| **Statistic** | **Usefulness for Volatility** | **Problem** |
| --- | --- | --- |
| **Raw price** | ❌ Misleading — not stationary | Includes trend, not comparable |
| **Price Delta** | 🚫 Better, but still scale-dependent | Can't compare across stocks |
| **Percent change** | ✅ Okay | Still additive bias over time |
| **Log return** | ✅✅ Best choice | Time-additive, scale-invariant |

**1. Stock Prices Are Non-Stationary**

* Prices **trend upward or downward over time**.
* The standard deviation of a trending series (like stock prices) grows over time — it's not a *stable* measure.
* Therefore, the volatility measured from raw prices **includes the trend** (drift), and **overstates true risk**.

📌 **Returns**, on the other hand, are (approximately) **stationary** — they fluctuate around a mean (often close to 0) and don’t trend like prices.

**📐 2. Standard Deviation Assumes Mean-Reverting Data**

* Volatility is a statistical concept that assumes data fluctuates around a mean.
* Prices **do not** revert to a mean — but **returns do**.
* If you apply standard deviation to prices, you're measuring *both* trend and noise, which confuses the interpretation.

**⚖️ 3. Comparability Across Assets**

* The price of **AAPL at $180** and **AMZN at $3500** are in different numerical ranges.
* You can’t compare standard deviation of prices across these assets.
* **Returns** normalize this. A 1% move is a 1% move, whether the price is $10 or $1000.

**📊 4. Volatility is About Risk — i.e., Price Movement Relative to Price Level**

* A $5 swing means different things for a $10 stock vs a $1000 stock.
* Risk should be measured **relative to the price**, which is exactly what returns capture.

**🔍 Core Concept: You Are Measuring the Std Dev of *Relative Returns*, Not *Annualized Returns***

Your Volatility input of 0.2 is **annualized volatility**. But your test simulates **1 trading day**. So the actual **standard deviation of the daily log return** is:

BUT you're **not directly measuring the standard deviation of log-returns** in your result — you’re measuring the **standard deviation of prices** derived from Brownian process expression as:

Let’s break that down:

**✅ The Distribution of S (Stock Price) Is Log-Normal**

For a log-normal variable:

If:

Then:

In your case:

* So:

Now multiply this by StockPrice = 1.0 → you get a standard deviation of **~0.202**, **but that’s the standard deviation of price**, **not of log-returns**.

**🚨 Why You Might See ~0.27 Instead**

If you simulate many samples and then measure **log-returns**, you'll find the standard deviation is **close to**:

Where CV is the **coefficient of variation** (std dev / mean) of the simulated stock prices. Since log-normal variables are skewed, this conversion leads to:

* A mean price slightly > 1.0
* A std dev around 0.202 (see above)
* Which, through the log transformation, maps to a log-std-dev of **slightly less than 0.2**, but with **measurement noise**, it might overshoot to 0.27 depending on how you're estimating it.

**✅ Proper Way to Validate**

If you want to **confirm** that the volatility parameter is correct, you should do test this code:

' Generate 10000 samples:

Dim LogReturns As New List(Of Double)

For i = 1 To 10000

Dim p = StockOption.StockPricePredictionSample(1, 1.0, 0, 0.0, 0.2)

LogReturns.Add(Math.Log(p))

Next

' Now compute standard deviation of log returns

Dim MeanLog = LogReturns.Average()

Dim StdDevLog = Math.Sqrt(LogReturns.Average(Function(x) (x - MeanLog) ^ 2))

' Multiply back to annualize:

Dim AnnualizedStdDev = StdDevLog \* Math.Sqrt(252)