FORECASTING STARTUP SUSTAINABILITY USING MONTE CARLO SIMULATION IN PYTHON: A CASH FLOW RISK ANALYSIS APPROACH

1. Project Background and Objective

A **seed-stage tech startup** in the US, offering a subscription-based productivity app, needed to assess its financial runway and risk of insolvency before launching a hiring and marketing expansion. Key revenue and cost drivers were uncertain, and traditional deterministic models were insufficient.

Objective: Use **Monte Carlo simulation** in Python to estimate the likelihood of **monthly cash flow deficit** over the next 12 months, accounting for variability in customer acquisition, churn, and operating costs.

2. Financial Inputs and Assumptions

Component	**Base Assumption**	**Distribution Applied**
Starting Cash	\$250,000	Fixed
Monthly Revenue (Initial)	\$30,000	Triangular(25k, 30k, 40k)
Revenue Growth Rate	5% monthly compounding	Normal(0.05, 0.015)
Monthly Fixed Costs	\$20,000	Normal(20k, 3k)
Variable Costs	20% of revenue	No randomness
Unexpected Costs	\$0	Poisson(lam=1) * \$5,000
Time Horizon	12 months	
Iterations	10,000 simulations	

3. Python Implementation Overview

Libraries Used: numpy, pandas, matplotlib, seaborn

Core Simulation Logic:

```
import numpy as np

n_simulations = 10000
```

```
months = 12
results = []
for _ in range(n_simulations):
    cash = 250000
    monthly_revenue = 30000
    trajectory = []
    for _ in range(months):
        revenue_growth = np.random.normal(0.05, 0.015)
        revenue = np.random.triangular(25000, 30000, 40000)
        monthly_revenue *= (1 + revenue_growth)
        fixed_cost = np.random.normal(20000, 3000)
        unexpected = np.random.poisson(1) * 5000
        total_cost = fixed_cost + (0.2 * monthly_revenue) + unexpected
        cash += (monthly_revenue - total_cost)
        trajectory.append(cash)
    results.append(trajectory)
```

4. Results and Interpretation

- **Probability of Negative Cash Balance in Month 12: 27.3%**
- **Median Ending Cash: \$58,440**
- **Worst 5% (5th percentile):** –\$92,700 (insolvency)
- **Best 5% (95th percentile):** \$278,600

Risk Insight: There is a **1 in 4 chance** the startup would run out of money within the next year unless external funding is secured or costs are reduced.

5. Visualizations

- **Histogram of ending cash balance (all 10,000 runs)**
- **Line plot of 100 sample trajectories** (random subset)

- **Confidence interval band for expected cash range**
- **Heatmap:** Probability of negative cash by month

```
import seaborn as sns
import matplotlib.pyplot as plt

# Convert results to DataFrame
df = pd.DataFrame(results).T
sns.lineplot(data=df.iloc[:, :100], legend=False)
plt.axhline(0, color='red', linestyle='--')
plt.title("Sample Startup Cash Flow Trajectories")
```

6. Deliverables Provided

- Full Jupyter Notebook with clean documentation
- Excel export of key results (mean, median, 5th/95th percentiles)
- Visualization pack (PNG + SVG) for investor presentation
- PDF report: methodology, results, interpretations, assumptions
- Optional: Dockerized simulation app (CLI-based)

7. Strategic Outcome

- Informed decision to **delay expansion by 2 months**
- Opted to **secure bridge funding of \$100k** with milestone triggers
- Built the same simulation logic into a **monthly CFO dashboard**

8. Stakeholder Relevance

- **Startups and SMEs:** Supports capital budgeting, growth forecasting, and financial risk mitigation
- **Academic Use:** Suitable for MBA finance, decision science, and entrepreneurship programs—demonstrates practical use of probabilistic modeling in startup contexts