outstanding claims from its own cash account.

Baker needs to determine how likely it is that premiums collected will be able to cover claims made on this health insurance plan (i.e. that this insurance plan will be profitable) in 2017. If the insurance plan is likely to be profitable, Baker would not need to accrue any money to pay for customer claims (because they can be paid from profits). However, if the plan is not likely to be profitable, Baker would then have to determine how much money to accrue in order to pay for outstanding customer claims (from its own cash account).

DESIGNING THE SPREADSHEET MODEL

A simulation model built on an Excel spreadsheet can be used to examine this problem. The first step in conducting a simulation in Excel is to develop a spreadsheet model of the business problem. Exhibit 2 presents the business problem modeled in a spreadsheet.

The following formulae are used in the spreadsheet:

- **Number of customers.** In cell B10, the formula = B3*1.02 is used to determine the expected number of customers in January 2017 following a 2% increase from December 2016. In cell B11, the formula = B10*1.02 is used to determine the expected number of customers in February. This formula is then copied down to all cells in the column to determine the expected number of customers in the remaining months of 2017.
- **Total customer contribution**. In cell C10, the formula = B10*200 is used to calculate total expected customer contributions (i.e. total premiums paid) in January 2017. This formula is then copied to all cells in the column to calculate the expected contributions in the remaining months of 2017.
- **Average claim per customer**. In cell D10, the formula = B4*1.01 is used to determine the expected average claim per customer in January 2017 following a 1% increase from December 2017. In cell D11, the formula = D10*1.01 is used to determine the expected average claim per customer in February. The formula is then copied to all cells in the column to determine the expected average claim per customer in the remaining months of 2017.
- **Total claims.** In cell E10, the formula = D10*B10 is used to calculate the expected total claims in January 2017. The formula is then copied to all cells in the column to calculate the expected total claims in the remaining months of 2017.
- **Company profits.** In cell F10, the formula = C10-E10 is used to calculate the expected profits to the company in January 2017. The formula is then copied

Exhibit 1

Summary of Expected Trends Related to the Insurance Plan in 2017

	A	B	C	D
1		2016	2017	
2		December	Assumptions	Rate
3	No of customers	15,222	Increasing	2%
4	Average claim per customer	$185	Increasing	1%
5	Premiums per customer	$200	Constant	

to the subsequent 11 cells in the column to calculate the expected profits to the company in the remaining months of 2017. In cell F22, the formula = SUM(F10:F21) is used to calculate the total expected profit for 2017. In Exhibit 2, we observe that the health insurance plan is expected to make a profit of $428,875 in 2017.

Inserting Random Number Generators (RNGs) Into the Model

In our spreadsheet model, we assumed that the number of customers signed on to the health insurance plan will increase at an average rate of 2% per month and that the average claim per customer will increase at an average rate of 1% per month in 2017. It is based on these assumptions that we determine that the insurance plan is expected to make a profit of $428,875 in 2017 (as presented in Exhibit 2).

However, these growth rates are only estimates, and there is uncertainty over what the actual growth rates will actually turn out to be. Due to factors outside of Baker's control, there could be months where the growth rates exceed forecasted rates and other months where growth rates are lower than forecasted rates. An important step in spreadsheet simulation is to explicitly model uncertainty by placing a random number generator (RNG) formula in each cell that represents an uncertain outcome.

In particular, for each cell where an outcome is uncertain, an RNG formula will generate a value that represents a randomly selected value from a distribution of values that should mimic actual outcomes. In our example, although we specify an average monthly growth rate of 2% for the number of customers signed on to the insurance plan and an average monthly growth rate of 1% for the average claim per customer, there is uncertainty over what actual monthly growth rates will actually be. While

Exhibit 2

Details of Baker's Insurance Plan Modeled on a Spreadsheet

	A	B	C	D	E	F
1			Coming Year			
2		December	Assumptions	Rate		
3	No of customers	15,222	Increasing	2%		
4	Average claim per customer	185	Increasing	1%		
5	Premiums per customer	200	Constant			
6						
7						
8						
9	Month	Number of customers	Total customer contribution	Average claim per customer	Total claims	Company Profits
10	January	15,526	3,105,288	187	2,901,115	204,173
11	February	15,837	3,167,394	189	2,988,729	178,665
12	March	16,154	3,230,742	191	3,078,989	151,753
13	April	16,477	3,295,356	193	3,171,974	123,382
14	May	16,806	3,361,264	194	3,267,768	93,496
15	June	17,142	3,428,489	196	3,366,454	62,035
16	July	17,485	3,497,059	198	3,468,121	28,937
17	August	17,835	3,567,000	200	3,572,858	(5,859)
18	September	18,192	3,638,340	202	3,680,759	(42,419)
19	October	18,556	3,711,107	204	3,791,918	(80,811)
20	November	18,927	3,785,329	206	3,906,434	(121,105)
21	December	19,305	3,861,035	208	4,024,408	(163,373)
22						428,875
23						

Exhibit 3

A Profit/Loss Scenario for Baker's Insurance Plan Based on a Model Incorporating Relevant RNGs

	A	B	C	D	E	F
1			Coming Year			
2		December	Assumptions	Rate	Distribution	
3	No of customers	15,222	Increasing	2%	Uniform distribution between -3% and +7%	
4	Average claim per customer	185	Increasing	1%	Uniform distribution between -5% and +7%	
5	Premiums per customer	200	Constant			
6						
7						
8						
9	Month	Number of customers	Total customer contribution	Average claim per customer	Total claims	Company Profits
10	January	14,765	2,953,068	196	2,895,483	57,585
11	February	14,913	2,982,599	208	3,099,904	(117,306)
12	March	14,466	2,893,121	204	2,946,769	(53,648)
13	April	15,044	3,008,846	198	2,972,701	36,145
14	May	15,345	3,069,022	204	3,123,119	(54,097)
15	June	15,652	3,130,403	218	3,408,572	(278,169)
16	July	15,339	3,067,795	218	3,340,401	(272,606)
17	August	15,186	3,037,117	220	3,340,067	(302,950)
18	September	15,641	3,128,230	209	3,268,255	(140,025)
19	October	16,423	3,284,642	215	3,534,618	(249,976)
20	November	17,573	3,514,567	224	3,933,323	(418,756)
21	December	17,221	3,444,276	239	4,124,483	(680,207)
22						(2,474,011)

average monthly growth rates over the year might indeed be 2% and 1% respectively, it is likely that there will be some variations in monthly growth rates over the year.

In our example, let's assume that, even as average growth rates are 2% for number of customers signed on and 1% for average claim per customer, we expect these growth rates to follow the following distributions:

- **Number of customers**: Uniform distribution with discrete values from −3% to +7 (note that the average growth rate per month is still 2%)
- **Average claim per customer**: Uniform distribution with discrete values from −5% to 7% (note that the average growth rate per month is still 1%).

To model this uncertain monthly growth rates in our spreadsheet model, we would need to insert the following RNGs into our spreadsheet:

- **Number of customers**. In cell B10, the original formula is replaced with = B3*(1+(RANDBETWEEN(-3,7))/100). This is used to calculate the expected number of customers in January 2017 given our expectation that the increase from December 2017 will follow a uniform distribution with discrete values from −3% to 7% (the RANDBETWEEN function in the formula generates discrete numbers randomly distributed between −3 and 7). In cell B11, the formula = B10*(1+(RANDBETWEEN(-3,7))/100) is used to determine the expected number of customers in February 2017. This formula is then copied down to all cells in the column to determine the expected number of customers in the remaining months of 2017.

Exhibit 4

Extract of the First 13 Replications Carried Out in the Spreadsheet Model

	A	B	C	D	E	F
7						
8						
9	Month	Number of customers	Total customer contribution	Average claim per customer	Total claims	Company Profits
10	January	15,222	3,044,400	178	2,703,427	340,973
11	February	15,831	3,166,176	183	2,895,911	270,265
12	March	15,356	3,071,191	183	2,809,034	262,157
13	April	15,202	3,040,479	188	2,864,372	176,107
14	May	16,115	3,222,908	200	3,218,408	4,499
15	June	16,759	3,351,824	210	3,514,502	(162,678)
16	July	17,262	3,452,379	203	3,511,339	(58,960)
17	August	17,780	3,555,950	207	3,689,012	(133,063)
18	September	17,958	3,591,509	222	3,986,716	(395,206)
19	October	19,215	3,842,915	215	4,137,812	(294,897)
20	November	19,599	3,919,773	205	4,009,540	(89,767)
21	December	20,775	4,154,960	217	4,505,119	(350,159)
22						(430,730)
23						
24						
25						
26	Data Tables for replication (1000 replications)			Parameters		
27	Replication	Company cost		Mean	345,370	
28		(430,730)		Standard Deviation	3,326,196	
29	1	(2,049,870)		Min	(11,831,095)	
30	2	3,254,500		Max	9,521,680	
31	3	1,687,787		Range	21,352,775	
32	4	(674,157)				
33	5	1,702,502				
34	6	(2,887,334)				
35	7	(1,537,068)				
36	8	1,623,532				
37	9	(497,307)				
38	10	(2,087,437)				
39	11	(115,369)				
40	12	520,971				
41	13	(6,467,217)				

- **Average claim per customer**. In cell D10, the original formula is replaced with = B4*(1+(RANDBETWEEN(-5,7)/100)) to calculate the expected average claim per customer in January 2017 given our expectation that the increase from December 2016 will follow a uniform distribution with discrete values from −5% to 7%. In cell D11, the formula = D10*(1+(RAND BETWEEN(-5,7)/100)) is used to calculate the expected average claim per customer in February 2017. The formula is then copied to all cells in the column to determine the expected average claim per customer in the remaining months of 2017.

The spreadsheet model in Exhibit 3, which incorporates the relevant RNGs in the Number of customers and Average claim per customer columns, shows that Baker can expect to make a loss of $2,474,011 based on this particular set of growth rates generated by the RNGs. Recalculating the model (press F9 to do so) will cause the RNGs to generate a different set of growth rates, leading to a different profit/loss scenario for Baker.

Running the Simulation

The next step in performing a simulation involves formally recalculating the spreadsheet model hundreds or even thousands of times (to generate a large number of "trial runs"), and systematically recording the relevant outputs generated (the company profits for 2017). To do so, we will make use of the data table function in Excel. A data table is a range of cells (arranged in columns or rows) in which the values of specific cells can be changed in order to come up with different values to a problem.

Cells A26:B41 in Exhibit 4 show a small part of 1,000 replications carried out in our example. The data table generates these replications by systematically substituting values from cells A29 to A1028 into cell C28, and populating the corresponding cells in column B (from B29 to B1028) with the value that is calculated in cell B28. Accordingly, the data table causes the RNGs to generate 1,000 separate sets of number of customer and average claim per customer growth rates and thus allows our model to calculate overall company profits for each of these replications, and to record them in cells B29 to B1028.

Analysis of Outputs

The output from the simulation is summarized in cells D26:E31 in Exhibit 4. Examining this information would be very helpful to Baker in understanding the potential profitability of its health insurance plan. For instance, while the mean profits for the 1,000 replication (or trial runs') is $345,370, the simulation also indicates that there is a relatively large variance in the potential profitability of the health insurance plan given that the minimum recorded profits are –$11,831,095 and the maximum recorded profits are $9,532,680. Based on this information, Baker can then determine an appropriate amount of money to accrue to pay for outstanding claims.

As this example demonstrates, careful analysis of the outputs obtained from simulation can greatly improve the insights available to decision makers and provides valuable information for decision-making, particularly in instances where outcomes of events that can influence outputs are uncertain.

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