What Drives the Consumer Price Index?
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ABSTRACT
The Consumer Price Index (CPI) is widely referenced as a measure of health for the US economy. Users frequently cite rising or falling consumer prices as indicated by the All Urban Consumers CPI-U index. Price change for an aggregate index is driven by price change from component indexes. This paper evaluates aggregate and component index series for consumer prices. A secondary purpose of this paper is to visualize the relationship between the aggregate and component consumer price indexes using JMP® software. JMP® Tree Maps are used to provide perspective about the components. Second, JMP® Bar Charts from Graph Builder highlight which components have the greatest impact on the All Items index. Lastly, a JMP® Bubble Plot displays month-to-month price change of the components relative to the aggregate.

BACKGROUND
The CPI evaluates month to month price change of consumer goods and services for the urban population (Bureau of Labor Statistics, 2009). The CPI is composed of 211 goods and service item categories and 38 geographic areas. Goods and services range from Wireless Telephone Service to Bananas. Additionally, price change is measured for the residents of metropolitan geographic areas. 1 211 consumer Items multiplied by 38 geographic areas yields 8018 basic level cells. The first step of CPI estimation is measuring the price change for each of these 8018 cells. In the second step of estimation, price change is measured across aggregates of the consumer items and geographic areas. The focus of this paper is on upper level change for the All Items (SAO) aggregate index and across Major Group (MG) component indexes. Major Groups are as follows: Apparel (A), Education and Communication (E), Food (F), Other Goods and Services (G), Housing (H), Medical (M), Recreation (R), and Transportation (T).

Upper level aggregates for the CPI are calculated using the Laspeyres index formula. The weights for a Laspeyres price index are referred to as fixed quantity weights because they are fixed to the base period. The weights are based on data from the Consumer Expenditure Survey and are updated once every 24 months. The survey time period for these expenditure weights occurs prior to use in the CPI. Aggregation weights account for moving the expenditure weights from the survey time period to the pivot month of a two-year price index period, which occurs in December of an odd year.

The Cost Weight (CW) is equal to the Aggregation Weight (AW), or \( \frac{P_a Q_b}{100} \), multiplied by the index (IX), or \( \frac{P_t}{P_a} \), for all 8018 elementary cells. \(^2\)

\[
CW_t = \frac{P_a Q_b}{100} \times \frac{P_t}{P_a}
\]

The subscript variables are defined as follows:
1. \( t \) = current month
2. \( a \) = previous month
3. \( b \) = December pivot month used to move the expenditure weights from the survey time period to the index time period

The value of using cost weights is that components can be compared against one another to determine relative importance and rate of change for each pricing month. \(^3\) Last, and perhaps most importantly, the

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1 The residents are defined as the urban population, which makes up about 80% of the US population. The CPI excludes the institutionalized, farmer, and military populations.
2 The US City Average for All Items for the urban population is equal to the sum of the AWs multiplied by their corresponding indexes. An alternative formula consists of the relative importance of the CW, which is just a CW for an Area and Item divided by the US City Average for All Items.
3 The Aggregation Weights contain different base periods, and thus cannot be compared across components.
cost weights from a current month divided by the cost weights from the previous month yield the CPI released each month.

CONTEXT

VISUALIZING THE CPI

How can one visualize the CPI? Generally, users of the CPI data prepare a line chart that graphs the change in the index values for the CPI-U from month to month. Even economists who work for the Bureau of Labor Statistics use this type of display. Line charts are useful to demonstrate trends over time, but they lack an explanation of what drives movement to the index. To effectively display what drives this movement, one can compare aggregate to component series. Before visualizing this relationship it is useful to understand which items are most important.

Method 1

That’s right! Some items are more important than others in terms of their relative importance, i.e., relative to the sum of all items. The JMP® Tree Map in Figure 1. below displays the size of the relative importance of the January 2010 Cost Weight by the area of space colored for each Major Group. Additionally, the Tree Map displays the relative importance of each consumer item and service by the size of the box within the Major Group color. For example, housing (in pink) stands out because it represents about 40% of the SA0 expenditure weight. Also, notice that the lower-level consumer item HC01 (Owners’ Equivalent Rent of Primary Residence) is larger than any of the 7 other individual Major Groups. HC01 is the most important consumer item for the CPI-U. The relative importances of Major Groups H, T, and F occupy nearly 75% of the relative importance space. Major Groups M, E, R, A and G occupy the other 25% of relative importance space.

Figure 1. Tree Map of Relative Importance by Major Group. Includes Item with largest Relative Importance.

The New York Times prepared a similar Tree Map where the relative importance was accounted for by the size of the shape for each consumer item (Balzer, Bloch, Carter, & Cox, 2008). Additionally, the Tree Map accounted for price change using different colors to indicate percent change in the index from one month to the next. The Tree Map from the New York Times allowed users to visualize the change to the
index at the lowest level – accounting for all 211 consumer items – but it did not explain the impact of component indexes to aggregate indexes. This relationship between component and aggregate indexes is highlighted by Methods 2 and 3 below.

**Method 2**

The JMP® Bar Charts in Figure 2a. display various measures of Cost Weights comparable across Major Group. The uppermost chart provides relative importance values by Major Group.\(^4\) Housing is important, as indicated by the 41% relative importance, but what does that mean? The middle chart identifies the \(\% \Delta\) from a MG CW that is required to result in a 1\%\(\Delta\) to the SA0 CW – ceteris peribus.\(^5\) This means that Housing is so important that a 1.5% change in the Housing price index will move the SA0 index by 1%. In contrast, it takes a 17% change in either the Apparel or Other Goods index to cause an SA0 index change of 1%. In other words, the CPI is 17 times as sensitive to Housing price change as it is to price change from either Apparel or Other Goods. The bottom chart displays the RSQUARE correlation between the individual Major Group indexes and the SA0 index. The RSQUARE for Apparel is 0, and for Transportation it is .4. One of the primary reasons these indexes display no correlation and a low correlation respectively is due to the volatility in prices. For example, imagine the on sale off sale pricing for Apparel goods. Similarly, think back to the run up of Gasoline prices in the summer of 2008, followed by their severe drop in the fall of 2008.

**Figure 2a. Cost Weight Major Group Comparison**

\(^4\) The Relative Importance Bar Chart and the \(\% \Delta\) for 1\%\(\Delta\) to SA0 Bar Charts are from February of 2010 and are identified by the * symbol. The third Bar Chart is the RSQUARE of the component against the SA0 aggregate from January of 2005 to June of 2010.

\(^5\) Ceteris Peribus is implied for the rate of change comparisons used throughout this paper. Of course this concept does not hold true when accounting for price change of many goods and services. That said, take note of Method 3, which supports the concept of a small price change for Housing or Transportation index components causing a noticeable change in the aggregate index SA0. Likewise, large seasonal price changes to Apparel have little to no effect on the aggregate SA0 index.
Next, consider the lower level consumer items and services with the largest relative importance within Major Group in the list below. These Items are also labeled in the Tree Map above.

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Code Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>HC01 Owners’ Equivalent Rent of Primary Residence</td>
</tr>
<tr>
<td>2.</td>
<td>TB01 Gasoline (All Types)</td>
</tr>
<tr>
<td>3.</td>
<td>FV01 Full Service Meals and Snacks</td>
</tr>
<tr>
<td>4.</td>
<td>EB01 College Tuition and Fees</td>
</tr>
<tr>
<td>5.</td>
<td>MC01 Physicians’ Services</td>
</tr>
<tr>
<td>6.</td>
<td>RA02 Cable and Satellite Television and Radio Service</td>
</tr>
<tr>
<td>7.</td>
<td>AC03 Women’s Suits and Separates</td>
</tr>
<tr>
<td>8.</td>
<td>GA01 Cigarettes</td>
</tr>
</tbody>
</table>

There are two points of interest in evaluating the Cost Weights in Figure 2b. First, the CW relative importance from the uppermost chart for HC01 is more than 5 times as great as the next largest consumer item or service, and it is greater than the 7 other individual MG components. Remarkably, it takes only a 4% price change to HC01 to move the SA0 index by 1%, as indicated by the middle chart. Second, the CW relative importance for AC03 and GA01 is 1% for each component, as displayed in the uppermost chart. In contrast to HC01, a price change of over 125% for either of these component indexes is required in order to move the SA0 index by 1%. Enough of the summary statistic data- let’s visualize the movement of component and aggregate indexes!

**Figure 2b. Cost Weight Of Item With Largest Relative Importance Within Major Group Comparison**
Method 3

The JMP® Bubble Plot in Figure 3 below displays the movement of MG component indexes relative to the SA0 aggregate index. The relative importance of each index is represented by the size of the bubble; thus the sum of the areas of the component bubbles equals the aggregate bubble. Given the constraints of this paper format, readers are unable to visualize the dynamic movement. Trailing Lines, however, are the next best alternative in that they display the previous period index value.

There are a few constraints to consider before comparing component and aggregate indexes. The bubble plot displays the indexes of all of the MGs relative to SA0, and therefore it is not possible to identify an individual MG that caused the change SA0 unless there is either a) little to no change for the other component MGs, or b) the change of the component MG is opposite that of the aggregate SA0.

With the understanding of the points above, what stands out when comparing components relative to the aggregate? The Apparel component (in green) displays nearly 10 point index fluctuations from 105 to 95 over the entire time period due to sales for the outgoing season and markups for the upcoming season. Note that the aggregate SA0 index is not affected by Apparel, which is confirmed by the RSQUARE of 0, and the seasonal price fluctuation is much less than the 17% required to move the SA0 aggregate by 1%.

The Recreation (in light blue), Education and Communication (in blue), Other Goods and Services (in aqua), and Medical Care (in yellow) components display an uptrend over nearly the entire time period. Most notable were M and G, which increased by 25 index points from February to December of 2009. The sum of the relative importance values for these four component indexes is small at 23%. The marginal impact of all of these indexes is highlighted when calculating an AEGM hybrid index, which increased by about 2.3 points over the July 2008 to January 2009 time period, while the SA0 decreased nearly 5 points over the same time period.

The Food component (in orange) is similar to the 4 components described above in that it trended upward for nearly the entire time period. The Food component moved counter to the AEGM components when it peaked in January of 2009, and then decreased moderately by about 1.3 points through July of 2009. In contrast, the AEGM components hybrid index increased by about 2.8 points over this January to July 2009 period.

The Transportation component (in pink) displayed the largest increase. Transportation reached an index value of 135 in July of 2008, which is over 10 points greater than the next highest index value for Medical Care in November of 2009. The large price swings for Transportation are one reason why the RSQUARE was only .4. However, the Transportation component’s large relative importance and the small change required to move the SA0 aggregate index indicate that it had a significant impact. We know from the previous sections that any change to the Housing component (in purple) will have a large impact on the aggregate SA0. As luck would have it, both Transportation and Housing increased beginning in February of 2008, reached a peak in July of 2008, and then decreased significantly through December of 2008. The net impact of these two components was the primary reason the aggregate rose 4 points from February to July and then declined 4 points from July through December.

Using this information one could evaluate the contribution and effect of these components over these time periods to determine the actual value of the impact. Attempting to perform this type of analysis without visually identifying the components and trends would be difficult at best in determining which indexes had the greatest impact over each time period.

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6 The time period is from December 2003 through December 2009, and all of the indexes are rebased to December of 2003.
SUMMARY

The CPI has been charted numerous times—primarily with line charts to display the trends of the All Urban Consumers CPI-U and various individual price movements. Understanding the relative importance of CW and the rate of change required for components to impact the aggregate, highlights that price movements alone do not drive movements to the US All Items index. Rather, consumer items and services with the greatest CW, like HC01 and TB01, and the greatest price movements drive the CPI-U aggregate index. Using the concept of relative importance and rates of change of components relative to aggregates will enable users to determine which components are actually driving the CPI-U.

A secondary goal of this paper is to visually display the relationship between component and aggregate consumer price index series. Effective visualization enables the summary of chunks of information, which enables the reader both to analyze more information and to make multifaceted observations about the data (Few 2009). The examples of JMP® Tree Maps, Charts from Graph Builder, and the Bubble Plot provided in this paper are nothing more than a starting point to further users’ analysis of the CPI. Future applications of JMP® for my research include accounting for lower level components such as consumer Items and geography, and comparing the CPI-U to alternative US economic statistical measures such as the Producer Price Index and Unemployment.

REFERENCES


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