Comparative Statics

When maximum run speed increases from 5 to 10 m/sec, you run longer and dive in after running nearly 80 meters. Thus, you run roughly 23 meters more than when your max speed was 5 m/sec. This is about a 40% increase ($=\frac{23}{56}$). Running more (and swimming less) makes sense, after all, you are much faster running now that you are a world-class sprinter so you should take advantage of this.

Changing an exogenous variable while holding everything else constant (called ceteris paribus) is known as *comparative statics analysis*. It is comparative because you are comparing the new to the initial optimal solution and it is statics because you focus only on the beginning and the end, ignoring any kind of adjustment process (which would be dynamic analysis).

One way to understand what we are doing is by creating a simple graph to show the optimal solution. The x-axis will be how far we run before diving in and the y-axis will be the corresponding time.

STEP Using the initial problem (make sure cell A4 is set to 5), enter the labels Distance Run, Distance Swim, and Time to Victim, in cells G1, H1, and I1, respectively. Create a series from 0 to 100 by 5 by entering 0 in cell G2, 5 in cell G3, and then filling it down. In cell H2, enter the formula for the hypotenuse based on the value in cell G2. Fill down. Compute the Time to Victim in cell I2 and fill it down. Check your numbers with Figure 2.6 and if there are any discrepancies fix your formulas or, if you cannot do it, proceed to the appendix to get help.

Now that we have data for how Time to Victim responds to Distance Run, we can visualize the lifeguard problem by creating a chart. You may know how to make a chart in Excel, but it is worth reviewing basic charting principles before diving in.

STEP Click the link and watch this 3-minute video on making a chart in Excel: vimeo.com/econexcel/how-to-chart-in-excel

Selecting data, clicking the desired chart type, and cleaning up the chart are the three steps. Always check the axes and titles and avoid the dreaded “Series 1” legend text like the plague. Stay away from chartjunk (wild colors and crazy fonts). Best-practice is minimalist—let the data speak for itself (Tufte, 1983).

STEP Make a Scatter chart of Time to Victim as a function of Distance Run. Check that your chart looks like Figure 2.6.

G	H	I
Distance Run	Distance Swim	Time to Victim
0	141.4213562	70.71067812
5	137.9311422	69.96557112
10	134.5362405	69.26812024
15	131.2440475	68.62202374
20	128.0624847	68.03124237
25	125	67.5
30	122.0655562	67.03277808
35	119.2686044	66.63430221
40	116.6190379	66.30951895
45	114.1271221	66.06356105
50	111.8033989	65.90169944
55	109.658561	65.8292805
60	107.7032961	65.85164807
65	105.9481005	65.97405025
70	104.4030651	66.20153254
75	103.0776406	66.53882032
80	101.9803903	66.99019514
85	101.1187421	67.55937104
90	100.4987562	68.24937811
95	100.124922	69.06246099
100	100	70

Figure 2.6: Visualizing the Lifeguard Problem

Figure 2.6 shows pretty clearly that the optimal solution is at the bottom of the U-shaped Time to Victim function. The lifeguard really does face an optimization problem. Correctly solving it means the lifeguard will get to the drowning person as fast as possible.

We can highlight the optimal solution and learn how to add controls to a spreadsheet. The Developer tab needs to be visible on the Ribbon. If it is not, click File, then click Options, then click Customize Ribbon, and check the Developer item.

With the Developer tab available in the Ribbon, we are ready to add a scroll bar. First, we will get a coordinate point, then we will add it to the chart, and, finally, we will connect it to a scroll bar control.

STEP Select cell range G22:I22 and copy (ctrl-c), select cell G24, and paste (ctrl-v). In cell G24, enter the formula =A8 so that we have the optimal solution.

To add this single point to the chart, we will use a powerful, advanced method: we will directly edit the SERIES formula. This approach allows you to easily and quickly reuse or update a chart.

STEP Watch this 5-minute video on how to modify the SERIES formula in a chart: vimeo.com/econexcel/using-series-formula.

We can now add the single point to the chart by copying the existing SERIES formula and editing it, replacing the x and y axes data with the cell addresses of the single point.

STEP Click on the Time to Victim function (click on one of the points), copy, press the ESC key (to clear the formula bar), click on the northwest corner of the chart, paste, and then edit the SERIES formula so it looks like this: =SERIES(Sheet1!$I$1,Sheet1!$G$24:$G$24,Sheet1!$I$24:$I$24,2)

Notice the 2 at the end—this ensures that the point is always visible because it is on top of the first series. To highlight it further, increase the size of the point by clicking on it and increasing the width of the marker size to 5 pts.

You can enter any number from 0 to 100 in the cell A8 to display that point on the Time to Victim function. We can make it easy for the user to move the point on the chart by adding a scroll bar connected to cell A8.

STEP Click the *Developer* tab on the *Ribbon*, click the down arrow in the *Insert* button, and select the scroll bar icon (in the top, *Form Control* group) as shown in Figure 2.7. Click and drag on the spreadsheet (roughly under the chart) to create the scroll bar control.

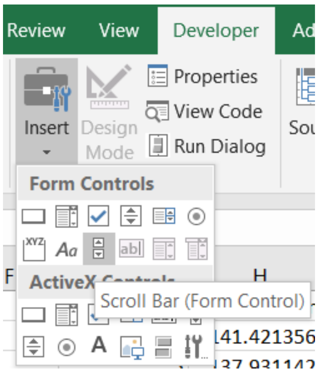

Figure 2.7: Accessing the scroll bar form control.

STEP Right-click the scroll bar control (that you just created), click the *Control* tab, click in the *Cell link* field, and click cell G24 (it appears in the field). Click OK and click on a cell in the spreadsheet. Click a few times on the scroll bar to make the red dot on the chart move along the Time to Victim function.

You can also click the scroll box itself (sometimes called a thumb) and drag it. You can also manually change the value in cell G24 and the scroll bar box will reflect that value.

STEP Enter the formula =A8 in cell G24 to display the optimal solution and see that scroll box moves to this value.

We now have a clear display of the optimal solution and understand that it minimizes Time to Victim, but the correct solution depends on the exogenous variables. What happens, for example, when you become Usain Bolt and can run, not 5 m/sec, but 10 m/sec?

STEP Change cell A4 to 10 and watch what happens.

Excel immediately updates the chart and the changes are dramatic. It is clear that the function has shifted down and there is a new minimum to the right of the initial solution.

How can we compare the two situations? One way is by displaying the two environments (initial with 5 m/sec and new with 10 m/sec) on the same chart. We can do this with a clever trick that has many applications: create a transparent image and lay it on top of the chart.

To make the comparison display correctly, we need to lock down the y-axis in the chart.

STEP Right-click any number on the y-axis and change the minimum and maximum axis bounds to 55 and 75, respectively. Change the major unit to 5.0.

If the step above is skipped, the “chart stacking” strategy will not work because Excel will automatically adjust the y axis scale. Manually setting and fixing the scale is a necessary step when stacking charts.

STEP Click the chart, click the *Format* tab in the Ribbon, click *Shape Fill*, and select, *No Fill*. Click and drag the chart around a little to see that it is transparent.

The cell borders are now visible and this is distracting so we will remove them.

STEP Click *Page Layout* in the Ribbon and uncheck *View* under *Gridlines* (in the *Sheet Options* group).

The chart is still transparent, but there are no cell borders so the chart’s background is white.

STEP Select and copy the chart, then click on a cell (to unselect the chart). Click the down arrow on the Paste menu item (in the Home tab) and click on the picture icon as shown in Figure 2.8.

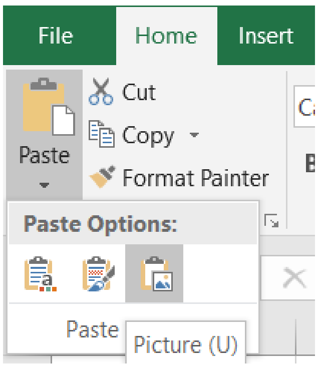

Figure 2.8: Pasting as a Picture.

The chart you just pasted is "dead" in the sense that it is a fixed image and is not connected to the data like the original chart. It can be pasted in a doc or slide and will not change even if you alter the data.

STEP Drag the chart you just pasted so it is exactly on top of the live, original chart. Add text boxes to label the initial and new solutions (remove the border and fill of the text boxes to improve the display).

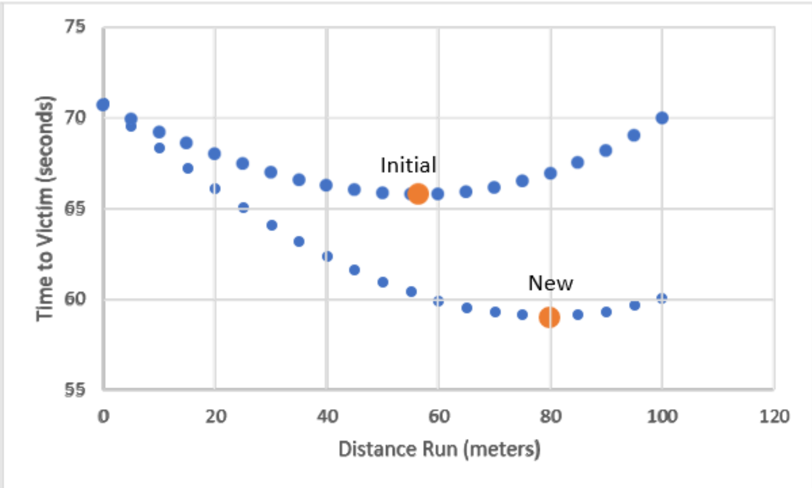

Figure 2.9: Comparative statics visualization.

Your final product should look like Figure 2.9. It clearly shows the impact of the shock to running speed on the lifeguard problem. The entire function shifts down and the minimum moves to the right.

What other exogenous variables are there in the lifeguard problem that we ignored? Imagine yourself as a real lifeguard on a crowded beach, perched on a chair looking out over the ocean. What else would influence your decision of where to enter the water?

Takeaways

We shocked the lifeguard problem by changing max run speed from 5 m/sec to 10 m/sec, ceteris paribus, and found that the optimal distance to run on the sand increased. This is an example of comparative statics analysis.

We visualized the lifeguard problem by creating a chart in Excel of Time to Victim as a function of distance run. This made it easy to see that we are working on a minimization problem and that the solution is at the bottom of the bowl.

Creating a chart in Excel always involves three steps:

1. Select the data: hold down the *ctrl* key to select non-contiguous cells

2. Insert the desired chart type: usually it is a *Scatter* chart, but Excel has many chart types

3. Clean up the chart: be sure to check the title, the legend text, and the axes labels

Data visualization is a mixture of art and science. In Excel, always remember the third step in charting: label axes, add a descriptive title and make sure the chart is clear and easy to understand. Be sure that the legend is needed and makes sense. A minimalist approach is best.

The bible of chart design is Tufte (1983). This classic preaches simple, clean chart design. Excel allows you to do all kinds of word art and color schemes. You should avoid this.

Excel is a complicated software with many features and capabilities. Understanding that a chart is really a SERIES formula is a big step forward. Directly editing the SERIES formula has many powerful applications.

The transparency trick is also quite useful. You are slowly building a library of skills and knowledge. There is not a single, specific thing that makes you an Excel expert. It is like a wall, every brick matters.

References

Tufte, E. (1983) *The Visual Display of Quantitative Information* (Cheshire, CT: Graphics Press). Open access: archive.org/details/visualdisplayofq0000tuft

For more on how graphs and data visualization evolved, see Friendly, M. and Wainer, H. (2021) *A History of Data Visualization and Graphic Communication* (Cambridge, MA: Harvard University Press).

Appendix

To replicate Figure 2.6, follow the steps below, but think about the formulas you are entering and what each cell is doing instead of mindlessly typing:

1) In cell H2, enter the formula =SQRT(($A$2-G2)^2+$A$3^2) and fill it down. Note that if you do not use absolute references (the $ before cell column and row), then the formula does not work when you fill it down.

An absolute reference, like $A$2, means when you copy and paste the cell (or fill it down), the formula remains unchanged and will continue to refer to $A$2. A relative reference, like G2 (no $ signs) means the formula will change because entering =G2 in cell H2 means “the cell one column to the left of this cell.”

2) In cell I2, enter the formula =G2/$A$4+H2/$A$5 and fill it down. Again, note the use of absolute references.

Both formulas were used earlier and neither hard-code the variables—in other words, cell addresses are used instead of numbers. This maximizes spreadsheet flexibility.

Use the *ctrl* key to select non-contiguous data to make the chart.