

## **Excel-Based Interactive Teaching and Assessment Tool for Forecasting Methods**

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*Teaching business statistics is a challenging task because of the abstract nature of many of its concepts. On the other hand, many students are visual learners and prefer to see the actual concepts in action instead of having a theoretical discussion about them. In this study an interactive Excel-based tool is presented, which can be used in four different ways: as a teaching tool for instructors, as a learning instrument for students, as a self-assessment tool for students, and as a real time series forecasting tool for both instructors and students. The tool provides a very user-friendly environment for teaching and/or mastering the "Forecasting" topic in business statistics. It can be successfully used by anyone with little or no experience in Excel.*

**EHS Codes:** 1301, 1302

**MIS Code:** 0104

### **1. Introduction**

It is well known that teaching statistical methods is a challenging task. There are many abstract concepts in statistics that are hard to present in an easy and understandable manner. It is even more challenging to teach these concepts to business students, because not only do they have to learn the theory, but they also must be able to apply the statistical techniques in their field of study or work (Tsai & Wardell 2006). If we continue to teach business statistics in the traditional manner then the students will remain passive participants of the entire education process, with their activities restricted to listening, taking notes, and re-solving already solved problems and examples. Alternatively, one can follow a teaching method that encourages more active student involvement. There are several ways to encourage students to leave their comfort zones and become more proactive. Back in mid 1990s, Cobb (1994) noted that instructors had started using computer simulations more frequently to demonstrate important statistical concepts and to allow students to discover those concepts themselves. There are two commonly used environments for developing statistical simulations - Interactive technologies such as Java and Flash (Lane & Peres 2006), and Microsoft Excel™ (Viali 2002, Tsai & Wardell 2006). The latter is becoming increasingly popular because of its familiarity, availability, great number of statistical and financial functions, and the ability to extend its functionality by using VBA -Visual Basic for Application (Albright 2001).

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The research question addressed in this study is the following: can we combine three attributes related to statistical concepts – teaching, learning, and assessment, in a single Excel-based interactive tool? The study was motivated by the fact that almost all tools developed for visualizing various statistical concepts, are limited with demonstration of the concepts only. Adding interactive assessment component is a new approach. Also, the ability to use this tool not only for teaching and learning, but also for real business forecasting applications, distinguishes the tool from similar tools published in the literature. The tool introduced in this study, can be used in various ways: as a teaching tool for instructors, as a learning instrument for students, as a self-assessment tool for students, and as a forecasting tool for actual time series. The tool provides a very user-friendly environment for teaching and/or mastering the “Forecasting” topic in business statistics. Dynamically updated graphs are used to demonstrate effects of changing the parameters of the smoothing methods (moving average period and exponential smoothing coefficient) on the forecast values. Additionally, the Mean Absolute Distance (MAD) is used to compare the different models. Hints are implemented to indicate the calculation logic. The self-study module asks students various questions on the topic, hints them how to find the solution (if asked) and solves the problem for them (if requested). It also keeps track of the student’s performance and generates a summary result with a grade. This entire functionality is programmed in VBA and is hidden from the user. The tool can be successfully used by anyone with little or no experience in Excel.

The rest of the paper is organized as follows. The section 2 provides a general overview of relevant research in the interactive teaching tools. The section 3 presents the methodology used in the paper. It contains detailed description of the tool as well as the interpretation of various outcomes generated by the tool. Section 3 summarizes the basic features of the tool and compares the tool with the similar tools presented in previous studies. The paper concludes with the list of research articles used as references.

## 2. Literature Review

Interactive systems were used in statistics since the early 1970s. Makridakis, Hodgson and Wheelwright (1974) developed the first interactive forecasting system using time-sharing computer configurations. The system allowed the user to conduct preliminary data analysis, to identify the forecasting technique(s) most appropriate for the task at hand, and to build the forecasts. The advances in information technologies provide better platforms for developing such interactive tools. Tsai et al. (2006) made an attempt to study the pace of growth of the development in the interactive statistical tools using Java applets. They used the Google search engine to search for the topic “Statistics applets” and found 1840000 related hyperlinks. The same search in September, 2011 found 2210000 related links. Of those, 1500000 were related to forecasting methods. Lane et al. (2006) analyzed the promise and pitfalls of using interactive simulations in teaching statistics. They provide a concise review of the various simulations developed in the Rice Virtual Lab in Statistics (RVLS) (<http://onlinestatbook.com/rvls.html>), such as the sampling distribution simulation, simulation on the effect of range restrictions, etc. In 2002, Mills performed a literature search on simulation methods to teach statistics in business, economics, mathematics, and other disciplines. Chance and Rossman (2006) provided examples of using Minitab macros and specifically designed applets

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to enhance coverage of various topics, such as probabilities, random sampling, and the sampling distribution of the regression lines. Garfield & Ben-Zvi (2007) provide an excellent overview of research on teaching and learning statistics. It is a summary of studies that have been conducted by researchers from various disciplines.

In recent years, Microsoft Excel became a popular environment for developing interactive tools for teaching various subject, especially statistics (Jones, Hagtvedt & Jone 2004, Tsai et al. 2006, Hayrapetyan 2010, Balakrishnan & Oh 2005, Warner & Meehan 2001). There are several reasons for this new phenomenon: Excel is widely available and provides a very familiar environment for many students and instructors; it contains a rich library of build-in statistical functions; it integrates a programming language called VBA (Visual Basic for Application) that allows the developer to dramatically enhance the basic functionalities of Excel (Mansfield 2008). Balakrishnan et al. (2005) have developed an interactive VBA tool for teaching SPC and process management issues. Students can experiment with the tool to interactively examine the various issues that affect SPC and gain insight into the important issues in managing a process. The graphical nature of the interface allows students to visually see the effect of changes in process parameters. Tsai et al. (2006) have developed a VBA- driven Excel spreadsheet that is built around one simple business scenario and aimed to improve the effectiveness of teaching three concepts in business statistics: the Central Limit Theorem, interval estimation and hypothesis testing. The scenario involves setting the filling speed in a cereal filling plant. Through interactively finding the optimal filling speed, students are exposed to these key statistics concepts as well as to the random sampling techniques. Obviously, not every single statistical concept can be effectively visualized and demonstrated in Excel. Nash (2008) specified which activities in teaching statistics may be suitable candidates for the application of Excel.

Almost all visual tools developed for demonstrating various statistical concepts are pure teaching tools and don't have an assessment component. Besides, those tools do not have practical applications in solving real life problems. This study introduces an Excel-based tool dedicated to teaching and learning some forecasting methods in statistics, namely simple moving averages and exponential smoothing. The tool can be used in business statistics and finance courses in a variety of ways: as a teaching tool for instructors, as a learning instrument for students, and as a self-assessment tool for students. The user (the instructor or the student) can change parameters of the smoothing methods (i.e., the moving average period, the exponential smoothing coefficient) and instantly see the effects of those changes. The Mean Absolute Distance (MAD) is used to compare each of the methods with various parameters and to select the best method with the smallest MAD. Hints are implemented to visualize the calculation logic for each method. There are two key features implemented in this tool, which are not present in the tools referenced above:

a) It has a self-assessment module, which students can use to measure the level of their understanding of the topic. This module asks students randomly generated questions, and keeps track of the student's performance. During this process student may request a hint or even the complete solution of the problem. At the end of the process the system generates a summary result with the student's grade.

b) The tool is not only educational, but also can be used in real applications for

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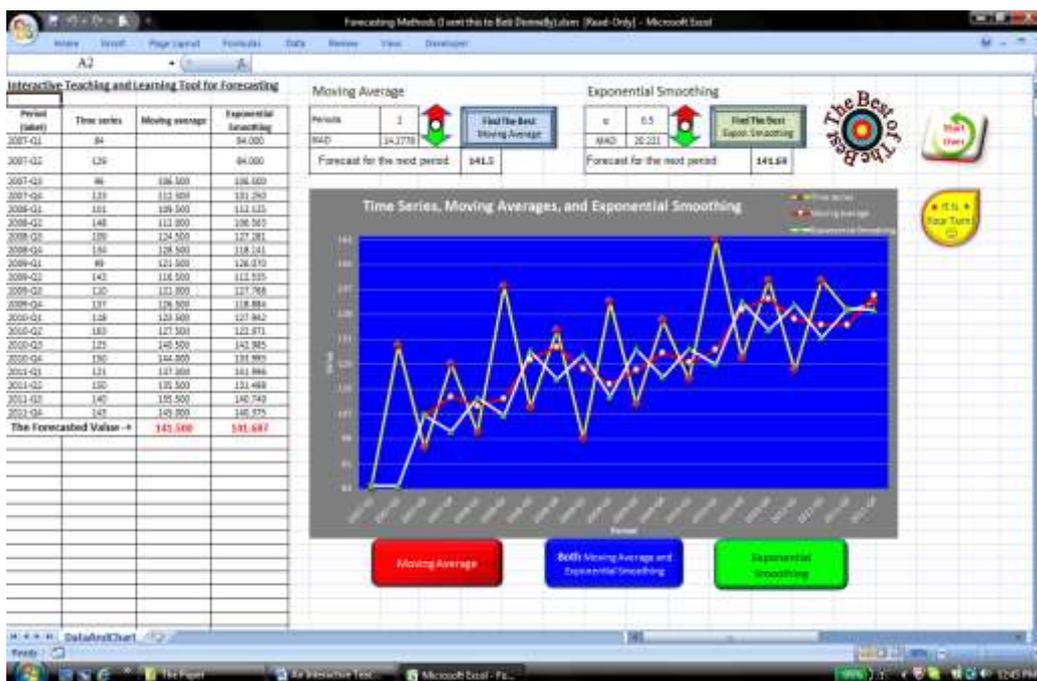
finding the best smoothing method of an actual time series (e.g. a list of daily stock returns) and constructing a forecast (the stock return on the following day).

The entire functionality of the tool is programmed in VBA and is hidden from the user. The tool can be successfully used by anyone with little or no experience in Excel.

### 3. The Methodology and the Model

As mentioned above, the system is a single Excel file with hidden programming modules written in VBA. To launch the system, one should just open the file *Forecasting.xlsm*. Once the system is launched, it will start in *teaching and learning* mode. In this mode the user is asked whether he wants to use a sample time series provided by the system or would like to provide his/her own time series. In the latter case, the user may simply copy a time series data from anywhere and paste it into the predefined area on the spreadsheet. In the former case the user will be provided a sample time series. The next step in both cases is to click on the “Start” button which will do the following calculations and visualizations (See Fig. 1 for a sample data generated by the system):

**Figure 1: Initial Calculations and Graphs for a Sample Data**



- It will calculate 2-period moving averages for the current and all previous time periods including the forecast moving average for the next time period;
- It will perform exponential smoothing with  $\alpha = 0.5$  for the current and all previous time periods including the forecast for the next period. The exponential smoothing is done by using the following formula:

$$S_t = S_{t-1} + \alpha(Y_{t-1} - S_{t-1}) \quad (1)$$

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where

$S_t$  is the forecast value for period  $t$

$Y_{t-1}$  is the actual value for period  $t - 1$

$S_{t-1}$  is the forecast value for period  $t - 1$

$\alpha$  is the smoothing factor (decay rate) of the model

- c. It will calculate the Mean Absolute Deviation (MAD) for both smoothing techniques;
- d. It will graph all three time series: the original, moving averages, and exponential smoothing.

The system also creates various control buttons which are self-explanatory and are designed to perform the following tasks:

- **Up (red) and Down (green) arrows** are created for increasing or decreasing the period  $p$  of the moving averages or the value of  $\alpha$  for the exponential smoothing. The single increment or decrement for the period  $p$  is 1, and for the coefficient  $\alpha$  is 0.05. Each time when the user clicks on one of these control arrows, the corresponding forecasts are recalculated and the graph is updated instantly.
- **Find the Best Moving Average** calculates MADs for all periods from 2 to  $(n + 1)/2$  ( $n$  is the number of actual data points in the time series) and finds the one with the smallest MAD;
- **Find the Best Exponential Smoothing** calculates MADs for all values of  $\alpha$  from 0.05 to 0.95 with the increment of 0.05 and finds the one with the smallest MAD;
- **The Best of the Best** is the combination of the previous two results.
- **Start Over** clears all previous calculations and time series and allows the user to enter a new time series and start experimenting with it.
- **“Moving Average”, “Exponential Smoothing”, and “Both Moving Average and Exponential Smoothing”** buttons are designed to switch between displaying various graphs;
- **It is Your Turn** button switches from the current (teaching and learning) mode to the practicing and self-assessment mode (see more details in the corresponding section below).

While in this *teaching and learning mode*, when the user clicks on any cell with moving average or exponential smoothing, the system highlights all dependent values (cells) which are used to calculate the value in the selected cell. This is a very effective teaching technique for an instructor to emphasize how the calculations are done.

*Practicing and Self-Assessment Mode.* This mode is designed for the students and is selected by clicking on the **“It is Your Turn”** button (see Fig. 1). When it is selected



**Figure 3**  
**A Sample Summary Result**

	I	J	K	L	M	N	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17	<b>Your Progress</b>						
18	Question	Your Answer	Correct Answer	Hint?	Correct?		
19	1	648.33	648.33		Yes		
20	2	865.00	787.32		No		
21	3	750.00	748.50		No		
22	4	335.00	335.00		Yes		
23	5	597.07	597.07		Yes		
24	6	495.25	495.25		Yes		
25	7	412.50	412.50		Yes		
26	8	669.67	669.67	X	Yes		
27	9	697.00	698.75		No		
28	10	567.77	567.77	X	Yes		
29							

When the student wants to complete the self-assessment, he/she clicks on the “Done” button. The system summarizes the student’s answers in a simple worksheet which can be saved and submitted to the instructor if requested (see a sample summary result in the Fig. 3).

As it was mentioned above, this tool improves the previous studies in the field in two directions: a) it adds an assessment module to the tool; b) it allows doing two types of forecasting for the real life data sets.

## 4. Summary and Conclusions

Teaching abstract statistical concepts is very challenging and carefully crafted educational tools can significantly increase the efficiency of the teaching. Besides, many students are visual learners and integration of visual features into the teaching curriculum can also reinforce the understanding of many quantitative concepts. The learning and self-assessment system presented in this paper is developed to serve exactly this purpose. The system is a very user-friendly Excel-based application, which can be easily utilized by any instructor who teaches or uses forecasting methods in the classroom (business statistics, finance, economics, and

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management). The system can be used in two modes: *teaching and learning* mode and *practicing and self-assessment* mode. The instructor may use the teaching and learning mode to teach the simple moving averages and exponential smoothing techniques and visually demonstrate the effect of changing parameters on the forecasted results. Students also may use this mode to master the specified topic. The practicing and self-assessment mode allows the students to check their understanding of the topic. During this process, they can switch back and forth between the two modes. Based on numerous feedbacks received from MBA and undergraduate students, this tool was very helpful in understanding the concept of moving averages and exponential smoothing.

One important feature of the system is that the teaching and learning mode can also be used as an application tool for building forecasts of a real time series data. In order to utilize this feature, the user should enter his/her input data into the predetermined location in the spreadsheet and click on the “The Best of the Best” button. The system will find the best smoothing technique for that particular time series and will calculate the forecast value for the next time period. This feature is unique compare to the similar tools provided in the previous studies.

This tool is used extensively by the author in the undergraduate statistics course and in the decision science course for MBA students. While no formal assessment of its efficiency has yet been conducted, here are some testimonials from students:

- “I enjoyed this tool – it is fun, informative and helps me develop a better understanding of the smoothing techniques.”
- “The self-assessment part was great! I like the “Hint” button and repeatedly used it until I got a B.”
- “Graphs are colorful and change each time I change a parameter. I can immediately see the effects of changing the smoothing parameters”.

Many of them specifically emphasized the usefulness of the self-assessment module, which helped them to check their knowledge and see their weaknesses.

This study has some limitations related to the statistical concepts used. Namely, the tool is designed for two types of smoothing techniques only – moving averages and exponential smoothing. The author is in the process of extending the tool by adding other types of smoothing techniques to the tool.

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