A UNIQUE APPROACH TO PREDICTING SLOWING IN THE PURCHASING MANAGERS’ INDEX

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ABSTRACT

The Purchasing Managers’ Index (PMI) is a widely used economic indicator of the health of the economy. The ability to identify future declines in economy by identifying declines in the index is useful to economist as well as supply chain managers for purposes of strategic planning. This research uses an adaptation of single exponential smoothing to calculate the average negative change in the PMI when the change from month to month is negative and when the change from month to month is positive. The continuous change statistic from the NAPM ISM report is used here as a sentiment indicator for the index.

INTRODUCTION

The Purchasing Managers’ Index or PMI is widely followed statistic that is used to provide guidance on the state of the national economy in the United States. The index provides strategic information to the supply chain manager that is used to adjust production levels, inventory levels, employment levels and orders. During periods of economic contraction it is especially important that output is adjusted appropriately. The ability to tell when stretches of expansion or contraction in the economy as indicated by the PMI is valuable.

The “continuous change” statistic utilized here, indicates the amount of increase or decrease since the last reported period for the PMI. It is generally positive or negative for several periods, before it changes directions and moves in the opposite direction for a time. This research adapts methodology that uses single exponential smoothing to capture the average negative percent change or rate during the periods that the PMI is decreasing. This information provides the average rate of change during the periods the statistic is negative and would provide the economist or manager an indication of the rate the economy is declining. In this way, the series is transformed into a string of zeros and negative rates of change. This methodology changes forecasting methods for different conditions. One for high and another for low rates.

The methodology applied in this paper is generally used to forecast demand rates for items that have intermittent demand. Croston (1972) suggested that SES forecasts for items with intermittent demand could be computed and then combined into one forecast, one SES forecast
for the demand rates and one SES forecast for the periods between demands. In terms of Croston’s method, demand is forecasted, however in this paper, we are not forecasting demand, but instead we are forecasting the percent reduction in the PMI.

**LITERATURE REVIEW**

This literature review will briefly describe the PMI and then discuss the literature related to the single exponential, Croston’s method and the proposed forecasting methodology.

**Purchasing Managers’ Index (PMI)**
The PMI is calculated from a monthly survey of business professionals near the first of every month. Supply chain managers are simply asked if several areas, such as production, inventories, backlogs and inventories, related to manufacturing are increasing, decreasing or staying the same. The PMI has long been considered an important strategic tool due to the correlation of the index with the gross domestic product (Klein and Moore, 1988; Kauffman, 1999; Pelaez, 2003) and furthermore, can even be used as a proxy for the general business cycle (Raedels, 1990) and assessing the general US economy (Tsuchiya, 2012; 2014). The PMI is included in the composite of leading indicators of the Federal Reserve published each month (Del Negro, 2001).

The PMI data for this investigation was obtained from the St. Louis Fed Economic Research web page at [https://research.stlouisfed.org/fred2/series/NAPM/downloaddata](https://research.stlouisfed.org/fred2/series/NAPM/downloaddata). The Seasonally Adjusted Continuously Compounded Rate of Change series was utilized in this report. The available data range was monthly data from January 1948 to September 2015. The following formulas were used to construct the data series from the original NAPM PMI data.

Percent Change

\[
\frac{(x(t)/x(t-1)) - 1) \times 100}{1}
\]

Continuously Compounded Rate of Change

\[
\text{\log}(x(t)) - \text{\log}(x(t-1) \times 100)
\]

**Single Exponential Smoothing (SES)**

SES is a preferred weighted-moving average technique often used to forecast demand for inventoried that is easy to use and not data intensive. The notation is as follows:

- \( X_t \) = binary indicator of demand at time \( t \)
- \( Z_t \) = size of demand
- \( Y_t = X_tZ_t \) = demand for an item at time \( t \)
- \( \alpha \) = smoothing parameter
- \( \gamma_t = \) exponential smoothing estimate of demand for period

The formula for SES is:

\[
\gamma_t = Y_t + \alpha( Y_t - Y_{t-1} )
\]

The forecast is equal to a fraction of the previous error term plus the previous smoothed forecast. Trigg and Pitts (1962) offer guidance for selection of the smoothing constant.
Croston’s Method
The simple but effective procedure for forecasting slow moving inventory makes one forecast for the demand size and another forecast for the interval between demands and combines them into one forecast. Croston’s (1972) method is often the standard to compare other methodologies for forecasting items with intermittent demand (Teunter, Syntetos and Babai, 2010; Ramaekers and Janssens, 2014). Croston’s method and SES are fundamentally identical when no period has zero demand. Levén and Segerstedt have suggested a variation that basically produces a general method when demand is slow or regular, but potentially introduces more bias than Croston (Teunter & Sani, 2009). Levén and Segerstedt (2004) provide a single procedure for any demand pattern but not when distinct demand rates occur in different periods. The authors have developed a hybrid technique to adjust for shifts in rates of demand from normal to slow. Reference Willimain, et al. (1994) for an explanation of Croston’s method. The technique is similar to SES and like SES it assumes a constant demand mean of size $\mu$ taking place every $p$ periods, so the average demand is not just $\mu/p$ using Croston’s method (1972), but rather

$$y^* = \left(\frac{\alpha}{p}\right) \left[ \frac{p\alpha}{1-(1-\alpha)^p} \right]$$

(4)

When demand occurs, the expected value is

$$E\{y_t^*\} = \frac{\mu}{p},$$

(5)

with the variance

$$V(y_t^*) = \left[ \frac{\alpha}{2-\alpha} \right] \left[ \frac{(p-1)^2 \mu^2 + \sigma^2}{p^2} \right].$$

(6)

This work utilizes lower alpha levels of 0.1, 0.2 and 0.3 as recommended by Croston (1972).

Hybrid Approach: Adapting Croston’s Method for Two Levels
The explanation of the Hybrid method will follow the notation used for Croston’s method for the two demand levels is shown below. A superscript of S and F are used to distinguish between two levels of demand, slow and fast. “Slow” is when the last 2 time periods did not have a demand.

If $X_{t-1} = 0$ and $X_{t-2} = 0$, Then

$$Z_t^S = Z_{t-1}^S, P_t^S = P_{t-1}^S, \quad q = q + 1$$

If $X_t = 1$, $Z_t^S = Z_{t-1}^S + \alpha(y_t - Z_{t-1}^S)$

$$P_t^S = P_{t-1}^S + \alpha(q - P_{t-1}^S), \quad q = 1.$$  

Count_Slow = Count_Slow + 1

Else $X_{t-1} = 1$ or $X_{t-2} = 1$,

Then If $X_t = 0$, $Z_t^F = Z_{t-1}^F, P_t^F = P_{t-1}^F$

$$q = q + 1$$

Else $X_t = 1$ $Z_t^F = Z_{t-1}^F + \alpha(y_t - Z_{t-1}^F)$

$$P_t^F = P_{t-1}^F + \alpha(q - P_{t-1}^F), \quad q = 1.$$  

Count_Fast = Count_Fast + 1

(9)

The mean demand per period is then

$$(\text{Count_Slow} * Z_t^S / P_t^S + \text{Count_Fast} * Z_t^F / P_t^F) / (\text{Count_Slow} + \text{Count_Fast})$$

(12)

METHODS
Forecasts for the PMI continuous change statistic are performed at three different smoothing constant levels using SES, Croston’s method and the Hybrid methodology. A total of 812
periods of monthly data are used to construct the forecasts. The amount of error is then computed using the Root Mean Square (RMSE) for the forecasts using SES, Croston’s method, and the Hybrid method. The forecast utilize three smoothing constants: \( \alpha \) levels of 0.1, 0.2 or 0.3. Forecast estimates using SES, Croston’s method, and “hybrid” method are computed for estimating the percent change over the 800 periods and also for estimating actual change. Since this study was focused on determining the negative percent decrease for the next month in the PMI, positive values were replaced with zero values and only negative values were considered. Series were classified as “slow” if the value is negative and either of the previous 2 months was positive and as “fast” if either of the 2 prior months was negative.

RESULTS

The results of forecasts performed with smoothing constants of 0.1, 0.2 and 0.3 are shown in Table 1. The assumed rates of change “fast” is 0.9 or “slow” is 0.7 and the assumed standard deviation is 3.7 for “fast” and 3.1 for “slow”. The forecast error is computed using the RMSE. The proposed “hybrid” methodology outperforms Croston’s method and SES in error reduction.

Table 1: Forecast Error and Percent Reduction in Error

<table>
<thead>
<tr>
<th>Alpha Level</th>
<th>Forecast Error with SES</th>
<th>Forecast Error with Croston</th>
<th>Percent Reduction in Error compared to SES</th>
<th>Forecast Error with Hybrid Methodology</th>
<th>Percent Reduction in Error compared to SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>2.147</td>
<td>1.43</td>
<td>33.38%</td>
<td>1.391</td>
<td>35.18%</td>
</tr>
<tr>
<td>0.2</td>
<td>2.323</td>
<td>1.663</td>
<td>28.39%</td>
<td>1.499</td>
<td>35.46%</td>
</tr>
<tr>
<td>0.3</td>
<td>2.443</td>
<td>1.826</td>
<td>25.24%</td>
<td>1.585</td>
<td>35.11%</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSIONS

The PMI is an important tool for economists and supply chain managers and provides useful insight into the direction of the economy. Knowing when periods of contraction are ending provide guidance for strategic decisions. When the sole concern is when a period of economic contraction is ending, this unique methodology could be employed. The proposed Hybrid methodology outperforms other methods of forecasting intermittent data. This methodology could be applied to a number of situations such as sentiment indices like the consumer sentiment index or the bearish sentiment index to determine “bottoms” in sentiment.

REFERENCES


