

How to perform Logarithmic Regression in Excel (Step-by-Step)?

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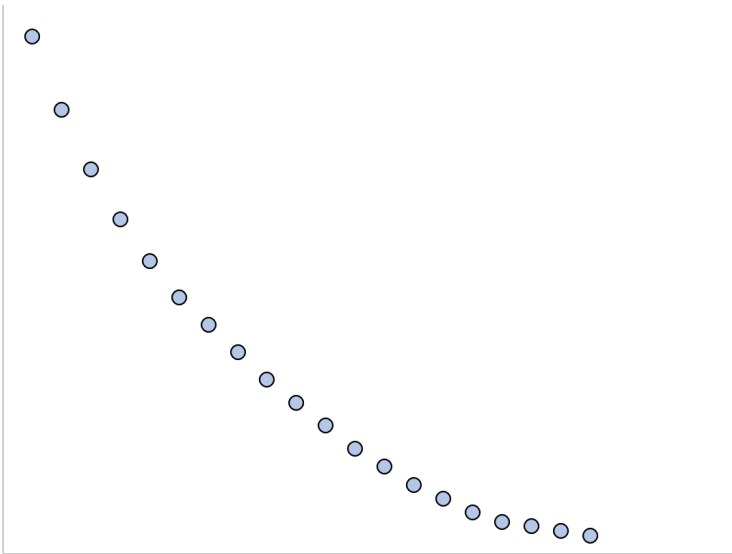
Logarithmic regression is a powerful technique within the broader field of regression analysis used specifically to model relationships where the rate of change is not constant. This model is exceptionally useful for phenomena exhibiting rapid initial growth or decline followed by a significant tapering off, eventually leveling out. Such patterns are common across various disciplines, including finance (diminishing marginal returns), biology (population growth deceleration), and physics. Understanding how to implement this analysis tool is crucial for accurate data modeling, and fortunately, Microsoft Excel provides robust features for performing this task efficiently.

Unlike simple linear models which assume a straight-line relationship, logarithmic models handle curves elegantly. The core assumption is that the relationship between the independent variable (predictor) and the dependent variable (response) follows a logarithmic curve. By transforming the independent variable using the natural log function, we convert the nonlinear relationship into a form that can be analyzed using standard linear regression analysis techniques, making the computation straightforward even in platforms like Excel.

Conceptual Foundation of Logarithmic Regression

Logarithmic regression is fundamentally different from exponential or power regression, though all deal with non-linear data. The signature characteristic of the logarithmic model is the asymptotic behavior--meaning the curve approaches a limit but never quite reaches it. This makes it ideal for modeling processes that have a maximum capacity or a saturation point, such as learning curves or the depletion of resources.

Consider a scenario involving decay, where the change is initially sharp. The following visualization illustrates a classic example of logarithmic decay, where the value drops steeply early on, but the rate of decline slows considerably as the predictor variable increases. This visual pattern is the first indicator that a logarithmic model may provide a superior fit compared to a linear one.



For data that exhibits this characteristic shape, where the impact of the predictor variable diminishes as its magnitude increases, logarithmic modeling provides the most appropriate mathematical structure. We rely on this method to define the precise mathematical relationship, allowing for accurate interpolation and prediction within the observed data range.

Mathematical Form and Components

The mathematical equation defining the logarithmic regression model transforms the relationship into a linear function of the natural log of the predictor variable. This transformation is key to using standard regression tools, like the Data Analysis ToolPak in Excel, which fundamentally rely on fitting linear models.

The equation for a logarithmic regression model takes the following standard form:

$$y = a + b * \ln(x)$$

Where the components are defined as follows:

y: Represents the response variable (dependent variable) we are attempting to predict or model.

x: Represents the predictor variable (independent variable) used in the analysis. Note that since we use the natural log of x , the variable x must always be a positive value ($x > 0$).

a, b: These are the regression coefficients. Coefficient 'a' is the intercept, and coefficient 'b' represents the slope or the change in y for a one-unit change in the natural log of x . These coefficients are what the regression analysis aims to calculate, as they mathematically define the curve of the relationship between x and y .

The following step-by-step guide details the process of executing a logarithmic regression analysis within Microsoft Excel, moving from raw data entry to the interpretation of the statistical output.

Step 1: Preparing Your Dataset in Excel

The initial stage of any regression analysis requires careful organization of the data. Excel expects the data to be structured in columns, with paired observations for the predictor (independent) and response variable (dependent). For demonstration purposes, we will utilize a simulated dataset containing observations for variables x and y .

It is crucial at this stage to ensure data cleanliness. Check for missing values, outliers, and confirm that all values for the predictor variable x are strictly positive, as the natural log function is undefined for zero or negative numbers. Any non-positive x values must be addressed (imputed, removed, or transformed using an alternative model) before proceeding with the logarithmic transformation.

Let's begin by entering the sample data into two columns, labeled x and y , respectively, starting from cell A1.

	A	B	C	D	E	F
1	x	y				
2	1	59				
3	2	50				
4	3	44				
5	4	38				
6	5	33				
7	6	28				
8	7	23				
9	8	20				
10	9	17				
11	10	15				
12	11	13				
13	12	12				
14	13	11				
15	14	10				
16	15	9.5				
17						
18						
19						
20						
21						
22						
23						
24						

Once the data is correctly entered and verified, we can move on to the essential transformation step that makes logarithmic regression possible using Excel's linear regression tools.

Step 2: Transforming the Predictor Variable using the Natural Logarithm

To fit the logarithmic model ($y = a + b * \ln(x)$), we must first calculate the natural logarithm of every observation of the predictor variable x . This transformed variable, which we can call ' $\ln(x)$ ', will act as our new independent variable in the subsequent linear regression calculation.

Create a new column adjacent to your existing data, perhaps labeled ' $\ln(x)$ '. In the first cell of this new column (e.g., cell C2), enter the Excel formula for the natural logarithm, referencing the corresponding x value in column A. The Excel function for the natural logarithm is `=LN()`.

For the first data point (assuming x is in A2), the formula would be: `=LN(A2)`. Drag this formula down to apply the transformation to all rows of the dataset. This step is non-negotiable for performing logarithmic regression using the standard Data Analysis ToolPak.

	A	B	C	D	E	F	G
1	x	y	ln(x)				
2	1	59	0	=LN(A2)			
3	2	50	0.693				
4	3	44	1.099				
5	4	38	1.386				
6	5	33	1.609				
7	6	28	1.792				
8	7	23	1.946				
9	8	20	2.079				
10	9	17	2.197				
11	10	15	2.303				
12	11	13	2.398				
13	12	12	2.485				
14	13	11	2.565				
15	14	10	2.639				
16	15	9.5	2.708				
17							
18							
19							
20							
21							
22							
23							
24							
25							

We have now successfully transformed our original dataset into the format required for linear regression analysis, where the response variable y (Column B) is regressed against the

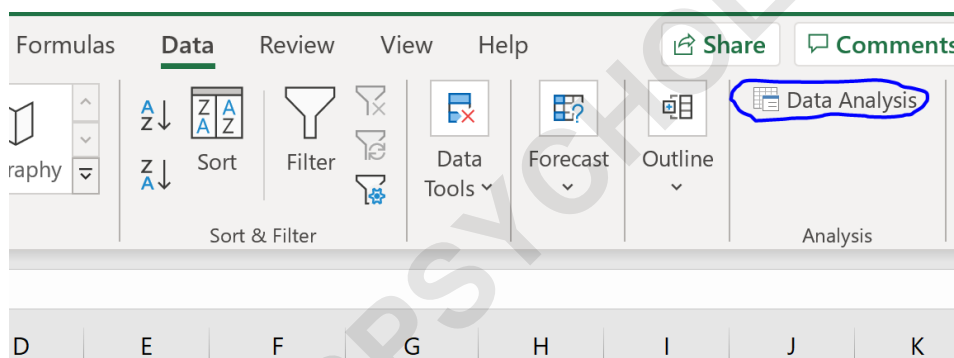
transformed predictor variable $\ln(x)$ (Column C).

Step 3: Enabling the Data Analysis ToolPak

The fitting of the logarithmic regression model relies on Excel's specialized statistical add-in: the Data Analysis ToolPak. If you have not used it before, you must ensure it is enabled, as it is often disabled by default. If you already see the 'Data Analysis' button under the Data tab, you may skip this preliminary instruction.

To activate the ToolPak: Navigate to the **File** tab, select **Options**, then choose **Add-ins**. In the Manage dropdown menu at the bottom, select **Excel Add-ins** and click **Go**. In the subsequent dialogue box, ensure the **Analysis ToolPak** is checked, and click **OK**. After this one-time activation, the Data Analysis option will permanently appear in the Data ribbon.

With the ToolPak enabled, proceed to the **Data** tab along the top menu ribbon, and then click the **Data Analysis** button located within the **Analysis** group on the far right. This action opens the gateway to fitting sophisticated statistical models, including the regression tool we require.



In the subsequent window that appears, scroll down the list of statistical tests and select **Regression**. Click **OK** to open the main Regression dialogue box, where you will specify your input and output ranges based on the data columns created in the previous steps.

Step 4: Configuring and Running the Regression Analysis

The Regression dialogue box requires specific inputs to correctly perform the analysis. It is absolutely vital to use the transformed variable, $\ln(x)$, as the predictor variable here. If the original x variable is used, the model will simply perform standard linear regression, failing to capture the logarithmic relationship.

Fill in the following parameters precisely:

Input Y Range: Select the range containing the response variable y (e.g., $\$B\$1:\$B\16 , including the header).

Input X Range: Select the range containing the **transformed predictor variable**, $\ln(x)$ (e.g., $\$C\$1:\$C\16 , including the header).

Labels: Check this box if you included the column headers in your selected ranges (highly recommended for clarity).

Output Options: Select a suitable location for the output (e.g., "New Worksheet Ply" or a specific cell on the current sheet).

Residuals: Optionally check boxes like Residuals or Standardized Residuals if you plan to perform further diagnostics on the model fit, although for the basic calculation, these are not strictly necessary.

	A	B	C	D	E	F	G	H	I	J
1	x	y	ln(x)							
2	1	59	0							
3	2	50	0.693							
4	3	44	1.099							
5	4	38	1.386							
6	5	33	1.609							
7	6	28	1.792							
8	7	23	1.946							
9	8	20	2.079							
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Once all parameters are accurately entered, click **OK**. Excel will instantly generate a

comprehensive statistical output table, which is the result of the linear regression performed on y and $\ln(x)$.

Step 5: Interpreting the Excel Regression Output

The output sheet generated by Excel contains several critical statistical measures necessary for assessing the quality and significance of the logarithmic regression model. We must focus on the Summary Output and the ANOVA and Coefficients tables.

	E	F	G	H	I	J
SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R		0.992242675				
R Square		0.984545526				
Adjusted R Square		0.98335672				
Standard Error		2.053603726				
Observations		15				
ANOVA						
		<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression		1	3492.675253	3492.675	828.1803	3.70174E-13
Residual		13	54.82474741	4.217288		
Total		14	3547.5			
<i>Coefficients</i>						
		<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept		63.06859979	1.409031708	44.76024	1.25E-15	60.02457185
$\ln(x)$		-20.19869943	0.701876896	-28.7781	3.7E-13	-21.71501227

First, examine the **ANOVA** table. The F-statistic (828.18 in this example) and its associated significance F (p-value: 3.70174E-13) tell us whether the model as a whole is statistically significant. An extremely small p-value (typically less than 0.05) strongly suggests that the model explains a significant amount of the variance in the response variable y , indicating that the logarithmic relationship is meaningful.

Second, the **R Square** value (or Coefficient of Determination) in the Summary Output indicates the proportion of the variance in y that is predictable from the transformed predictor $\ln(x)$. A value closer to 1 (e.g., 0.9829 or 98.29%) signifies an excellent fit.

Finally, the **Coefficients** table provides the estimates for the regression coefficients (a and b) that define the specific logarithmic equation for your data.

The Intercept coefficient corresponds to 'a' in our formula.

The coefficient next to 'ln(x)' (labeled as 'X Variable 1' since ln(x) was in the X range) corresponds to 'b'.

From the example output above, the intercept (a) is 63.0686, and the coefficient for ln(x) (b) is -20.1987.

Utilizing the Fitted Logarithmic Model

By extracting the estimated regression coefficients from the Excel output, we can construct the precise mathematical equation that models our data. This equation is the primary goal of the logarithmic regression process.

Using the coefficients derived:

$$y = 63.0686 - 20.1987 * \ln(x)$$

This fitted equation allows us to make predictions for the response variable y based on any positive value of the predictor variable x that falls within the domain of the original data. This process is known as interpolation.

For instance, if we wish to predict the value of y when the predictor variable x equals 12, we substitute 12 into the equation:

$$y = 63.0686 - 20.1987 * \ln(12)$$

Since the natural log of 12 is approximately 2.4849, the calculation becomes:

$$y = 63.0686 - 20.1987 * 2.4849 \approx 63.0686 - 50.1986 \approx \mathbf{12.87}$$

Therefore, our logarithmic model predicts that when x is 12, y will be 12.87. This predictive capability is the practical application of successful regression analysis.

Advanced Note: For users seeking instant computation without manual data manipulation, several specialized online calculators are available. These tools allow you to input your paired data directly and automatically compute the logarithmic regression equation and relevant statistics, serving as a quick validation or alternative method.

Further Regression Topics

To continue exploring data modeling techniques in Excel, consider learning about other regression forms:

[How to Perform Simple Linear Regression in Excel](#)

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