‹ Previous Next ›

## 15.3.5 Law of Large Numbers and Standard Error



MO2.13 MO2.14

While the sample mean is an unbiased estimator of the expectation, as we observed there is variation in the sample mean. This suggests we should calculate the variance of $\overline{x}$ about $\mu_x$. We give this quantity a special symbol,

$$\sigma_{\overline{x}}^2 \equiv E\left[(\overline{x} - \mu_x)^2\right] \tag{15.19}$$

where $\sigma_{\overline{x}}$ is referred to as the *standard error* of $\overline{x}$.

After a lot of algebra, we can find the following result for the standard error,

$$\sigma_{\overline{x}}^2 = E\left[(\overline{x} - \mu_x)^2\right] = \frac{\sigma_x^2}{N} \Rightarrow \sigma_{\overline{x}} = \frac{\sigma_x}{\sqrt{N}} \tag{15.20}$$

Recall in our demonstration in Section 15.3.2, we observed in the scatter plots and histograms that $\left|\overline{x} - \mu_x\right| \propto 1/\sqrt{N}$. The result in Eq. 15.20, which quantifies the square of $\overline{x} - \mu_x$ is consistent with this observation.

‹ Previous Next ›

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