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CompAct

Return on Information: Getting Value from Data

PAGE 3

By **Stuart Rose**

- 3 Return on Information:
Getting Value from Data
By Stuart Rose
- 5 Lifelong Learning
By Ben Kester
- 6 Excel and Beyond—
Valuation Symposium
By Jenna Fariss
- 7 R Corner—Predictive Models
By Steve Craighead
- 8 Down in the Hold
By Rich Junker and Andrew Chan



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Return on Information: Getting Value from Data

By Stuart Rose

Data has always played a critical role in insurance. Still, there is something different about what is happening today. Organizations are now amassing mountains of data. With silos, legacy systems are replicating data and new types of data are being created daily. For many insurance companies, managing all of the data is becoming impractical. Traditional data management strategies will not scale to effectively govern big data for high-performance analytics. The most common obstacle for companies is that they have too much data and too few resources.

But the real challenge begins when companies begin looking for meaningful insights from this explosion of data. Fortunately, the science of extracting insight from data is constantly evolving. Tools are more readily available as insurance companies begin to invest in the technology that supports big data.

DATA MANAGEMENT

The digital age has brought with it an exponential increase in the amount of data available to the modern organization. But it is not just the quantity of data that sets this time in history apart. The speed with which data reaches organizations, the variety of forms data takes and

the insights contained therein are completely changing everything we have known about the collection, analysis and management of data.

At the heart of most data management challenges is data governance, which helps companies define ownership, common language, process, policies and decision rights about how data is managed over its life cycle. IT departments are often overburdened with increasing workloads and meeting the ever-changing needs of the business. And it is more important than ever that IT and business are in alignment. A proper data management strategy can inform and prioritize IT functions so that IT activity is aligned with business priorities.



HADOOP

Data is often seen as a competitive differentiator; however, in today's big data environment, is having too much data really a problem? Many organizations find it too costly to store all the data and too time-consuming to analyze the data.

For a growing number of organizations, the answer has been to take advantage of distributed processing technologies

such as the Hadoop file system. Hadoop is an open source software framework for running applications on a large cluster of commodity hardware. Since Hadoop runs on commodity hardware that scales out easily and quickly, organizations are now able to store and archive a lot more data at a much lower cost. This is good news for IT, but it should also be music to the business professional's ears. No longer does data need to

Figure 1: Data Management Challenges Facing Insurance Companies



be destroyed after its regulatory life to save on storage costs. No longer do business analysts or data scientists need to limit their data analysis to the last three, five or seven years.

DATA VISUALIZATION

The science of extracting insight from data is constantly evolving. Tools are more readily available, and industries are beginning to invest in the technology that supports big data. As the competency levels of firms continue to move along the big data continuum, increasing value will be realized. Data visualization combines many different graphical techniques to enable users and insurance executives to better understand the stories their data is telling. Companies taking advantage of data visualization are able to extract maximum value

from their data and take their businesses to new heights.

BIG DATA ANALYTICS

What do organizations hope to derive from the increased volumes of data they collect? The end goal depends very much on the insurance company, the market conditions and the strategic imperatives of a given carrier. Organizations want more business value from big data, and analytics is an important route to value; hence the growth in big data analytics.

Big data technologies are relatively new and still maturing. However, combining the power of analytics with distributed processing technologies like Hadoop will help insurance companies transform big data to make better business decisions faster. It will enable stat-

isticians, actuaries and business users to examine and analyze more complex problems than ever before. The ability to quickly analyze big data can redefine many important insurance business functions, such as risk calculation, price optimization, catastrophe modeling, fraud detection and customer experience. It's hard to imagine any forward-looking company that is not considering its big data strategy, regardless of actual data volume.

Comprehensive analytics management capabilities, spanning from data to decision, make it possible to take advantage of sophisticated analytical techniques, a large number of analytical models, and a virtually unlimited number of variables and data volumes.

Insurers have long seen data as a source of competitive advantage. But data alone is worthless—it is insights derived from the data that matter, and with the emergence of big data, the possibility for deriving insights is increasing dramatically. Data can be the difference between success and failure. Better data leads to better decisions, which ultimately leads to a more profitable business. Today the return on information is just as important as the return on investment! ■



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Lifelong Learning

By Ben Kester

Do you remember studying for the exams? You're probably trying to forget that trauma, but bear with me.

Those fellowship exams had 2,500 pages of material. You didn't merely read this content, you mastered it. In six months! Only six months! Incredible!

Then what happened? Life got much busier. Maybe you raised a family. Maybe you discovered those things called hobbies.

How about learning? Have you continued to learn? Do you have a desire to?

The examination process that you have completed shows that you are one of the most effective learners on the planet.

Perhaps you are not ready for more learning. Maybe the exams are too fresh, or maybe you are still going through the exams. Did you get burned out and swear off books? That's fine.

What if you are ready for more? Ready for another adventure?

This one will be different. No one is holding a job or a raise to your head. There is no test. We are finished with scripted syllabi.

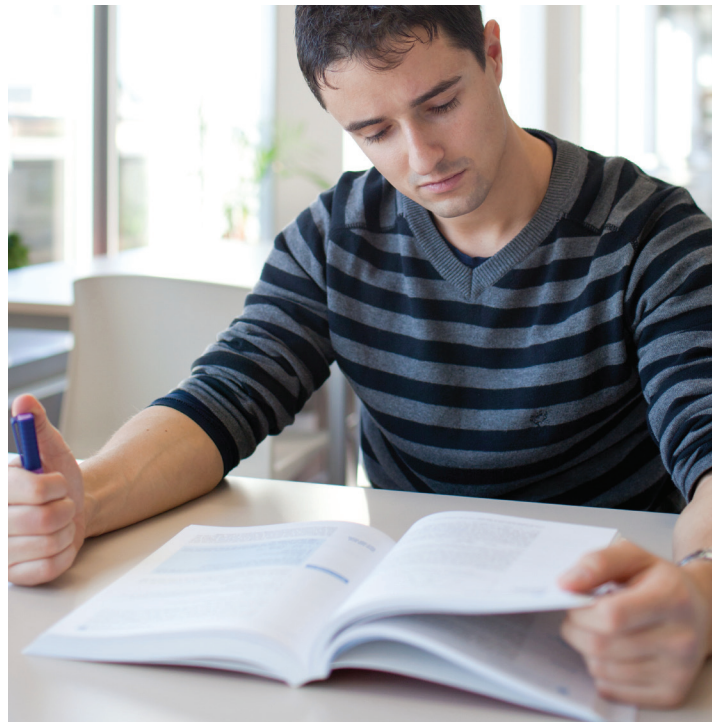
Who is your favorite author? Go find out what they read in their spare time.

Are you all business? Coursera has world-class experts waiting for you.

Maybe you haven't learned what you want to learn. YouTube is great for that. Start with something fun like Veritasium or C.G.P. Grey and see where you end up.

On the Technology Section website, you will find a few more learning resources. Email me for customized recommendations.

Time is short. Let's learn something amazing together. ■



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Excel and Beyond— Valuation Symposium

By Jenna Fariss

The Technology Section recently coordinated a session at the Valuation Symposium that was too good to miss! Microsoft MVP Brad Yundt presented a session titled “Beyond Excel.” As a mechanical engineer in the capital equipment industry, his day job involved calculating flow and heat transfer in pipes, heat exchangers and vessels—good tasks for Excel spreadsheets. When version 5 introduced the VBA language for macros, he saw its potential to handle much tougher problems, as any user could examine the code and determine how it was doing the calculations. Brad became active answering Excel questions in help forums, and has been recognized with Microsoft’s MVP Award for service to the technical community.

Excel is often the tool of choice for actuaries. Yet, do we maximize its full potential? Some features are never used, while living without other features is

unimaginable. This session presented helpful Excel tools that are either new or underutilized. From the surprisingly flexible data table to analyzing data that satisfy multiple criteria, the tools are there—but not always obvious. The presentation demonstrated how to use the features, and extend them beyond their apparent limitations. Attendance at the Valuation Actuary Symposium is growing each year. More than 800 actuaries attending the meeting and 50 educational sessions were planned for this year’s meeting at the Westin Boston Waterfront from Aug. 31 to Sept. 1. Brad’s session (83) provided 1.8 CPD credits in Technical Skills & Analytical Problem Solving Competency. This session was so well attended and received that there are future plans to present it as a webinar. Stay tuned for further details! Also, if you are interested in volunteering your time as a presenter or moderator at the future meetings, please submit your



contact information through the submission form located at <https://www.soa.org/About/Volunteer/form-volunteer-professional.aspx>. ■



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R Corner— Predictive Models

By Steve Craighead

Over the next few issues, I will be presenting various types of predictive models using R packages. My goal in this article is to give you an overview of the different types of models that are created in predictive modeling.

Most predictive models can be broken into regression, classifier, boundary or cluster models.

The regression model, besides standard linear regression, also includes various new techniques such as generalized linear models (GLMs), generalized additive models (GAMs), logistic, probit or quantile models. These new models are used to address issues of how to model the various vagaries of the predictors and the predictive result. The standard linear regression model assumes that the residuals and the coefficients of the predictors both follow a normal distribution (single variant or multi-variant). Also, traditional regression targets the mean of the different predictors as well as the mean of the observed dependent variable. Both the predictors and the dependent variable are assumed to be continuous. Using the newer regression models listed above gives you methods to reduce or eliminate these various restrictions placed by standard linear

regression. The Society of Actuaries' Research Department has just released a guide on how to use predictive models from a modeler's perspective. You can find this at: <https://www.soa.org/Research/Research-Projects/Finance-Investment/2015-predictive-modeling.aspx>.

This document discusses what you need to understand in order to build and use primarily GLM regression models. Since this document is so instructive, in the future I will only discuss GLM marginally. Please consider obtaining your own copy and reading through it.

The classifier models are various techniques that are similar to the biological taxonomy that allows you to classify a specific specimen into a specific species of plant or animal. Here you build some version of a tree model (tree or forest) that splits all of your data into different classes based on different fields. For instance, if you have a collection of policies with different premium paying statuses, your model may be able to determine based on policy duration, face amount, gender, and smoker class if the policyholder will continue to pay premium. These types of models can also be used to measure creditworthiness or an underwriting classification.

This document discusses what you need to understand in order to build and use primarily GLM regression models.

Boundary models are used when modeling turbulence of fluid flow or heat transfer, or some type of flow of information or values from specific locations to other locations through time. For instance, when you are working with a large dimension derivatives model, you may need to know when you are approaching a specific boundary condition, where an option goes into or out of money, or where you knock-in or knock-out. Boundary problems are primarily solved by path-dependent option pricing; however, if you can create a predictive boundary model, you may be able to use other methods that require fewer scenarios to measure an option price or feature as it nears or passes a boundary.

Both classifier and boundary models can be used to indicate membership (or partial membership such as in fuzzy models) to a specific cluster or subgroup. There are also very specific cluster models that can be used to determine a representative for an entire cluster or subgroup. For instance, you could have a collection of historical stock price returns, and conduct a cluster analysis on that universe of assets. If you obtain a cluster of size 1, you should look closely at that one because it has no peers. In stock picking, I have observed that these peerless assets are a good leading indicator of companies

that go bankrupt. Representatives of clusters can be used in both scenario and model point reduction. Another use is when examining a large collection of scenarios tied to specific corporate model values such as economic capital or present value of total surplus. Using cluster models on this type of data reduces the number of results that you need to understand, since you only look at the size and representative of each cluster.

FUTURE GOALS

My next step is to create one or more actuarial dataset(s) that will allow us to use various R packages to build examples of actuarial predictive models. My next article will describe those database(s) and communicate where you can locate them. In the subsequent articles, we will look at separate R packages, build several different models, and discuss various modeling techniques that you can also use when you build your own models. ■



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Best Article of CompAct – 2014

By Paul Ramirez

For the second year in a row, the editors of *CompAct* and the Technology Section council will be presenting an award to the three best *CompAct* articles in 2014. The hard work and talent of our authors is apparent in the fantastic articles that we continue to receive. It takes a lot of time and effort to produce the quality of articles that we do get, and we are very pleased to be able to honor a few of our outstanding articles. As was the

case last year, the voting process was quite difficult—but we were able to agree on a top three. The articles and authors, as well as a link to the original article are below. In addition, we will be giving cash awards as a small token of thanks, as well as copies of the book *The Innovators: How A Group of Hackers, Geniuses, and Geeks Created the Digital Revolution*. Congratulations to the winning authors, and thanks again to all of our past authors! ■

1st Place – \$300

“Incredible Heights – Achieving Massive Scale on Cloud Infrastructure,” by Avi Dowlatsingh, Chris Stiefeling, and Tyler Kroetsch

<https://www.soa.org/News-and-Publications/Newsletters/Compact/2014/january/Incredible-Heights-%E2%80%93-Achieving-Massive-Scale-on-Cloud-Infrastructure.aspx>

2nd Place – \$150

“Variations on Approximation – An Exploration in Calculation,” by Mary Pat Campbell

<https://www.soa.org/News-and-Publications/Newsletters/Compact/2014/january/Variations-On-Approximation-%E2%80%93-An-Exploration-in-Calculation.aspx>

3rd Place – \$50

“Finding Excel VBA Bottlenecks,” by Kevin Roper

<https://www.soa.org/News-and-Publications/Newsletters/Compact/2014/january/Finding-Excel-VBA-Bottlenecks.aspx>



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Down in the Hold

By Rich Junker and Andrew Chan

A couple years back, when the Annual Meeting was held in San Diego, I had the great fortune to tour the USS Midway, now decommissioned and a national museum, not a half mile away from the Convention Center. It was an aircraft carrier and instrumental to victory in the Pacific Theater during WWII. It has no end of fascinating features to explore on deck. I was no less amazed to explore *below* deck, to see how the soldiers lived, the kitchen, the conference room, the library, the bunks...

When you open this month's issue of CompAct, you, too, are touring the deck as you read the articles, the Letter from the Chair, the Letter from the Editor. Like the USS Midway, your CompAct newsletter has a wealth of fascinating and valuable information below deck. You access it through a modest hatch that is easy to overlook amid the splendor of the on-deck articles and pictures. That modest hatch is the following three links:

Technology Section Website
<https://www.soa.org/professional-interests/technology/tech-links-of-interest.aspx>

Learning Center
<https://www.soa.org/professional-interests/Technology/tech-learning-center.aspx> and

Data Analytics Resources
<https://soa.org/professional-interests/Technology/tech-data-analytics-resources.aspx>

Refer to these rich resources regularly, both when you explore the latest issue of CompAct, and whenever you are searching for the perfect tool for your work. These tools have been accumulated and refined by well over a decade's procession of dedicated Section Council leaders.

In the following material, we elevate content to the top deck where we stand now, so you can refresh your memory of all that is at your disposal through the links. We also comment on several of the tools—look in the right margin balloons.

The content is regularly updated. For example, with the current issue, we have introduced a totally new resource, *Data Analytics Resources*, a mother lode of tools in several categories for this rapidly growing actuarial discipline :

- **Open Data Sources**
- **Business Intelligence**
- **Data Integration**
- **Data Visualization**
- **Advanced Analytics**
- **Database**
- **NoSQL**
- **Programming Tools**
- **Development Platforms**
- **Excel Utilities**
- **Certification**
- **Free or Low-Cost Self-Directed and Massive Open Online Courses (MOOCs)**

The following information is what you can expect to find on the Technology Section website:

TECHNOLOGY SECTION

<https://www.soa.org/professional-interests/Technology/Tech-Detail.aspx>

Join the Technology Section!

As a member, you'll receive numerous benefits including:

- Four electronic issues of CompAct annually
- Participation in Apps for Actuaries Website
- Access to LinkedIn discussions

Who should join? Actuaries with IT careers, interest in IT software for company or personal use

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Latest News	Upcoming Events	Publications
New Podcast: Interview with Carol McManus at 2015 Life and Annuity Symposium 2015 Speculative Fiction Contest Winners Announced	2015 Annual Meeting - October 11 - 14 SOA Calendar	CompAct-Mar 2015 CompAct-Oct 2014 CompAct-May 2014 Past Issues Speculative Fiction Contest
Additional Information	Resources	Research
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Society of Actuaries Technology Section

Group Profile- *Private group.* To request membership, click Join and your request will be reviewed by the group manager.





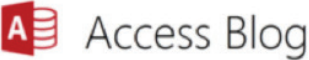



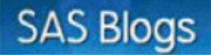

Society of Actuaries (SOA) members align themselves with one or more professional interest sections. These dynamic groups are active in many areas of the Society. The Society of Actuaries (SOA) Technology Section's role is to promote the exchange of information concerning technology as it relates to the work of actuaries through activities such as meetings, seminars, research studies and by facilitating the adoption of new technology. This LinkedIn group is accessible only to SOA Technology Section members. To join the Section, please visit <http://www.soa.org/files/pdf/SOAMembershipForm.pdf>.

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Find information of use to Technology Section members. Click on company logos to access their Web pages.

ONLINE TUTORIALS AND BLOGS

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	<p>Microsoft Power BI Blog If you are looking for self service business intelligence tools, you can't miss the Microsoft Power BI Blog.</p>
	<p>Microsoft Power Pivot Blog POWERPIVOT—THE ACTUARY'S ANSWER TO PIVOT TABLES Why use PowerPivot? These are two common reasons: 1. PowerPivot makes it easy to understand the data and, thus make decisions, and 2. PowerPivot has industrial strength controls to protect the data. Dave Kester, CompAct #54, October 2012 https://www.soa.org/News-and-Publications/Newsletters/Compact/2014/october/PowerPivot—The-Actuary-s-Answer-To-Pivot-Tables.aspx</p>
	<p>Microsoft Access Blog Microsoft Access Blog is the official Microsoft blog for the most current Access information.</p>
	<p>Microsoft Office 365 Blog Microsoft Office 365 is constantly improving every month, there is no easier way to keep you updated than with the Microsoft Office 365 Blog. An Office 365 Home subscription includes a host of valuable features:</p> <ul style="list-style-type: none"> • The full power of Office on all your favorite devices, including PCs, Mac, tablets, and even your iPad®2. • You can use up to five devices with your account. • Unlimited personal OneDrive cloud storage. Save all your documents, photos, and videos with virtually limitless storage. • The newest versions of your favorite Office applications, including Word, PowerPoint, Excel, Outlook, and OneNote.
	<p>R Blog R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS.</p>
	<p>MATLAB MATLAB Central gives you the inside view on MATLAB.</p>
	<p>SAS Blog SAS Blogs connecting you to people, products and ideas from SAS.</p>
	<p>Eddie Smith's blog</p>

CONTINUED ON PAGE 12





ONLINE COURSES

Codecademy

Codecademy is one of the best sites for absolute beginners to programming.

Khan Academy

Khan Academy, the free online educational site that was originally focused on K-12 math, has a section on learning programming. ■

Name	Cost	Link	Notes
Coursera	Free (audit) or ~\$50 (verified certificate)		Variety of courses from top universities
edX	Free (audit) or ~\$50 (verified certificate)		Fewer offerings than Coursera, though arguably more rigorous homework
Udacity	\$200/month		Emphasis on programming. Like Codecademy, Udacity has a coding focus. Unlike Codecademy, it can take you from beginner level of coding (though it is a steeper learning curve compared to the more gentle approach Codecademy takes).
MIT Open Courseware	Free		Variety of resources for educators. Lecture notes, readings, assignments, exams. Comprehensive listing of the university's undergraduate and graduate programs.



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You Can Look It Up: Select & Ultimate Table Lookup In Microsoft Excel

By Paul Margus

“Most people my age are dead at the present time and you can look it up.”

I. INTRODUCTION

This article describes two methods for extracting mortality rates from a Select and Ultimate Tables under Microsoft Excel.

I.A. Conventional Excel Spreadsheet Formulas

“Conventional Excel Spreadsheet Formulas” use the Excel MATCH() and INDEX() functions. Mortality rates are extracted into separate Select and Ultimate columns, and then combined into a single column containing all durations.

I.B. Custom VBA Function

The “Custom VBA Function” is named Sel_and_Ult_LookUp(). Its required arguments include issue age, sex, smoke, etc. It returns an entire column of mortality rates into a single-column Excel Array with an arbitrary number of rows. The custom function relies on VBA code to extract both Select and Ultimate mortality, and combine them into the Array.

To do the Lookups, Sel_and_Ult_LookUp() creates separate “Select” and “Ultimate” instances of pLookUp, a general purpose Class Module designed for very fast Lookups. On creation, each instance copies the Select or Ultimate data from the Worksheet into RAM. Then, the Microsoft Scripting Dictionary creates an indexed RAM roadmap for the Lookups.

The above methods have the following features.

- Both methods fetch their answers from two separate Excel Tables (List Objects), one for Select and the other for Ultimate. These two tables are designed according to database precepts, and each has its own Lookup Key (Mortality Table, sex, smoke, etc.). These two tables can be expanded indefinitely to accommodate any number of Mortality Tables (2015 and 2008 VBT, 2001 CSO, etc.) and any number of Lookup Keys.
- Both methods allow a variable select period. Therefore, the Select Table excludes any rate that is in reality an ultimate rate.



This article contemplates Select & Ultimate Mortality in the Life Insurance line of business. Accordingly, the Select Durations are labeled “001”, “002”, etc. though “025”. In other lines of business, the labels may be unequally spaced. They could even be some unit other than time, such as dollars.

II. SAMPLE WORKBOOK

The accompanying “**You Can Look It Up.xlsm**” (a Microsoft Excel Macro-Enabled Worksheet) illustrates the techniques described in this article. Although it was developed using Excel 2013, it should also work under Excel 2010 (fully) and Excel 2007 (with “Minor Loss of Fidelity”).

In Microsoft Office (including Excel) we can write procedures using Visual Basic for Applications (VBA). As a security precaution, this feature is often disabled by default. For part of its functionality, the Workbook depends on VBA, and will work only if VBA is enabled. To avoid damage from malicious software, you should enable VBA only for workbooks from trusted sources.

As mentioned above, the VBA code uses the Microsoft Scripting Dictionary. Therefore, under “Tools / References ...” I have enabled the “Microsoft Scripting Runtime” package. If the package is somehow disabled, you will get a compile error.

This workbook passes the “Excel Accessibility Checker” tests. Even if you are unaware of any disabilities in your audience, the Checker encourages good practices that may enhance readability. Among other things, Merged Cells are discouraged, although it’s OK to set the cell alignment to “center across selection.”

Following is a summary of the Worksheets.

II.A. Navigation and Documentation Worksheets (black tabs)

The “_DocS_Sheets”, “_DocS_RangeNames”, “_DocS_Tables”, “_DocS_Comments”, “Compatibility Report 2007” Worksheets

provide navigation and documentation. If desired, they can be deleted without affecting the Workbook operation.

II.B. “Sample Lookup” Worksheet (red tab)

Sample Lookups. You supply the Lookup Specs (age, sex, smoke, etc.) and Lookups are performed using both the “Custom VBA Function” and “Conventional Excel Spreadsheet Formulas.”

II.C. “Select” Worksheet (blue tab)

Select Mortality. The Select Period is also tabulated. It varies by Age, Sex, and Smoke. Therefore, Select Mortality Rates only through the applicable Select Period for the cell.

II.D. “Ult” Worksheet (blue tab)

Ultimate Mortality, arranged horizontally. Also includes documentation (names of Source Workbooks, and descriptive captions extracted from the original source).

II.E. “LookUp_Values” Worksheet (green tab)

Values and Descriptions for Data Validation Dropdowns. Includes TableName (“2015 VBT”, etc.), Sex, Smoke, RR, AgeBasis (“ANB” or “ALB”), IssueAge

III. SELECT AND ULTIMATE TABLES

Recently, the 2015 Valuation Basic Tables (2015 VBT) were made available on the SOA website. It’s organized into 10 Excel Workbooks, which are subdivided into a total of 68 Worksheets (tabs). Each Worksheet houses a single 25-year Select & Ultimate (S&U) Table. Each of the four unismoke tables contains 96 rows (one for each issue age from 0 through 95). Each of the remaining 64 tables contains 78 rows (one for each issue age from 18 through 95). All 68 tables contain 25 columns for the select rates, a 26th column for the ultimate rates, and a few additional rows and columns for labels and captions.

I have chosen this table to illustrate practical methods for fetching the needed mortality rates as needed. First, a word about format.

III.A. Customary Presentation and Lookup (Deprecated)

The format described above includes both Select and Ultimate mortality in numerous Worksheets. With each additional Mortality Table or class, the number of Worksheets increases without bound. However, this is the usual way of organizing mortality tables. To do a lookup, it’s necessary to focus on the proper Worksheet, which is a function of the table name (e.g. “2015 VBT”), Sex, Smoke, Relative Risk (or Class), and Age Basis (Nearest or Last). Then the Issue Age determines the correct row, and the Duration defines the column. Often, this means using an Excel spreadsheet formula to build a character string that represents the address. Here’s an example.

```
'[2015-vbt-male-non-rr-anb.xlsx]2015 RR100 MNS
ANB!$J$15
```

The above string indicates cell J15 in the “2015 RR100 MNS ANB” Worksheet of the “2015-vbt-male-non-rr-anb.xlsx” Workbook file. Because this address is only a string, it’s necessary to use Excel’s INDIRECT() function. Thus, the following Excel Formula returns a single mortality rate.

```
INDIRECT(“'[2015-vbt-male-non-rr-anb.xlsx]2015
RR100 MNS ANB!$J$15”)
```

I prefer not to use the foregoing “indirect” method. Depending on how it’s implemented, a seemingly innocuous operation may break the formula. For example, inserting a blank row or column can invalidate the address. If we add another mortality table (perhaps the 2008 VBT or the 2001 CSO), the formula may need modification. Such considerations can complicate routine formula maintenance.

III.B. Principles of Table Reorganization and Consolidation

Instead of using the INDIRECT() function, we can take a cue from standard database design. As before, we organize our data into tables, with one column for each item of data. But there are some differences.

1. Data Consolidation

All data of the same type should be included in the same table. Thus, all ultimate mortality can be accommodated on a single Worksheet, and all select mortality on another. If we create additional classes or even additional tables, we accommodate them as additional rows in the two existing Worksheets. Thus, once we have established our Workbook design, we needn’t change it as we add new data. Then subsequent design changes, column insertions, etc. are applied to just one Worksheet, rather than tediously replicated through 68 or more.

2. Lookup Key

The consolidated Ultimate and Select tables get a Lookup Key that uniquely identifies each row. We will use this key to locate the desired data.

3. Excel Tables

The consolidated Ultimate and Select tables are each organized into “Excel Tables” (“List Objects”). Although I discussed this technique in a previous article (“Table it in Microsoft Excel”), it may be worth mentioning two major advantages.

- Each data item is referred to using its Column Header name, both in Spreadsheet formulas and in VBA. For example, in a given table row of the Ultimate table, [@[Age Basis]] refers to the “ANB/ALB” spec, [@013] refers to the mortality rate at attained age 13, and tblUlt[@000]:[120]] refers to the entire attained age mortality vector.

CONTINUED ON PAGE 14

There is no need to type these expressions or even to remember the syntax. When we create a Spreadsheet formula, Excel inserts automatically these expressions in response to our clicks. Thus, they work in a way similar to Range Names.

- By judicious use of filters, we can audit any desired subset of the table.

III.C. The Consolidation in its Final Form

As described above, I have consolidated Ultimate and Select mortality into two tables.

1. Ultimate Mortality

All Ultimate mortality rates are contained in one Excel table in one Worksheet (the blue “Ult” tab). This table contains one row for each of the 68 tables in the original source. The Ultimate Mortality Rates are arranged horizontally, so that all attained age rates are contained in one row.

Ultimate Lookups are accomplished by searching the Lookup Key in the “Lookup Table” column. It is similar to the following:

2015 VBT:M:N:RR050:ANB

The above example indicates the following Lookup specs.

2015 Valuation Basic Tables
Male
Nonsmoker
50% Relative Risk
Age Nearest

2. Select Mortality

All Select mortality rates are contained in one Excel table in one Worksheet (the blue “Select” tab). This table contains all 5,376 issue age rows all 68 tables in the original source. The Select Mortality Rates are arranged horizontally. In addition, each row contains a “Select Period” field.

Select Lookups are accomplished by searching the Lookup Key in the “Lookup Iss. Age” column. It is identical to the Ultimate Key, except that the issue age is appended. For example:

2015 VBT:M:N:RR050:ANB:018

If desired, you can reformat the table as 120-year select and no ultimate. Although many mortality rates will then be redundant, it simplifies the “Conventional Excel Spreadsheet Formulas” method.

IV. LOOKUP METHODS AND RESULTS

The “Sample Lookup” Worksheet illustrates the two Lookup methods.

IV.A. Custom VBA Function

The “Custom VBA Function” Sel_and_Ult_LookUp () returns an Excel Array to J5:J124.

IV.B. Conventional Excel Spreadsheet Formulas

“Conventional Excel Spreadsheet Formulas” calculate Select mortality in N5:N124. For select periods less than 25 years, #N/A values populate the column through year 25. After year 25, this column always contains #REF! values. Neither #N/A nor #REF! presents any problem, because by then we have switched to Ultimate.

Ultimate Mortality appears in O5:O124.

In P5:P124, the Select and Ultimate results are combined into one column. The variable Select Period serves as the boundary between Select and Ultimate.

Of course, columns N and O can be combined into a single (complex) formula. But this may make the formulas harder to understand and audit.

IV.C. Input and Comparison

In the white areas of Column C, you can vary the input. Column R verifies that the two methods produce identical results. ■



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ASSOCIATED LINKS

Excel Array <http://www.cpearson.com/excel/ArrayFormulas.aspx>

You Can Look It Up Excel Worksheet <http://www.soa.org/Library/Newsletters/Compact/2015/compact-2015-you-can-look-it-up.xls>

Microsoft Scripting Dictionary [https://msdn.microsoft.com/en-us/library/ee784551\(v=cs.10\).aspx](https://msdn.microsoft.com/en-us/library/ee784551(v=cs.10).aspx)

Excel Accessibility Checker <https://support.office.com/en-us/article/Check-for-accessibility-issues-a16f6de0-2f39-4a2b-8bd8-5ad801426c7f?ui=en-US&rs=en-US&ad=US>

2015 Valuation Basic Tables <https://www.soa.org/Research/Experience-Study/Ind-Life/Valuation/2015-valuation-basic-tables.aspx>

Table it in Microsoft Excel <https://www.soa.org/News-and-Publications/Newsletters/Compact/2012/october/Table-it-in-Microsoft-Excel.aspx>

Data Tables— A Variable Forecast

By Mark Horowitz

This article is about Excel's **Data Table** feature—why it's so valuable and how to use it. Data Tables operate within a workbook, placing values in selected cells, recalculating, saving selected cells' values, and repeating as many times as desired—all without any VBA. Setup time is small and observed calculation speed is at least 25 times that of using VBA for the looping. Data Tables have proven useful in automating a complex actuarial valuation process with thousands of lives with only minor changes to the outer layer of the model needed.

Although Data Tables are considered an advanced topic, spending the time to read this article will leave you armed to use them with minimal effort. You can continue to use all of Excel's other features. And you may not need to have your model rewritten by the IT department just to run many employees or scenarios.

You may be wondering “why another article on Data Tables?” They are easy to employ and way too useful for an actuary using Excel not to know. Plus, I have found a new use for Data Tables not discussed in any of the references—model testing.

What's the plan for the rest of the article? (1) Calculation Basics, (2) Data Tables to the Rescue, (3) What Is a Data Table? (4) Making a Data Table (5) Data Tables—Dos and Don'ts, (6) Flipping for Data Tables, (7) Data Tables With Two Dimensions, (8) Really Fun Data Tables, (9) Final Comments. References on Data Tables are included for those still curious.

(1) CALCULATION BASICS

I assume that you've been using Excel for a while and are familiar with ranges, formulas and formatting. You have copied cells. You have used functions with different kinds of arguments. There's no need to have used VBA. You needn't be familiar with array constants like {0, 1, TRUE; #N/A, "7/4/1776", 1E+301, #DIV/0!}.

Excel is a calculator. What is the order in which it calculates? It examines all your formulas, determines dependencies between them and creates a “calculation tree”—the path it follows. The tree also allows it to be as fast as possible and to avoid unnecessary work. See [1] for the official word on this topic.

(2) DATA TABLES TO THE RESCUE

I begin with a little story about some calculations I was doing. It was a valuation model, consisting of about 50 linked worksheets with results flowing smoothly mainly left to right. I had inputs, assumptions, parameters and results for a single employee. I had a sheet of almost a thousand employees all to be processed in the valuation model and the results stored on yet another sheet, by employee. One calculation took well under a second. But getting results for all employees was a puzzle I solved with a little VBA. I accessed the data in a loop row by row, accessing each row's fields with the Index function. Convinced that it worked for a couple of employees, I ran it for all of them. It took two minutes—way too long; intolerable if others were to use it.

It was already optimized and efficient. I dreamt about a solution. Maybe the “solver” wizard would help. I asked a friend about this; instead, he mentioned that Data Tables might work. So, I read articles. The toy examples were about mortgages with a single input of the interest rates. When I realized that I could alter the meaning of this single input as an index to my employee data I knew I had simple solution. Creating my first Data Table was really easy. I clicked the final **OK** and expected to wait. Instead, thousands of results filled the Data Table in a flash—always a sign of hidden trouble. But each of the values I checked were correct! After two hours of checking, everything was still perfect and all the values agreed with

those produced by the VBA loop; it was just at least **25 times faster**. The really wacky thing was that every reference which talked about Data Tables” to speed warned that they were slow! I have not found any problems in over a year's experience.

So, let's talk about what Data Tables are and how to create them.

(3) WHAT IS A DATA TABLE?

Here's my mental model of a Data Table; and some definitions I've created for ease of reference. These identify the whys and the whats. The hows, dos and don'ts come later.

- [1] **Purpose:** why use a Data Table? Possibilities include: (1) producing multiple values for a set of calculations (e.g., mortgage for varying interest or periods) (2) (e.g., forecasting with stochastic returns) (3) testing a model (displaying lots of intermediate and final results or inputs or parameters may show mistakes in the model or its implementation only obvious in the pattern of results); (4) iterating a set of multiattribute elements through some calculations, e.g. employees with age, svc, gender, etc.
- [2] **Calculations:** a collection of formulas from which to capture results—from a single cell to an entire workbook (minus the Data Tables!)
- [3] **Input:** one cell used is in those calculations; it may be considered a parameter in

the **calculations**, such as an interest rate, loading, duration, pay, etc.

- [4] **Variations:** the values to be iteratively substituted for the input value,
- [5] **Result Definitions:** something to save for each **variation**—any cell in the **calculations**, even a new formula.
- [6] **Results Table:** the saved values for all **variations**.

Technically, only the last three items are part of the Data Table. I include the first three because Excel requires that you identify the **Input** cell while creating the Data Table, and without the **calculations** of interest and at least an implicit purpose there's no reason for the Data Table.

Some things to note:

- [1] the input value is usually numeric, but may be any data type you need, such as numeric, date, time, percent, Boolean, string or even error condition.
- [2] the **input** cell, whether row or column, must be on the same sheet as the Data Table, but need not be in the same row or column as its **variations**. The **calculations** may occur on any of the sheets.
- [3] the **variations** must occupy a single row or column of contiguous cells.
- [4] the **variations** are typically the same type as the input cell, but need not be; they may be any combination of data types, whether they be constants or formulas.

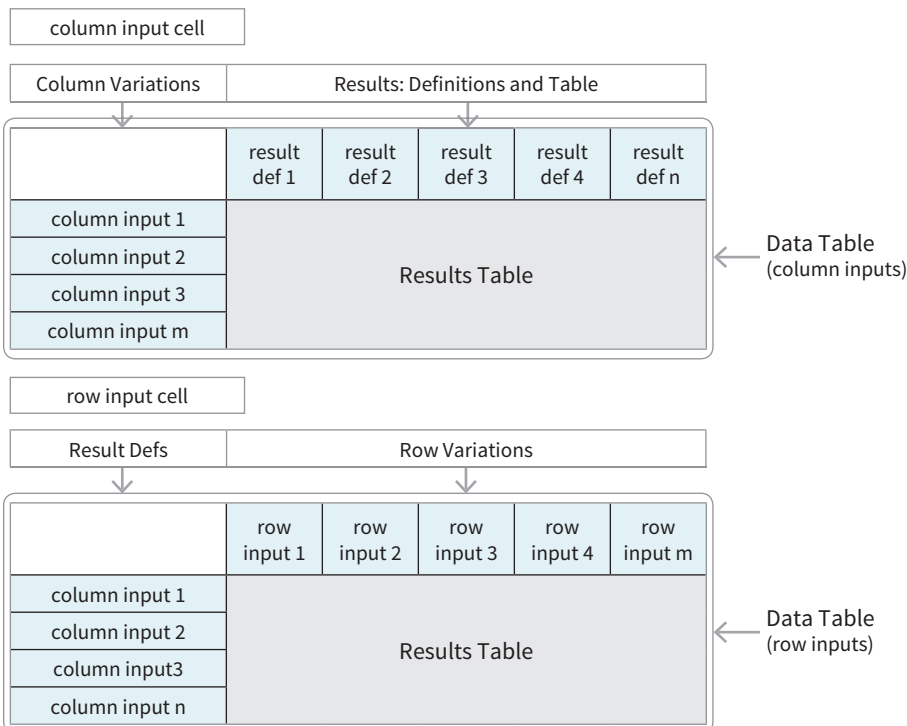
[5] the values in the **variations** need not be distinct—a Monte Carlo simulation might use multiple values according to a probability distribution's relative frequency to produce a distribution of transformed input.

[6] a cell in the **Results Table** may be referred to anywhere else in the workbook, in formulas, in functions such as SUM(...), in graphs or pivot tables.

Here is a picture of the components of a Data Table, showing both the row input type and column input type.

Calculations

calc			calc	
calc	calc		calc	calc
calc	calc			calc
	calc			calc
calc				calc



Enough theory! Let's make a Data Table.

(4) MAKING A DATA TABLE

The **purpose** for this Data Table is to test part of a model of employer contributions in a savings plan. It uses employee pay, contribution rate, maximum employee contribution, employer match percent and expected election rates above and below a typical employee contribution rate. I want to try lots of inputs and see the final and intermediate results all at once to see the pattern of results. Without a Data Table this would be hard to do.

I've labeled items to capture (0), (1), ..., (7) in columns H and J with the label ID in row 5. The **calculations** are in cells E5 through I19. The cells in rows 6, 7 and 8 are used in the formulas. The **input** cell I6 is dark grey; it's the maximum employee contribution; its current value is 18,000.

Inputs			ID		ID
Pay	#100,000	Max EeCont		\$17,500	(0)
EeCont % (Ass)	10%	EeCont %		100%	
Matching Er Cont	25%	EeCont		\$100,000	
Calculations		<i>up to 10%</i>		<i>over 10%</i>	
EeCont \$ split		\$10,000	(1)	\$90,000	(2)
...with max		\$10,000	(3)	\$7,500	(4)
Sum of above				\$17,500	
Election Rates		36%		18%	
Fraction of EeCont		0.5714		0.4286	
x Election Rates		0.2057		0.0771	
Sum of above				0.2829	(5)
x EeConts				\$4,950	(6)
x Match %				\$1,238	(7)

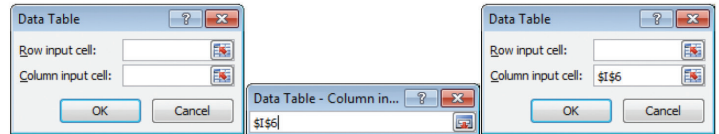
I'd like to see the employer contribution (I19) and intermediate values using **variations** of I6. They're in N7, ... N11; they need not be in ascending order. This column of five values in rows 7-11 of column N are the first piece of my **Data Table**; however, I haven't told Excel that any of this **is** part of a Data Table. That comes later.

To define the information I'd like to see in the Data Table, I place a formula for each item whose value I want in the row above the first variation (cell O7). I've put other labels in rows 4-6; they're not part of the Data Table.

In cell O7 I enter the formula "=\$G\$11"—this corresponds to ID (1). Cell P7's formula is "=\$I\$11". And so forth. I put a formula in cell I13: "=\$G\$12+\$I\$12" to show that it can be done in the **Results Definitions**. Setup for the Data Table is now complete.

Here are the steps to create the Data Table; they work in Excel 2007 and later.

- [1] Select cells N7 through V12, using the mouse or keyboard.
- [2] Click **Data** on the ribbon.
- [3] Click **What If Analysis**, then click the submenu item **Data Table**.
- [4] A dialog box appears. Since my variations are in a column, I supply my **input** cell in the **Column input cell** entry. Type I6 or click the cell address icon to its right and then click cell I6. These show the steps:



- [5] Now, click **OK**. Almost immediately cells O8 through V12 contain values as shown below.

Input	Intermediate Calculations							Output
(0)	(1)	(2)	(3)	(4)	(3) + (4)	(5)	(6)	(7)
	10000	90000	10000	7500	17500	0.28286	4950	1237.5
\$17,500	\$10,000	\$90,000	\$10,000	\$7,500	\$17,500	28.3%	\$4,950	\$1,238
5,000	10,000	90,000	5,000	0	5,000	36.0%	1,800	450
100,000	10,000	90,000	10,000	90,000	100,000	19.8%	19,800	4,950
1,000,000	10,000	90,000	10,000	90,000	100,000	19.8%	19,800	4,950
9,999	10,000	90,000	9,999	0	9,999	36.0%	3,600	900

Excel does not save the definition of the input cell anywhere to make changing easy later. But click anywhere in the **Results Table** and you'll see its cell referenced.

(5) DATA TABLES—DOS AND DON'TS

Before proceeding to more complicated Data Tables, here are some Dos and Don'ts of Data Tables, as well as a comment on what's really going on under the covers.

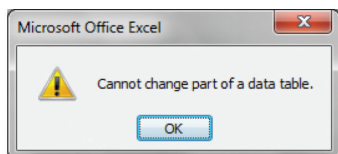
Microsoft discusses the dependency tree which guides (re)calculations in [1]. It points out that Data Tables are special structures but not where they fit into the tree. It's pretty clear that the evaluation of Data Tables happens after other cells are evaluated. Then, Excel evaluates the Data Table by setting the value of the **input** cell(s) to successive values of each **variation** and recalculates the entire workbook except for any other Data Tables—otherwise there would be a problem of circularity with multiple Data Tables—which there isn't. This is one reason why you cannot nest one Data Table's calculations within another. Reference [1] says that circular references are permitted when using Data Tables and that no error messages will be produced even if errors are encountered. Avoid them to maintain sanity.

Some Dos and Don'ts:

[1] **Range Names:** You may name your input cell. I could have given cell I6 a name such as MaxCont and typed that name in the Column input cell entry and clicked OK. That's easier and more clear in other uses.

[2] **Input cells:** different Data Tables may use the same input cells. Their calculations do not conflict.

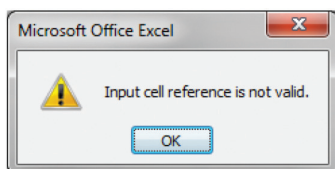
[3] **Result Table:** The cells here contain this: {=TABLE(I6)}. It shows that Excel has defined the Data Table using input cell I6, and has done so using an Array formula (a topic for more articles). Beware: you may not change any individual cell in an Array formula; they can only be modified by changing the formula for all cells. Otherwise you get a warning like the one below if you try to change any of the cells in the **Result Table**:



[4] **Recalculation:** If this were a huge Data Table it might take many seconds to recalculate. To allow automatic recalculation of the workbook except for the Data Table do the following. Then use F9 to do a recalculation including the Data Table.

- [1] Click File
- [2] Click Options
- [3] Click Automatic except for data tables.

[5] **Location:** Our first Data Table was on the same sheet as the **calculations** it captured. It need not be. The calculations may span multiple sheets. The **input** cell must be on the same sheet as the Data Table. If not, a message is displayed when you try to create the table



[6] **Multiple Tables:** You may create multiple Data Tables in one workbook as long as they don't overlap. They can use the same **input** cells. One Data Table may not be SUBORDINATE to another. Excel will prevent it.

[7] **Modifications:** once constructed, you can change some parts of a Data Table and recalculate the Results Table without needing to recreate it from scratch.

- [1] You may always change the format of any cells in the Data Table.
- [2] You may modify the **Result Definitions**; recalculate to see new values in the **Result Table**.
- [3] You may modify calculations anywhere in the workbook even those referenced in a Data Table.
- [4] You cannot add or remove rows or columns of the Data Table.

If you need to add new Result Definitions or variations, do this:

- [1] Select the Results Table
- [2] Click Home
- [3] Click Clear
- [4] Click Clear Contents
- [5] Add or remove what you need
- [6] Recreate the Data Table.

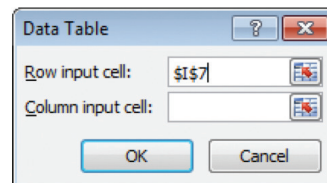
[8] **Externalities:** Data Tables do not impose any restrictions on supplying or accessing data in other workbooks.

(6) FLIPPING FOR DATA TABLES

You've now seen a Data Table with variations in a column. They may also occur in a row. The structure is very similar, but transposed.

- [1] The first, or top, row of the table contains the individual **variations**
- [2] The column below and to the left of the **variations** contains the **result definitions**

[3] The input cell definition goes in the Row cell, rather than the Column cell:



[4] The **results table** now contains a formula such as {=TABLE(I7,)}. I7 is now in the row position, rather than column position. Yes! there is a Data Table with both row and column used; see the next section.

[5] You may include as many **result definitions** as you want, just like the column **variation** table.

[6] Note the different formats in the last row: the factor is fractional with four decimal places; the others are whole dollar amounts.

Here's a picture of a Data Table with its variations in a row.

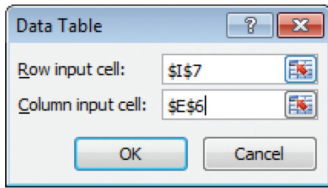
		Row Inputs					
		4.00%	6.00%	10.00%	25.00%	50.00%	100.00%
Result Defs	\$10,000	4000	6000	10000	10000	10000	10000
	\$1,238	360	540	900	1237.5	1237.5	1237.5
	\$10,000	4000	6000	10000	10000	10000	10000
	0.2829	0.36	0.36	0.36	0.28286	0.28286	0.28286

Ready for results based on two inputs? Coming up.

(7) DATA TABLES WITH TWO DIMENSIONS

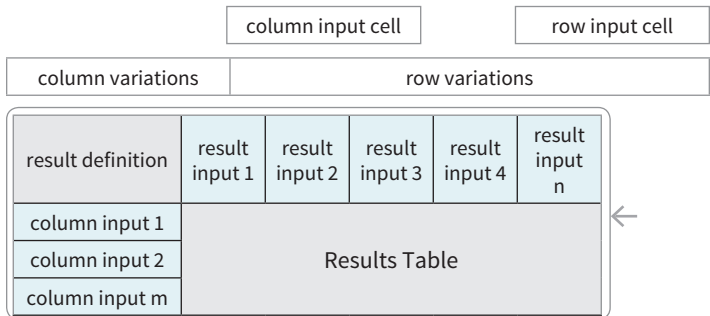
Excel has a Data Table with both row and column **variations**. How could you reasonably combine these?

- [1] The top row of the table would contain the row **variation**
- [2] The left column would contain the column **variations**
- [3] There would be both a row input cell and a column input cell, such as:



- [4] **Results definition:** There could be only one. Each value in the **results table** would correspond to the calculations based on those two values. For multiple results, you'd need to create a two-input Data Table.
- [5] The **results table** now looks like `{=TABLE(I7,I6)}` - I7 in the row position and I6 in the column position.

Here's the conceptual model of a two-dimensional Data Table, followed by an example.



		Row Inputs						
		\$1,238	2%	5%	8%	10%	12%	20%
Column Inputs	\$18,000	900	1,035	1,170	1,260	1,350	1,620	
	5,000	315	450	450	450	450	450	
	100,000	4,590	4,725	4,860	4,950	5,040	5,400	
	999,999	4,590	4,725	4,860	4,950	5,040	5,400	
	9,999	540	675	810	900	900	900	

Data Table (row and column input)

(8) REALLY FUN DATA TABLES

One-dimension Data Tables. Two-dimension Data Tables. Sometimes life is not so simple. Now my little model uses lots of inputs and spans many worksheets. Some are employees for seriatim val-

uation. Results need to be summarized, analyzed and graphed. Is it finally time for VBA macros? Has Excel run out of steam? Need we rewrite the model in a high-level programming language? Not necessarily. Some of us Excel hackers have found a way to use single-input Data Tables to handle multidimensional situations like this. The key idea is to use the single input field as an index to a table of **variations**, rather than the variation value itself. And let the Index function pluck the value needed by row and column. It works.

The steps below detail these primary tasks: (1) create and name a two-dimensional range; use one column for each **input** variable (e.g., age) and one row for each **variation** (e.g., employee); (2) create the Data Table skeleton using a column of row numbers, one for each **variation** (e.g., 1, 2, 3...), (3) identify the **input** cell that will contain a row number and (4) for each "real" input variable use the formula `=Index(range name, input variable, column number)`. (5) the **Results definitions** are coded normally. Here are the details:

- [1] This is a picture of my range **EmpData**, shaded to show its cells D4..H2718. An employee is defined by these variables: gender, age, service, salary and bonus. Each variable uses a separate column. Corresponding column numbers are shown in row 2, names in row 3; **gender** is 1, **age** is 2, etc.

	1	D	E	F	G	H
2		1	2	3	4	5
3		gender	age	service	salary	bonus
4	M		42	5	25,000	730
5	F		42	5	53,333	7,689
6	F		22	1	19,000	555
7	M		35	4	47,867	3,245
8	M		58	24	73,546	7,355
...
2,718	F		65	43	125,434	18,815

- [2] Suppose we are calculating an eligibility date and retirement date, for which we have individual cells named **EligDate** and **RetDate**. This could be the beginning of the Data Table's **result definitions**: the left hand column (dark shading) contains row numbers for **EmpData**, and the top row is three result definitions (light shading)—the formulas are shown as text rather than numeric values.

	=age	=EligDate	=RetDate
1			
2			
3			
4			
...			
2,715			

[3] Here is the input cell, with its name to the left:

Here is age, one of the “real” input variables. I would make the value 2 a named constant such as **ageIndex**, so the formula is easier to read and less brittle. We could use the Column() function in each variable’s column. This would even allow inserting a new column between existing ones defining the employees without breaking the Index() formula. Robust worksheets are so much more reliable.

(9) FINAL COMMENTS

We have discussed Data Tables, their theory and construction. They are extremely useful for some problems. I thank Excel’s developers for this great tool. And my wife for her editing expertise. ■

REFERENCES

Here is a link to the workbook mentioned above.

For other perspectives and treatments of Data Tables, here are some articles on the web:

1. Microsoft’s discussion of Recalculation: <https://msdn.microsoft.com/en-us/library/office/bb687891.aspx>
2. http://en.wikipedia.org/wiki/Numeric_precision_in_Microsoft_Excel
3. This is a basic treatment of Data Tables from Microsoft support: <https://support.office.com/en-us/article/Calculate-multiple-results-by-using-a-data-table-e95e2487-6ca6-4413-ad12-77542a5ea50b>

4. An introduction to 1- and 2-variable Data Tables: <http://www.excel-easy.com/examples/data-tables.html>
5. Chandoo’s weekly Excel email is for those who want to learn advanced techniques. This article is by a guest author and well worth perusing: [http://chandoo.org/wp/2010/05/06/data-tables-monte-carlo-simulations-in-excel-a-comprehensive-guide/Data Tables & Monte Carlo Simulations in Excel – A Comprehensive Guide](http://chandoo.org/wp/2010/05/06/data-tables-monte-carlo-simulations-in-excel-a-comprehensive-guide/Data%20Tables%20&%20Monte%20Carlo%20Simulations%20in%20Excel%20-%20A%20Comprehensive%20Guide)
6. This LinkedIn article shows how to use Index() with Data Tables to allow more than 2 input variables: <https://www.linkedin.com/pulse/improve-excel-performance-part-3-andrew-chan-asa?trk=prof-post>
7. This set of three articles from Microsoft are about performance and include comments about keeping the use of Data Tables from degrading performance, not an explanation of their improvement over that of VBA: Excel 2010 Performance: Performance and Limit Improvements: [https://msdn.microsoft.com/en-us/library/office/ff700514\(v=office.14\).aspx](https://msdn.microsoft.com/en-us/library/office/ff700514(v=office.14).aspx), Excel 2010 Performance: Improving Calculation Performance: [https://msdn.microsoft.com/en-us/library/office/ff700515\(v=office.14\).aspx](https://msdn.microsoft.com/en-us/library/office/ff700515(v=office.14).aspx), Excel 2010 Performance: Tips for Optimizing Performance Obstructions: [https://msdn.microsoft.com/en-us/library/office/ff726673\(v=office.14\).aspx](https://msdn.microsoft.com/en-us/library/office/ff726673(v=office.14).aspx)
8. Walkenbach, John, 2010, Microsoft Excel 2010 Bible. Excellent organization of basic through advanced topics, many tips and techniques not easily found elsewhere.
9. Fuqua School of Business: Introduction to Data Tables and Data Table Exercises <https://faculty.fuqua.duke.edu/~pecklund/ExcelReview/DataTablesIntro.PDF>
10. <http://www.sumproduct.com/thought/data-tables-with-off-sheet-inputs>
11. <http://www.sumproduct.com/thought/data-tables>



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ASSOCIATED SPREADSHEET

To see the spreadsheet associated with this article, visit:

<http://www.soa.org/Library/Newsletters/Compact/2015/compact-2015-data-table-articles.xlsx>

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The **Professionalism Ready-to-Go Kit** aims to increase awareness of potential professionalism issues and resources available for solving them, which will lead to a better understanding of the Code of Professional Conduct.

Learn more at www.soa.org/ReadyToGoKit.

Contact Sherri Blyth at sblyth@soa.org with questions.

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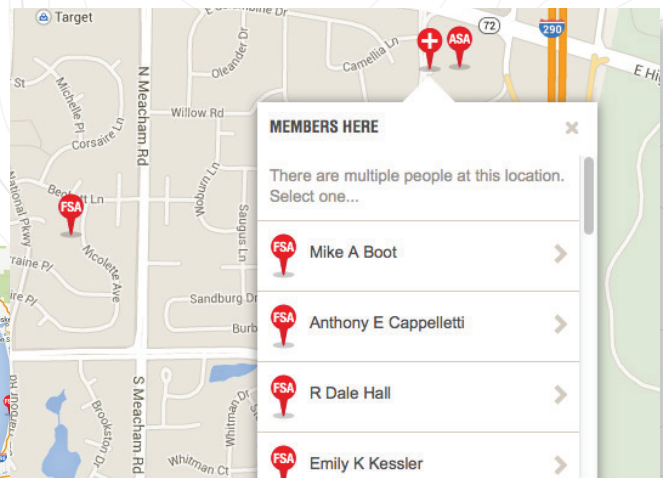
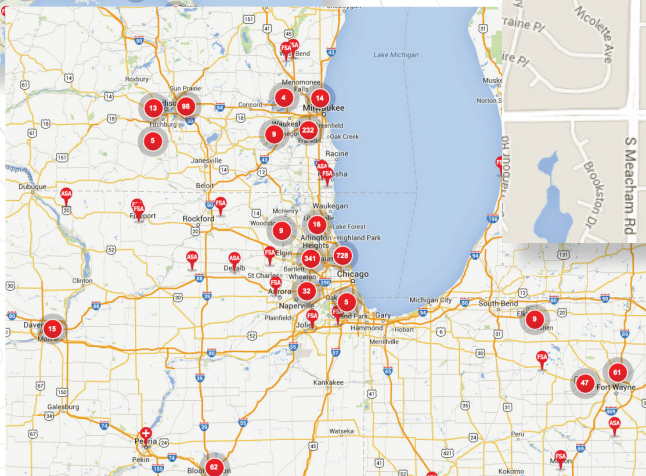
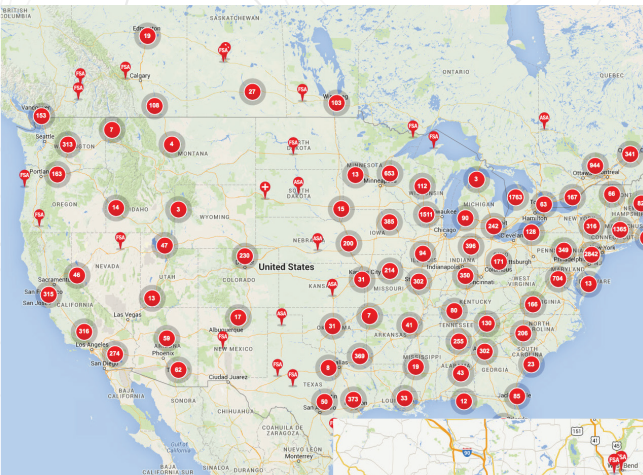
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