

## Paper JP-05

**Evaluating Consumer Price Behavior Using JMP®**

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**ABSTRACT**

The Consumer Price Index for the urban population (CPI-U) represents the month-to-month inflation experience of the average urban consumer within the United States. The CPI-U is based on expenditure weights and price changes for a defined market basket of goods and services. The expenditure weights are derived from the Consumer Expenditure Survey (CES) and are updated biennially. The change in prices is based on the Bureau of Labor Statistics (BLS) price survey, which accounts for nearly 90,000 price quotes collected each month. The purpose of this paper is to demonstrate an interactive analysis of the impact of hypothetical component inflation on overall inflation using JMP® Prediction Profiler. First, we will set up our CPI-U model in Microsoft Excel based on data queried from the BLS website. Next, we will define the model using the JMP® application within Excel. Last, we will interactively analyze how the change in a component group index impacts the All-Items aggregate index.

**BACKGROUND**

The CPI-U is composed of item categories and geographic areas. The market basket is divided into item categories of 211 consumer goods and services, and the country is divided into 38 geographic areas. The first step is to estimate price change within these item-area combinations, a process referred to as lower level estimation. The second step is to estimate price change across aggregates of the item-area basic cells, which is referred to as upper-level estimation. This paper evaluates price change of these aggregate combinations. The All-Items index is composed of eight Major Group components: Apparel, Education and Communication, Food and Beverages, Other Goods and Services, Housing, Medical Care, Recreation, and Transportation.

Upper-level estimation is based on a Laspeyres index formula. The expenditure weights are fixed quantities because they are fixed to a base period. For this paper, the CPI-U data displayed in Figure 1 are calculated as follows:

1. Query the 2010 monthly indexes by Major Group from the CPI Database table available on the BLS website. Query the cost weight relative importances from the Relative Importance of Items in the Consumer Price Index, December 2010, and the 2007-2008 weights data from the BLS website.
2. The Major Group relative importances are based on the December 2009 cost weights, derived from the 2007-2008 CES annual average expenditure weights pivoted from the survey time period to the index time period. Cost weights are equal to an aggregation weight  $\left(\frac{\hat{P}_0 \hat{Q}_B}{100}\right)$  multiplied by the price index  $(IX_T)$  and are available from the BLS website. Cost weights for Major Group components divided by the sum of cost weights for all Major Groups yields a value relative to the All-Items category.

$$\text{Cost Weight Relative Importance}_{(MG,T)} = \left( \frac{(\hat{P}_0 \hat{Q}_B)_{MG} * (IX_T)_{MG}}{(\hat{P}_0 \hat{Q}_B)_A * (IX_T)_A} \right)$$

The variables are defined as follows:

- |              |  |
|--------------|--|
| a. $\hat{P}$ | Estimated Price  |
| b. $\hat{Q}$ | Estimated Quantity based on Consumer Expenditure data                    |
| c. $IX$      | Consumer Price Index   |
| d. $MG$      | Major Group  |
| e. $A$       | All-Items  |
| f. $B$       | Biennial expenditure weight time period – 2007-2008                      |
| g. $O$       | Pivot Month - December of 2009   |
| h. $T$       | Index month first used in index - January of 2010. Base Month- see below |

3. The 2010 monthly CPI-U Not Seasonally Adjusted Indexes by Major Group are rebased to January 2010. The M variable takes on the values of the months January – December of 2010.

$$\text{Rebased 2010 Indexes}_{M,MG} = 100 * \left( \frac{(IX_M)_{MG}}{(IX_T)_{MG}} \right)$$

4. The product of the cost weight Relative Importance and the 2010 annual average index is calculated for each Major Group and then summed. This final value defines the model and will be used as the output factor for the JMP® Prediction Profile.

$$\text{Annual Average Index} = \sum \left( \left( \text{Cost Weight Relative Importance}_{(MG)} \right) * \left( \frac{\sum_{MG} \text{Rebased 2010 Monthly Indexes}_{M,MG}}{12} \right) \right)$$

## PREDICTION PROFILER OVERVIEW

The Prediction Profiler JMP® add-in for Excel enables a user to visualize a cell-based model, and analyze the effect that changes to inputs have on that model. Profiling estimates the predicted response of a Y dependent variable, the output factor, based on X independent variables, the input factors. The value of the Prediction Profiler is that it allows a user to interactively change an input factor value and then evaluate the impact of that change on the output factor, while holding the other input factors constant. When the input factor value changes, a new output factor value is dynamically calculated.

The input factors are displayed as individual graphs on the X axis, where the input factor value is displayed in the X-axis numerical value and a vertical red dotted line for each of these individual graphs. The Trace Line is the solid black line that defines the predicted response. The steepness of the trace line for the CPI model indicates the importance of the input factor. The output factor is displayed as a Y-axis numerical value and as a horizontal red dotted line across all of the input factor graphs.

## DEFINING AND RUNNING THE CPI MODEL

For the CPI model, the Major Group 2010 annual average component indexes serve as input factors, and the All-Items annual average aggregate index will serve as the output factor. The slope is based on the Major Group cost weight relative importance. For this CPI model, there are no interaction effects; therefore, change of the Y horizontal red dotted line is limited to the movement up or down along the Trace Line, and there are no changes to the slope or the shape of the input factor line.

To define the CPI Model displayed in Figure 3 click on the Edit / New Model button from Figure 2 under the JMP® tab within Excel. In the Define Model Window create a new Model Name, such as Profile CPI 2010 by MG, and then click the + button. Define the input factors based on the annual average indexes by creating an Input Name, and Initial Value, both of which can be set by clicking on the CELL buttons and then clicking the appropriate cell within Excel. Note that the Minimum Value and the Maximum Value were set to 95 and 105, respectively, as default values. If these values are not entered, then JMP® calculates them based on +/-5% of the Initial Value. Next, define the output factors based on the CPI model that was created in a separate cell. JMP® Prediction Profiler has the capability to read in Excel functions. For the Profile CPI 2010 by MG Model, the output cell formula is defined as =SUMPRODUCT(B2:B9,C2:C9). Last, click OK to enter the input and output factor values.

To create the Prediction Profiler click on the Run Model button displayed in Figure 3. A new window within JMP® pops up displaying the Profile CPI 2010 by MG Model.

## SETTING USER OPTIONS

Before beginning analysis of the data it is useful to review three option settings. The X and Y-axis settings are defined by right-clicking on the gray area to the left of or under the input factor graphs, selecting Axis Settings, and then an X- or Y-Axis Specification window pops up. For this CPI model, the Minimum value was set to 95, the Maximum value was set to 105, and the Increment value was set to 2. The Axis settings may be copied and pasted across a series of graphs by right-clicking on the newly defined Axis, and then selecting Edit > Copy or Paste

Settings. The settings can be applied to all input factor graphs at the same time by clicking on the Ctrl button, selecting an input factor graph, and then selecting Edit > Paste Settings.

The Sensitivity Indicator is a useful option that displays a purple triangle where the length and direction are relative to a partial derivative of the model defined in the output cell. For the CPI model, the Sensitivity Indicator is a measure of the cost weight relative importance. To add the Sensitivity Indicator, click on the red triangle to the left of the Prediction Profiler Title, and then select Sensitivity Indicator.

The Remember Settings option allows a user to reset Prediction Profiler to original input factor values. To create the Remembered Settings Table displayed at the bottom of Figure 5, click on the red triangle to the left of the Prediction Profiler Title, select Factor Settings, and then select Remember Settings Options.

## INTERACTIVE ANALYSIS OF THE CPI MODEL

Now that the settings are customized let's evaluate 3 scenarios within Prediction Profiler.

Scenario 1. Evaluate a 2-point increase to the Housing component index.

A move of the Housing component index to the right by two points yields an All-Items aggregate index move from 100.63 to 101.47, or a .84 point increase. Notice the movement upward and to the right along the Trace Line for the Housing input factor, which results in a large move of the All-Items aggregate index.

Scenario 2. Evaluate a 2-point decrease to the Apparel component index.

Reset the indexes to original values by clicking on the Original Settings. A move of the Apparel component index by two points to the left causes the All-Items aggregate index to decrease from 100.63 to 100.56, or a .07 point decrease. The Apparel input factor displays a flat Trace Line. Therefore this 2-point decrease causes a small change to the All-Items aggregate index.

Scenario 3. Evaluate a 2-point increase to both Food and Beverages, and Transportation indexes.

Reset the indexes to the Original Settings. A move of the Food and Beverages and the Transportation component indexes by two points to the right causes the All-Items aggregate index to move from 100.63 to 101.26, or a .63 point increase. The steepness of the slopes for Food and Beverages, and Transportation input factors are moderate. The increase of both of these components causes a moderate change in the All-Items aggregate.

## SUMMARY

The JMP® add in for Excel allows a user to define a cell-based model using input and output factors. Additionally, the interactivity allows each user to make evaluations based on their individual analysis. The CPI model in this paper focuses on price indexes; however, a user could extend the analysis of a cell-based model to any number of work or research-related projects. For future research I plan to evaluate lower-level component price indexes such as Gasoline, create a Laspeyres/Geomeans model to evaluate micro level price quotes, and create a consumer price elasticity of substitution model to evaluate Laspeyres based preferences.

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Figure 1. Table Summary of Cost Weight Relative Importance, Annual Average Index by Major Group

	A	B	C
1	Item Code	CWRI_0912	2010_AVG
2	Apparel	0.04	102.421
3	Education	0.06	100.656
4	Food and Beverages	0.15	100.347
5	Other Goods and Services	0.03	100.964
6	Housing	0.42	100.153
7	Medical Care	0.07	101.502
8	Recreation	0.06	100.003
9	Transportation	0.17	101.514

Figure 2. JMP® Tab and Profile Buttons



Figure 3. Defining Model Window

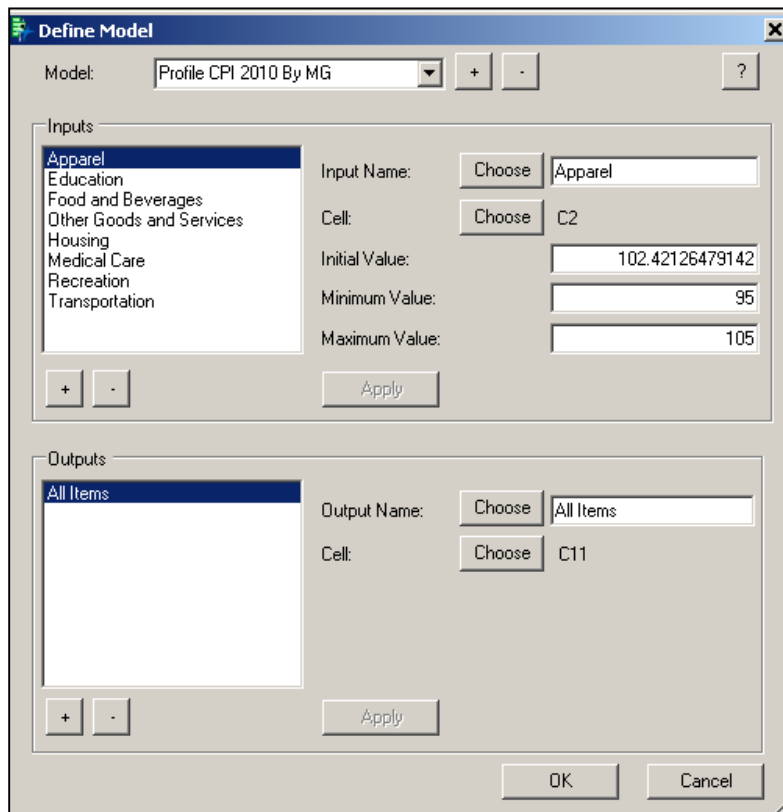


Figure 4. Run Model Pop Up

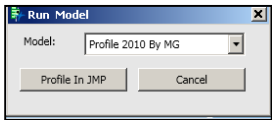


Figure 5. Prediction Profiler of CPI Model

