

# How to use the CINV function in SAS?

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The CINV function in SAS is a fundamental statistical tool used to calculate the inverse of a cumulative distribution function (CDF) for a specific input probability. This process is crucial in statistical inference as it allows analysts to determine the precise quantile, or critical cutoff value, associated with a given statistical distribution.

The general conceptual syntax of the function is structured to accept the desired probability and the parameters defining the shape of the distribution, such as the mean and standard deviation for certain continuous distributions. For instance, in theory, the form could be `CINV(probability, mean, standard_deviation)`. The function then returns the value (the inverse cumulative distribution) that corresponds to the cumulative area specified by the input probability.

The most frequent statistical application of the CINV function in SAS involves finding critical values required for common statistical tests. Specifically, it is excellent for deriving these thresholds from the Chi-Square distribution, a necessity when conducting goodness-of-fit or independence tests.

## Understanding the Inverse Cumulative Distribution Function

To appreciate the utility of the SAS CINV function, it is essential to understand its statistical foundation. A standard cumulative distribution function (CDF) calculates the probability that a random variable falls below a certain value  $x$ . The inverse CDF, or quantile function (which CINV performs), reverses this process: it accepts a probability  $p$  and returns the exact value  $x$  on the distribution scale up to which the cumulative probability is  $p$ .

In the context of formal hypothesis testing, the input probability  $p$  is often calculated directly from the chosen significance level ( $\alpha$ ). For distributions typically associated with right-tailed tests, such as the F or Chi-Square distribution, the function requires the cumulative probability,  $p = 1 - \alpha$ . This calculation ensures that the output critical value correctly defines the boundary between the region where the null hypothesis is accepted and the rejection region.

SAS performs this calculation with high computational accuracy, providing results far more precise than those typically interpolated from physical statistical tables. This accuracy and automation capability make the CINV function an indispensable tool for analysts handling large datasets or requiring highly specific probability thresholds that might not be available in standard tabular formats.

## The Role and Syntax of CINV for the Chi-Square Distribution

When specifically used to find critical thresholds for the Chi-Square distribution, the CINV function uses a concise and targeted syntax:

**CINV( $p$ ,  $df$ )**

This specialized syntax defines the required parameters efficiently. The function is designed to work within any SAS DATA step or procedure that allows function calls, enabling dynamic calculation of critical values during data processing.

The parameters are defined clearly based on standard statistical notation:

**p:** This argument represents the cumulative probability. As noted, this is typically derived from the significance level ( $\alpha$ ) by calculating  $1 - \alpha$ . For example, a standard 5% significance level ( $\alpha = 0.05$ ) requires an input of  $p = 0.95$ .

**df:** This refers to the degrees of freedom. The degrees of freedom parameter dictates the precise shape of the Chi-Square distribution curve, which in turn significantly influences the magnitude of the resulting critical value.

The successful execution of this function returns the boundary value on the horizontal axis of the distribution. This value is the critical threshold used to compare against the calculated Chi-Square test statistic.

### Example 1: Calculating the Chi-Square Critical Value (Alpha = 0.05)

We will demonstrate how to use the **CINV** function in practice to calculate a specific Chi-Square critical value. Suppose we are required to find the critical threshold for a test conducted at a significance level ( $\alpha$ ) of **0.05**, with the distribution possessing **11** degrees of freedom.

First, we calculate the required cumulative probability  $p$ :  $p = 1 - 0.05 = 0.95$ . We then embed the CINV function call directly within a SAS DATA step. This allows us to create a new dataset that specifically records this calculated critical value, making it available for subsequent analysis or reporting.

The code below executes the calculation and utilizes the `PUT` statement to print the resulting critical value to the SAS log for immediate confirmation, followed by a `PROC PRINT` step to display the contents of the generated dataset:

```
/*create dataset that contains Chi-Square critical value*/
```

```
data my_data;  
critical_val=cinv(.95, 11);  
put critical_val=;  
run;
```

```
/*view results*/
```

```
proc print data=my_data;
```

Obs	critical_val
1	19.6751

## Interpreting the Critical Value for Statistical Decision-Making

The execution of the SAS code reveals that the Chi-Square critical value for the specified parameters (significance level of 0.05 and 11 degrees of freedom) is exactly **19.67514**. This numerical result serves as the absolute boundary for deciding the outcome of the statistical hypothesis test.

This figure, **19.67514**, is the dividing line. When conducting a Chi-Square test, the test statistic calculated from the collected sample data must be compared against this threshold. If the calculated test statistic is greater than **19.67514**, it means the observed result is sufficiently rare (occurring only 5% of the time or less by chance) to warrant rejecting the null hypothesis. In this event, we conclude that the observed differences or associations are statistically significant.

If, however, the calculated Chi-Square test statistic is less than or equal to 19.67514, the evidence is deemed insufficient to reject the null hypothesis at the 0.05 significance level. In practice, analysts rely heavily on the accuracy of the CINV function to set this benchmark, ensuring that their conclusions regarding statistical significance are statistically sound and reproducible.

### Example 2: Impact of a Smaller Significance Level (Alpha = 0.01)

To illustrate the direct relationship between the significance level and the magnitude of the critical value, let us analyze a scenario where the requirement for statistical proof is stricter. We will use a smaller significance level of  $\alpha = 0.01$ , while maintaining the degrees of freedom at 11.

A stricter significance level means we are only willing to accept a 1% chance of committing a Type I error (false rejection of the null hypothesis). To achieve this, the rejection region must shrink, pushing the critical boundary further into the tail of the Chi-Square distribution. The required cumulative probability  $p$  is therefore calculated as  $1 - 0.01 = 0.99$ .

We adjust the CINV function call to reflect this new probability input (0.99) and run the SAS code again. Notice that only the probability argument changes, demonstrating how flexible the function is for exploring different statistical confidence intervals.

```
/*create dataset that contains Chi-Square critical value*/  
data my_data;  
critical_val=cinv(.99, 11);
```

```
put critical_val=;
run;

/*view results*/
proc print data=my_data;
```

Obs	critical_val
1	24.7250

The resulting Chi-Square critical value for a significance level of 0.01 and degrees of freedom = 11 is **24.7250**. This confirms the statistical axiom: reducing the allowable error (alpha) increases the required threshold (critical value), making it more difficult to declare a result statistically significant, thereby increasing confidence in any rejection of the null hypothesis.

## Comparison to Traditional Methods

The efficiency of using the CINV function in SAS contrasts sharply with traditional manual methods. While it is possible to use printed statistical tables to find these critical values by interpolating across the appropriate degrees of freedom and significance level columns, the values calculated by the **CINV** function in SAS offer superior precision.

**Note:** You can also use the traditional Chi-Square table to find critical values by hand. The values that you find in the table, assuming no rounding errors, will closely match the ones calculated by the **CINV** function in SAS, confirming the functional accuracy of the SAS routine.

## Concluding Thoughts on CINV

Mastering the CINV function is a prerequisite for advanced statistical work in SAS, especially in areas requiring precise hypothesis testing. It serves as a programmatic bridge between the chosen statistical error rate ( $\alpha$ ) and the physical cutoff point on the distribution curve, ensuring objectivity and accuracy in the decision to reject or retain the null hypothesis.

The flexibility of the CINV function allows it to be adapted across numerous statistical distributions supported by SAS (e.g., normal, t, F, and chi-square), making it one of the most versatile functions available for statistical programming and analysis.

The following tutorials explain how to perform other common statistical and data manipulation tasks in SAS, often building upon the foundation laid by functions like CINV: