## 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.

---

| Statistic | Usefulness for Volatility | Problem |
|---|---|---|
| **Raw price** | ❌ Misleading — not stationary | Includes trend, not comparable |
| **Price Delta** $P_t - P_{t-1}$ | 🚫 Better, but still scale-dependent | Can't compare across stocks |
| **Percent change** $\frac{P_t - P_{t-1}}{P_{t-1}}$ | ✅ Okay | Still additive bias over time |
| **Log return** $\log\left(\frac{P_t}{P_{t-1}}\right)$ | ✅✅ Best choice | Time-additive, scale-invariant |

## 📐 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.