In [3]:
```python
# ================================================================
#    MONTE CARLO BEAR-MARKET SCENARIOS – RELATIVE PERFORMANCE
# ================================================================

import numpy as np
import matplotlib.pyplot as plt

# ---------- PARAMETERS ----------
np.random.seed(2025)
n_years, days_per_year = 5, 252
dt = 1 / days_per_year
n_steps, n_sims = n_years * days_per_year, 10_000

# ---------- PORTFOLIO WEIGHTS ----------
weights = np.array([
    0.0764,0.0998,0.0327,0.0278,0.0245,0.0178,0.0470,0.0223,0.0556,0.0272,
    0.0340,0.0350,0.0479,0.0193,0.0200,0.0407,0.0215,0.0326,0.0319,0.0357,
    0.0154,0.0273,0.0323,0.0418,0.0286,0.0565,0.0366,0.0117
])
weights /= weights.sum()

# ---------- BEAR SCENARIOS ----------
regimes = {
    "normal"                : {"mu": 0.09,  "vol": 0.15},
    "tech_collapse"         : {"mu": -0.20, "vol": 0.35},
    "runaway_inflation"     : {"mu": -0.05, "vol": 0.25},
    "banking_crisis"        : {"mu": -0.15, "vol": 0.30},
    "credit_crunch"         : {"mu": -0.25, "vol": 0.40},
    "sovereign_crisis"      : {"mu": -0.30, "vol": 0.45},
    "geopolitical_war"      : {"mu": -0.10, "vol": 0.30},
    "deflation_stagnation"  : {"mu": -0.05, "vol": 0.20},
    "pandemic_supplyshock"  : {"mu": -0.08, "vol": 0.35},
    "policy_error_tightening": {"mu": -0.12, "vol": 0.28},
    "valuation_compression" : {"mu": -0.06, "vol": 0.18}
}

spy_regimes = {
    "normal"                : {"mu": 0.09,  "vol": 0.15},
    "tech_collapse"         : {"mu": -0.25, "vol": 0.40},
    "runaway_inflation"     : {"mu": -0.03, "vol": 0.20},
    "banking_crisis"        : {"mu": -0.18, "vol": 0.35},
```
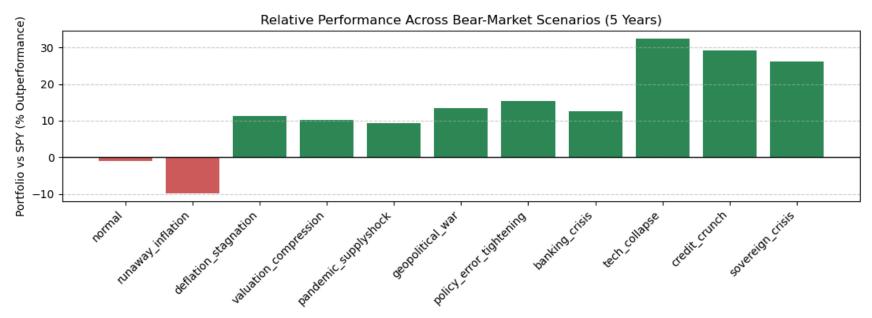
```python
    "credit_crunch"          : {"mu": -0.30, "vol": 0.45},
    "sovereign_crisis"       : {"mu": -0.35, "vol": 0.50},
    "geopolitical_war"       : {"mu": -0.12, "vol": 0.32},
    "deflation_stagnation"   : {"mu": -0.07, "vol": 0.22},
    "pandemic_supplyshock"   : {"mu": -0.10, "vol": 0.38},
    "policy_error_tightening": {"mu": -0.15, "vol": 0.30},
    "valuation_compression"  : {"mu": -0.08, "vol": 0.20}
}

# ---------- SIMULATION FUNCTION ----------
def simulate_regime(mu_p, vol_p, mu_s, vol_s):
    port = np.ones((n_sims, n_steps + 1))
    spy  = np.ones((n_sims, n_steps + 1))
    for t in range(1, n_steps + 1):
        z_p, z_s = np.random.normal(size=n_sims), np.random.normal(size=n_sims)
        port[:, t] = port[:, t-1] * np.exp(mu_p*dt + vol_p*np.sqrt(dt)*z_p)
        spy[:,  t] = spy[:,  t-1] * np.exp(mu_s*dt + vol_s*np.sqrt(dt)*z_s)
    return port, spy

# ---------- RUN ALL REGIMES ----------
results = {}
for name in regimes:
    print(f"Simulating: {name}")
    mu_p, vol_p = regimes[name]["mu"], regimes[name]["vol"]
    mu_s, vol_s = spy_regimes[name]["mu"], spy_regimes[name]["vol"]
    results[name] = simulate_regime(mu_p, vol_p, mu_s, vol_s)

# ---------- SUMMARY TABLE ----------
summary = []
for r in regimes:
    port, spy = results[r]
    pf, sf = port[:, -1], spy[:, -1]
    med_p, med_s = np.median(pf), np.median(sf)
    rel = (med_p / med_s - 1) * 100     # relative out/under-performance %
    summary.append([r, med_p, med_s, rel])

summary = sorted(summary, key=lambda x: x[2], reverse=True)
print("\n--- RELATIVE PERFORMANCE SUMMARY ---")
print(f"{'Scenario':25s}{'Port Median':>14s}{'SPY Median':>14s}{'Outperf%':>12s}")
for s in summary:
    print(f"{s[0]:25s}{s[1]:14.2f}{s[2]:14.2f}{s[3]:12.1f}")

# ---------- BAR CHART OF RELATIVE PERFORMANCE ----------
```

```python
labels  = [s[0] for s in summary]
relperf = [s[3] for s in summary]

plt.figure(figsize=(11,4))
bars = plt.bar(labels, relperf, color=np.where(np.array(relperf)>=0, 'seagreen','indianred'))
plt.axhline(0, color='black', lw=1)
plt.xticks(rotation=45, ha='right')
plt.ylabel("Portfolio vs SPY (% Outperformance)")
plt.title("Relative Performance Across Bear-Market Scenarios (5 Years)")
plt.grid(axis='y', linestyle='--', alpha=0.6)
plt.tight_layout()
plt.show()
```

```
Simulating: normal
Simulating: tech_collapse
Simulating: runaway_inflation
Simulating: banking_crisis
Simulating: credit_crunch
Simulating: sovereign_crisis
Simulating: geopolitical_war
Simulating: deflation_stagnation
Simulating: pandemic_supplyshock
Simulating: policy_error_tightening
Simulating: valuation_compression
```

```
--- RELATIVE PERFORMANCE SUMMARY ---
```

Scenario	Port Median	SPY Median	Outperf%
normal	1.56	1.57	-1.0
runaway_inflation	0.78	0.86	-9.9
deflation_stagnation	0.79	0.71	11.4
valuation_compression	0.74	0.67	10.3
pandemic_supplyshock	0.67	0.61	9.4
geopolitical_war	0.62	0.54	13.5
policy_error_tightening	0.54	0.47	15.5
banking_crisis	0.47	0.42	12.7
tech_collapse	0.37	0.28	32.3
credit_crunch	0.29	0.23	29.1
sovereign_crisis	0.22	0.18	26.1

Relative Performance Across Bear-Market Scenarios (5 Years)

In [ ]: