12.6 Sign test (Web)

12.6.1 Introduction

The Sign Test is a **one sample** test that compares the median of a data set with a specific target value. The Sign Test performs the same function as the One Sample Wilcoxon Test, but it *does not rank* data values. Without the information provided by ranking, the Sign Test is less powerful (9.4.5) than the Wilcoxon Test. However, the Sign Test is useful for problems involving 'binomial' data, where observed data values are either above or below a target value.

12.6.2 Sign Test

The Sign Test aims to test whether the observed data sample has been drawn from a population that has a median value, m, that is significantly different from (or greater/less than) a specific value, m_O. The hypotheses are the same as in 12.1.2.

We will illustrate the use of the Sign Test in Example 12.14 by using the same data as in Example 12.2.

Example 12.14
The generation times, t, (5.2.4) of ten cultures of the same micro-organisms were recorded.

Time, t (hr)	6.3	4.8	7.2	5.0	6.3	4.2	8.9	4.4	5.6	9.3

The microbiologist wishes to test whether the generation time for this micro-organism is significantly greater than a specific value of 5.0 hours.
See following text for calculations:

In performing the Sign Test, each data value, t_i, is compared with the target value, m_O, using the following conditions:

$t_i < m_O$ replace the data value with '-'
$t_i = m_O$ exclude the data value
$t_i > m_O$ replace the data value with '+'

giving the results in Table 12.14

Difference	+	-	+	-----	+	-	+	-	+	+

Table 12.14 Signs of Differences in Example 12.14

We now calculate the values of

r^+ = number of '+' values: $\qquad\qquad\qquad$ $r^+ = 6$ in Example 12.14

n = total number of data values *not excluded*: $\;\; n = 9$ in Example 12.14

Decision making in this test is based on the probability of observing particular values of r^+ for a given value of n. For example, when choosing n data values at random from the population, it is more likely that they would be evenly spread on either side of the true median value, rather than predominately either above or below the median.

We are therefore concerned with the *cumulative* binomial probability distribution, $p(r^+)$, of observing r^+ specific outcomes from n random selections.

The *p*-value for the test can be calculated from the binomial distribution, using the EXCEL function BINOMDIST with a probability $p = 0.5$ (see 8.4.6), and using the entry 'TRUE' to return the 'cumulative' value:

1-tailed Sign Test:
For $r^+ > n/2$ p-value = $p(r \geq r^+)$ = 1 - BINOMDIST(r^+-1, n, 0.5, TRUE)   [12.8]
For $r^+ < n/2$ p-value = $p(r \leq r^+)$ = BINOMDIST(r^+, n, 0.5, TRUE)   [12.9]
(If $r^+ = n/2$, then there is no significant difference!)

2-tailed Sign Test:
$\qquad$ p-value = 2 × p-value for 1-tailed test $\qquad\qquad\qquad\qquad$ [12.10]

Example Example 12.7 is a 1-tailed problem with $n = 9$ and $r^+ = 6$, giving $r^+ > n/2$, and we calculate the *p*-value using [12.8]:

$\qquad$ p-value = $p(r \geq 6)$ = 1 - BINOMDIST(6-1, 9, 0.5, TRUE) = 0.2539

Since *p*-value > 0.05 - we Do Not Reject the Null Hypothesis.

The Sign Test is not sufficiently powerful to detect a significant difference in this data. However, the more powerful One Sample Wilcoxon Test, which ranks data values, was capable of detecting a significant difference with the same data as in Example 12.2.

Q12.10	In monitoring animal response to stimuli, an index on a scale -10 to +10 was used to record the response of each animal to the stimulus. The values of the indices for 20 trials is given in the Table:

0	7	-2	8	3	6	1	9	1	9	2
7	6	6	3	5	0	3	-3	-2	-2	-1

Use the Sign Test to test whether the animals showed a significant response (positive or negative) to the stimuli.