Consumer Sentiment, Hypothesis Testing, Manufacturing Sector

Analyzing the Relationship Between Consumer Expectations and Manufacturing PMI

Using Python to Implement a Mann-Whitney U-test

In December, the University of Michigan's gauge of consumer expectations grew to 98.2, the highest reading since 2004.

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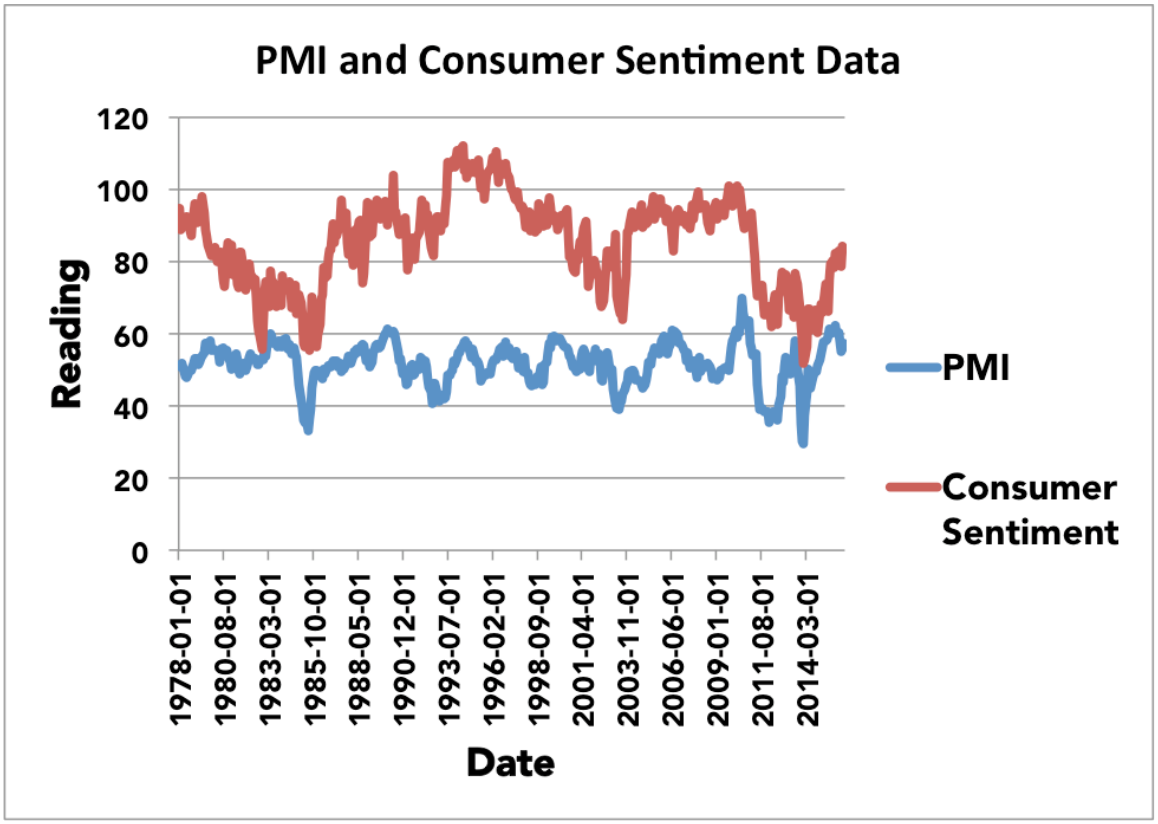
President-elect Donald Trump has painted a murky picture of the economy, often referencing the decline of the manufacturing sector in the United States during his speeches and rallies. Trump has also stressed the importance of manufacturing jobs to the health of the U.S. economy. Many economic research papers also argue that a strong manufacturing sector is vital to an expanding economy. According to some economists, manufacturing is the single most important contributor to economic growth. Thus, we would expect a clear relationship to exist between consumer sentiment about the economy and the strength of the manufacturing sector. In this report, using the Mann-Whitney U-test, we look to statistically analyze this relationship between consumer sentiment and the strength of the manufacturing sector in the United States.

Consumer sentiment data is gathered from the University of Michigan Survey of Consumers (MSCI Index). Each month, the University of Michigan releases telephone surveys to Americans across the country in an attempt to analyze the overall tone in the economy. This MSCI index is well regarded by

investors, as the surveys have been shown to be an accurate predictor of whether consumers will spend more money in upcoming months.

On the other hand, the data for the strength of the manufacturing sector is gathered from the Manufacturing Purchasing Managers' Index (PMI). The Manufacturing PMI is an indication of the overall health of the manufacturing sector, with a reading above 50 indicating expansion of the sector compared to previous months. Like the MSCI Index, data for the Manufacturing PMI is collected each month. This PMI reading is based on five main indicators gathered from key executives at approximately 300 U.S. companies: inventory levels, production levels, supplier deliveries, employment environment, and new orders.

Manufacturing PMI readings and consumer sentiment readings are collected for a variety of countries, but, in this report, we will only analyze consumer sentiment and manufacturing data from the United States. All data was retrieved from the Federal Reserve Economic Data Catalog (FRED), and the dataset used in this report analyzed monthly PMI and consumer sentiment readings dating back to 1978. A graph of both historical consumer sentiment readings and historical Manufacturing PMI readings over this time period can be seen below.



As in previous reports, the Mann-Whitney U-test was the hypothesis test of choice in this study. Again, as stated previously, this hypothesis test does *not* assume normality or symmetry of the underlying distributions specified in $H_0$and H_1. Thus, this hypothesis test makes fewer assumptions

about the data, and, unlike t-tests and the Wilcoxon Signed Rank Test, the Mann-Whitney U-test can fit distributions that deviate from normality and symmetry (i.e. “fat-tailed” distributions).

To construct a proper hypothesis test for this analysis, we assume all PMI readings and Consumer Sentiment readings are independent and identically distributed (typical IID assumption). Let $X_1 \ldots X_n$ represent the University of Michigan consumer sentiment readings for months where PMI > 50 (e.g. X_i = the consumer sentiment reading from the University of Michigan Survey of Consumers for the i^{th} period in the dataset where PMI > 50). Note: ‘n’ is the number of months in the dataset with PMI > 50. For i = 1…n, we let each X_i be distributed as an IID random variable from f, where f is the true distribution of consumer sentiment readings when the manufacturing sector is expanding (PMI > 50).

Similarly, let $Y_1 \ldots Y_m$ represent the University of Michigan consumer sentiment readings for months where PMI < 50 (e.g. Y_i = the consumer sentiment reading from the University of Michigan Survey of Consumers for the i^{th} period in the dataset where PMI < 50). Note: ‘m’ is the number of months in the dataset with PMI < 50, and, in this report, it is possible that m ≠ n if the number of PMI readings > 50 is not equal to the number of PMI readings < 50. For i = 1…m, we let each Y_i be distributed as an IID random variable from g, where g is the true distribution of consumer sentiment readings when the manufacturing sector is contracting (PMI < 50). Note: in this analysis, we do not know the true distributions of f and g.

The null and alternative hypotheses used in this report are as follows: H_0: $f = g$, H_1: $f > g$, significance level $\alpha = 0.05$. Note: unlike in previous analyses, in this report, we are using a one-sided alternative hypothesis. Intuitively, H_1means that consumer sentiment readings are stochastically greater for months where PMI > 50 compared to months in the dataset where PMI < 50 (H_1: $f > g$).

Again, to test this hypothesis defined above, we use the Wilcoxon rank-sum test, which is alternatively known as the Mann-Whitney U-test. As stated in previous reports, this test is truly beautiful, simply exploiting symmetry under the null hypothesis. The Mann-Whitney U-test converts all observed data values to just their ranks, allowing the test to deal with deviations from normality that are often seen in financial distributions (e.g. “fat tails”).

The test statistic T_y of the Mann-Whitney U-test is defined as follows. We pool all of our observations $X_1 \ldots X_n$, $Y_1 \ldots Y_m$ into one dataset, where, again, ‘n’ is the number of months in the dataset with PMI > 50, and ‘m’ is the number of months in the dataset with PMI < 50. We then sort and rank each of these values, with the smallest value of the joint dataset having rank 1, and the largest value of the joint dataset having rank m + n. Next, we define T_Y as the sum of ranks corresponding to only the Y values from the dataset. In other words, T_y in this report is sum of ranks of consumer sentiment readings for months where Manufacturing PMI < 50.

Under the null hypothesis H_0, we assume that $X_1 \ldots X_n$ and $Y_1 \ldots Y_m$ all come from the same distribution, as H_0: $f = g$. Thus, since our hypothesis test is one-sided, only abnormally small T_Y values indicate we should reject the null hypothesis.

In this analysis, the Mann-Whitney U-test was completed in Python. For this dataset, Python returned T_y= 82848 and p = $1.90336697724 * 10^{-10}$. Clearly, we reject H_0 ($p < \alpha = 0.05$), and the data suggest that periods of manufacturing growth (PMI > 50) lead to greater consumer expectations about the economy compared to periods of manufacturing contraction (PMI < 50).

Since the p-value found in this analysis is extremely small (p = $1.90336697724 * 10^{-10}$), it is clear that changes in the strength of the manufacturing sector have an immediate impact on consumer expectations about the economy. Thus, although consumer sentiment readings have climbed in the past few months, reaching the highest levels seen since 2004, I would not be surprised if these readings begin to slip in early 2017. With the dollar strengthening, the manufacturing sector is at risk, as a stronger dollar threatens to make our exports more expensive to other countries, weakening demand for U.S. products. This three-way relationship between dollar strength, manufacturing sector strength, and consumer expectations should continue to be watched closely in upcoming months.