Jupyter Notebook Execution Report

Name: Your Name

Date: February 02, 2026

Cell 1: ■ Markdown

Goal (Module 1: Pain-Adjusted Screen)

We want to select ETF components for a Defensive Growth portfolio by ranking ETFs on efficiency (return per unit of pain), not return alone.

Cell 2: ■ Code

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

```
df = pd.read_csv('../processed/etf_returns.csv', parse_dates=['Date'])
```

```
# Keep only what we need
df = df[['Date', 'Ticker', 'Daily_Return']].dropna()
```

```
# Pivot to have tickers as columns
returns_wide = df.pivot(index='Date', columns='Ticker',
values='Daily_Return').sort_index()
```

```
print("returns_wide shape:", returns_wide.shape)
print("Date Range:", returns_wide.index.min(), "to", returns_wide.index.max())
returns_wide.head()
```

Output:

```
returns_wide shape: (3093, 12)
Date Range: 2014-01-03 00:00:00 to 2026-01-30 00:00:00
Ticker           BND       IAU      SCHD  ...    XIC.TO    ZAG.TO    ZLB.TO
Date                                      ...
2014-01-03  0.000125  0.010943  0.001377  ... -0.002796  0.000661 -0.000989
2014-01-06  0.000874  0.000000 -0.003576  ... -0.004205  0.000662 -0.001483
```

```
2014-01-07  0.001247 -0.004996  0.005522  ...  0.008446  0.002642  0.009906
2014-01-08 -0.003238 -0.005021 -0.003570  ...  0.000931  0.000658  0.001471
2014-01-09  0.001874  0.002523  0.001653  ...  0.000930 -0.000658  0.000980

[5 rows x 12 columns]
```

Cell 3: ■ Code

```
print("Date range:", returns_wide.index.min(), "to", returns_wide.index.max())
print("Shape:", returns_wide.shape)
print("\nMissing % per ticker (top 10):")
display((returns_wide.isna().mean().sort_values(ascending=False).head(10) *
100).to_frame("missing_%"))
```

```
print("\nNon-null counts (top 10):")
display(returns_wide.notna().sum().sort_values(ascending=False).head(10).to_frame("
non_null_days"))
```

Output:

```
Date range: 2014-01-03 00:00:00 to 2026-01-30 00:00:00
Shape: (3093, 12)
Missing % per ticker (top 10):
```

Index	missing_%
XIC.TO	2.004526349822179
VFV.TO	2.004526349822179
VDY.TO	2.004526349822179
VCN.TO	2.004526349822179
ZLB.TO	2.004526349822179
ZAG.TO	2.004526349822179
IAU	1.8105399288716457
BND	1.8105399288716457
SPLV	1.8105399288716457
SCHD	1.8105399288716457

```
Non-null counts (top 10):
```

Index	non_null_days
BND	3037
IAU	3037
SCHD	3037
SPLV	3037
SPY	3037
VTI	3037
VDY.TO	3031
VCN.TO	3031
VFV.TO	3031
XIC.TO	3031

Cell 4: ■ Code

```
TRADING_DAYS = 252
```

```
def annualized_return(r):
r = r.dropna()
growth = (1 + r).prod()
years = len(r) / TRADING_DAYS
return growth ** (1 / years) - 1
```

Cell 5: ■ Code

```
def annualized_volatility(r):
return r.std(ddof=0) * np.sqrt(TRADING_DAYS)
```

Cell 6: ■ Code

```
def sharpe_ratio(r, rf=0):
excess = r -rf / TRADING_DAYS
return excess.mean() / excess.std(ddof=0) * np.sqrt(TRADING_DAYS)
```

Cell 7: ■ Code

```
def sortino_ratio(r, mar=0.0):
```

```
downside = r[r &lt; mar]
downside_dev = downside.std(ddof=0) * np.sqrt(TRADING_DAYS)
return (r.mean() * TRADING_DAYS) / downside_dev if downside_dev != 0 else np.nan
```

```
# Why this matters (key talking point):
# Penalizes only harmful volatility
# Aligns with your Defensive Growth mandate
# Replaces “psychological” metrics with math
```

Cell 8: ■ Code

```
def max_drawdown(r):
cumulative = (1 + r).cumprod()
peak = cumulative.cummax()
drawdown = (cumulative - peak) / peak
return drawdown.min()
```

```
#Why: This is the worst-case investor experience.
```

Cell 9: ■ Code

```
def ulcer_index(r):
r = r.dropna()
if len(r) &lt; 2:
return np.nan
eq = (1 + r).cumprod()
peak = eq.cummax()
dd_pct = (eq / peak - 1) * 100.0
return np.sqrt(np.mean(dd_pct**2))
```

```
# Why this is powerful:
# Two ETFs can have the same max drawdown
# The one that stays underwater longer is worse
# Ulcer Index captures that better than volatility
```

Cell 10: ■ Code

```
candidates =
["SPY","SCHD","USMV","QUAL","MOAT","VDY.TO","ZLB.TO","BND","ZAG.TO","GLD","IAU"]

candidates = [c for c in candidates if c in returns_wide.columns]
```

```
# candidates under consideration.
```

Cell 11: ■ Code

```
rows = []

for t in candidates:

r = returns_wide[t].dropna()

rows.append({

"ETF": t,

"Annualized Return": annualized_return(r),

"Sharpe": sharpe_ratio(r),

"Sortino": sortino_ratio(r),

"Max Drawdown": max_drawdown(r),

"Ulcer Index": ulcer_index(r),

})
```

```
metrics_df = pd.DataFrame(rows).set_index("ETF")
```

```
# Efficiency Score = Return per unit of pain (Ulcer)

metrics_df["Efficiency Score"] = metrics_df["Annualized Return"] /
metrics_df["Ulcer Index"]
```

```
ranked = metrics_df.sort_values("Efficiency Score", ascending=False)

ranked
```

Output:

```
        Annualized Return    Sharpe  ...  Ulcer Index  Efficiency Score

ETF                                  ...

ZLB.TO           0.113721  0.966760  ...     4.717556          0.024106

SCHD             0.113185  0.745962  ...     5.525437          0.020484

SPY              0.135901  0.823656  ...     6.692120          0.020308

VDY.TO           0.107323  0.729913  ...     7.612603          0.014098

IAU              0.118074  0.812973  ...     9.955536          0.011860

ZAG.TO           0.024836  0.401733  ...     6.352288          0.003910

BND              0.022273  0.451371  ...     6.367642          0.003498
```

```
[7 rows x 6 columns]
```

Cell 12: ■ Code

```python
equity_list = ["SPY","SCHD","USMV","QUAL","MOAT","VDY.TO","ZLB.TO"]
hedge_bond_list = ["IAU","GLD","BND","ZAG.TO"]

equity_list = [t for t in equity_list if t in ranked.index]
hedge_bond_list = [t for t in hedge_bond_list if t in ranked.index]

top_2_equity = ranked.loc[equity_list].head(2)
top_1_hedge_bond = ranked.loc[hedge_bond_list].head(1)

print("Top 2 Equity ETFs (Pain-Adjusted):")
display(top_2_equity)

print("Top 1 Hedge/Bond ETF (Pain-Adjusted):")
display(top_1_hedge_bond)
```

Output:

```
Top 2 Equity ETFs (Pain-Adjusted):
```

Index	Annualized Return	Sharpe	Sortino	Max Drawdown	Ulcer Index	Efficiency Score
SPY	0.13590122299623442	0.8236559802180848	1.000340254541153	-0.3371726255744883	6.692119967009219	0.020307648946253146
SCHD	0.1131853922430297	0.7459618699190989	0.9403215290743057	-0.33367064372804434	5.52543742269685	0.020484422061880177

```
Top 1 Hedge/Bond ETF (Pain-Adjusted):
```

Index	Annualized Return	Sharpe	Sortino	Max Drawdown	Ulcer Index	Efficiency Score
IAU	0.11807428579221435	0.8129725971111994	1.1224722999176557	-0.24253732033735118	9.955535773380571	0.011860163880674823

Cell 13: ■ Code

```python
equity_candidates = ["SPY", "SCHD", "USMV", "QUAL", "MOAT", "VDY.TO", "ZLB.TO"]
hedge_candidates = ["BND", "ZAG.TO", "GLD", "IAU"]

equity_candidates = [t for t in equity_candidates if t in returns_wide.columns]
hedge_candidates = [t for t in hedge_candidates if t in returns_wide.columns]

winners = ["SPY", "SCHD", "BND"]
```

```
winners = [t for t in winners if t in returns_wide.columns]
```

Cell 14: ■ Code

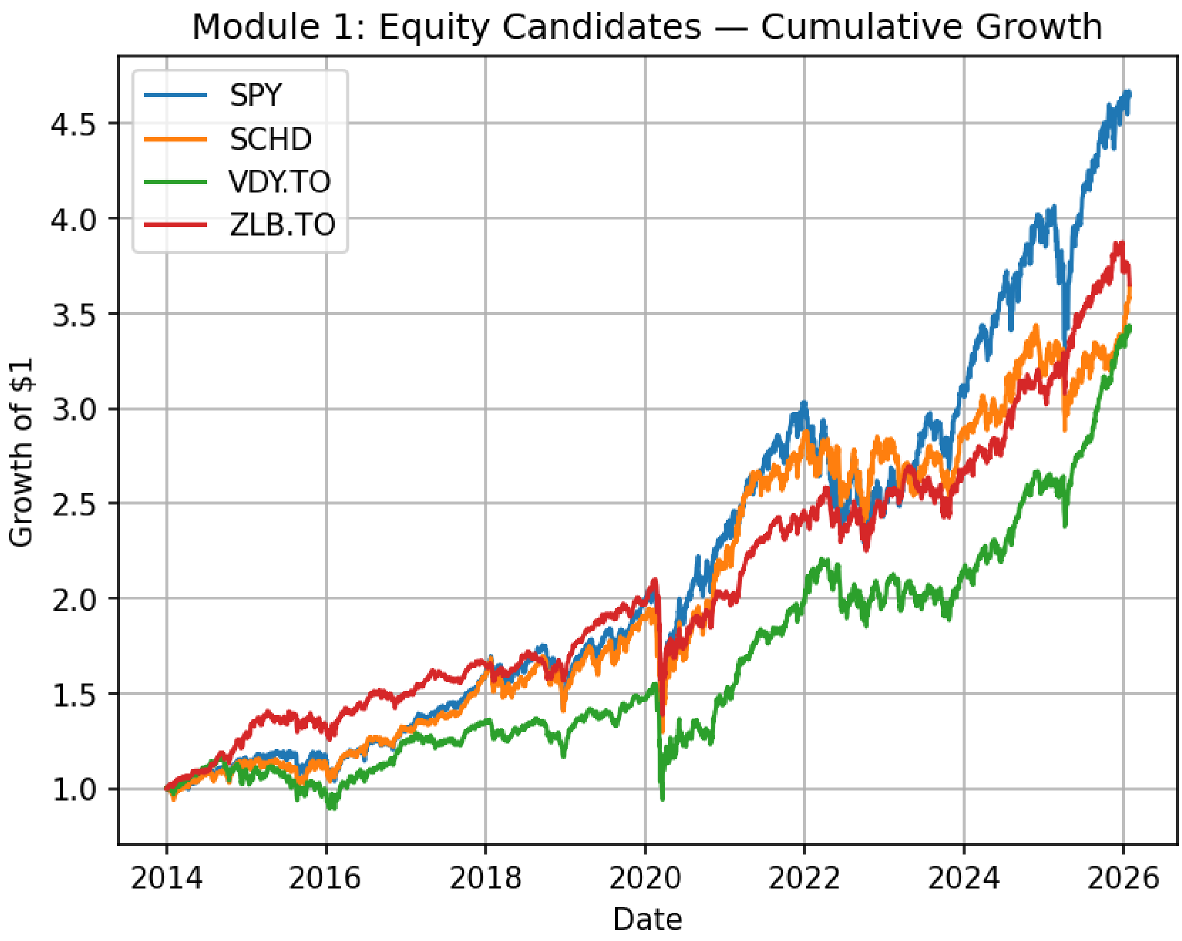
```
def equity_curve(r):
return (1 + r.fillna(0)).cumprod()
```

```
plt.figure()
for t in equity_candidates:
plt.plot(equity_curve(returns_wide[t]), label=t)
```

```
plt.title("Module 1: Equity Candidates — Cumulative Growth")
plt.xlabel("Date")
plt.ylabel("Growth of $1")
plt.legend()
plt.grid(True)
plt.show()
```

Output:

```
[STDERR]
&lt;string&gt;:1: UserWarning: FigureCanvasAgg is non-interactive, and thus cannot be shown
```



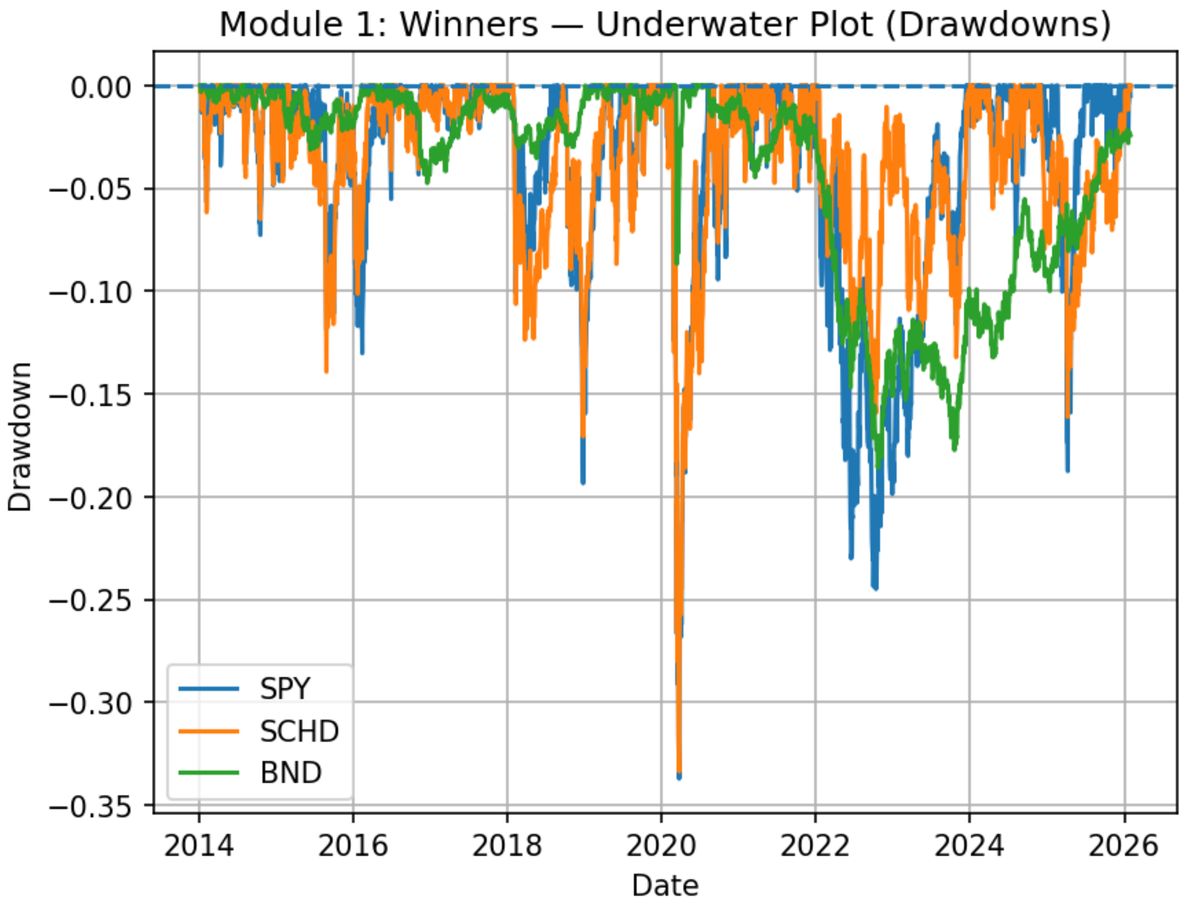
Cell 15: ■ Code

```
def drawdown_series(r):
eq = (1 + r.fillna(0)).cumprod()
peak = eq.cummax()
return (eq / peak - 1)
```

```
plt.figure()
for t in winners:
plt.plot(drawdown_series(returns_wide[t]), label=t)
```

```
plt.axhline(0, linestyle="--")
plt.title("Module 1: Winners — Underwater Plot (Drawdowns)")
plt.xlabel("Date")
plt.ylabel("Drawdown")
plt.legend()
```

```
plt.grid(True)
plt.show()
```



Cell 16: ■ Code

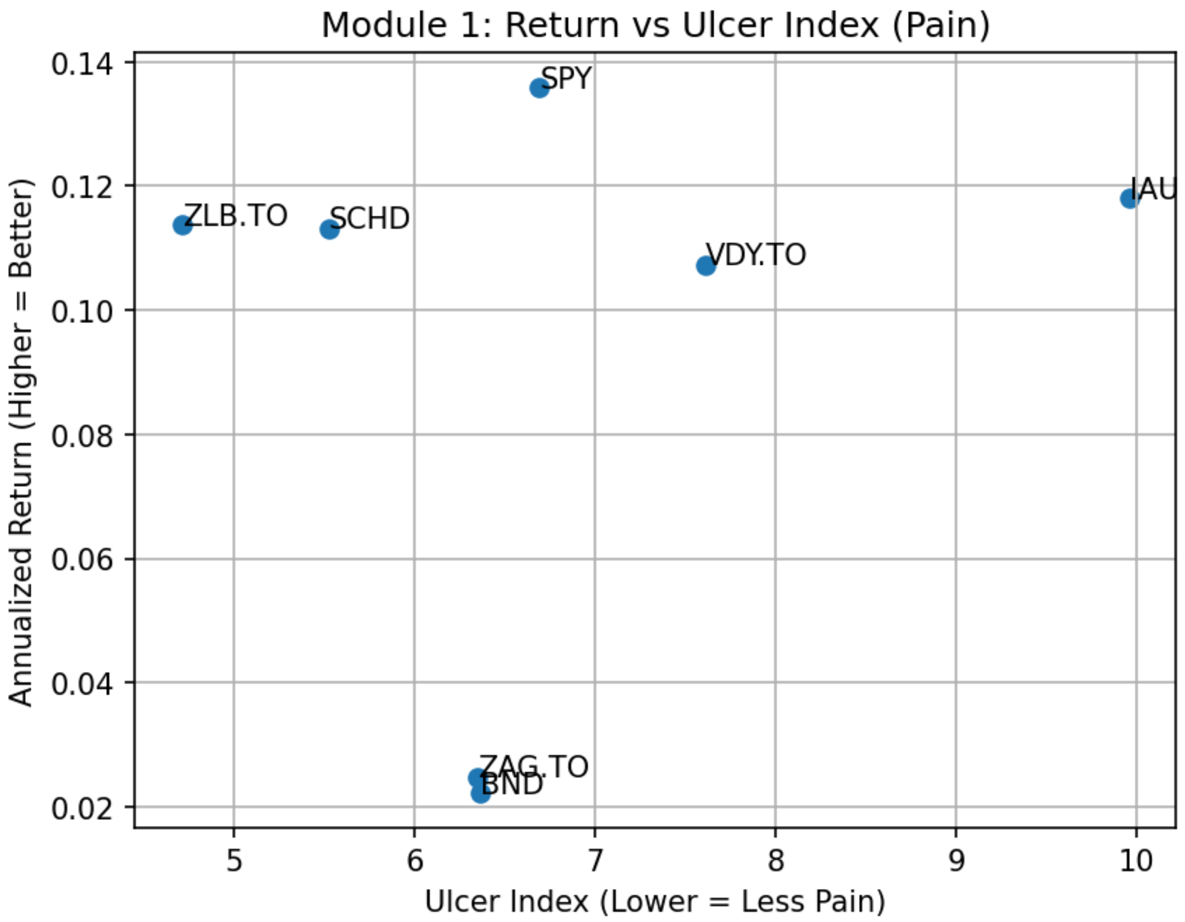
```
plt.figure()
x = metrics_df["Ulcer Index"]
y = metrics_df["Annualized Return"]
```

```
plt.scatter(x, y)
```

```
for etf in metrics_df.index:
plt.text(x.loc[etf], y.loc[etf], etf)
```

```
plt.title("Module 1: Return vs Ulcer Index (Pain)")
plt.xlabel("Ulcer Index (Lower = Less Pain)")
plt.ylabel("Annualized Return (Higher = Better)")
plt.grid(True)
```

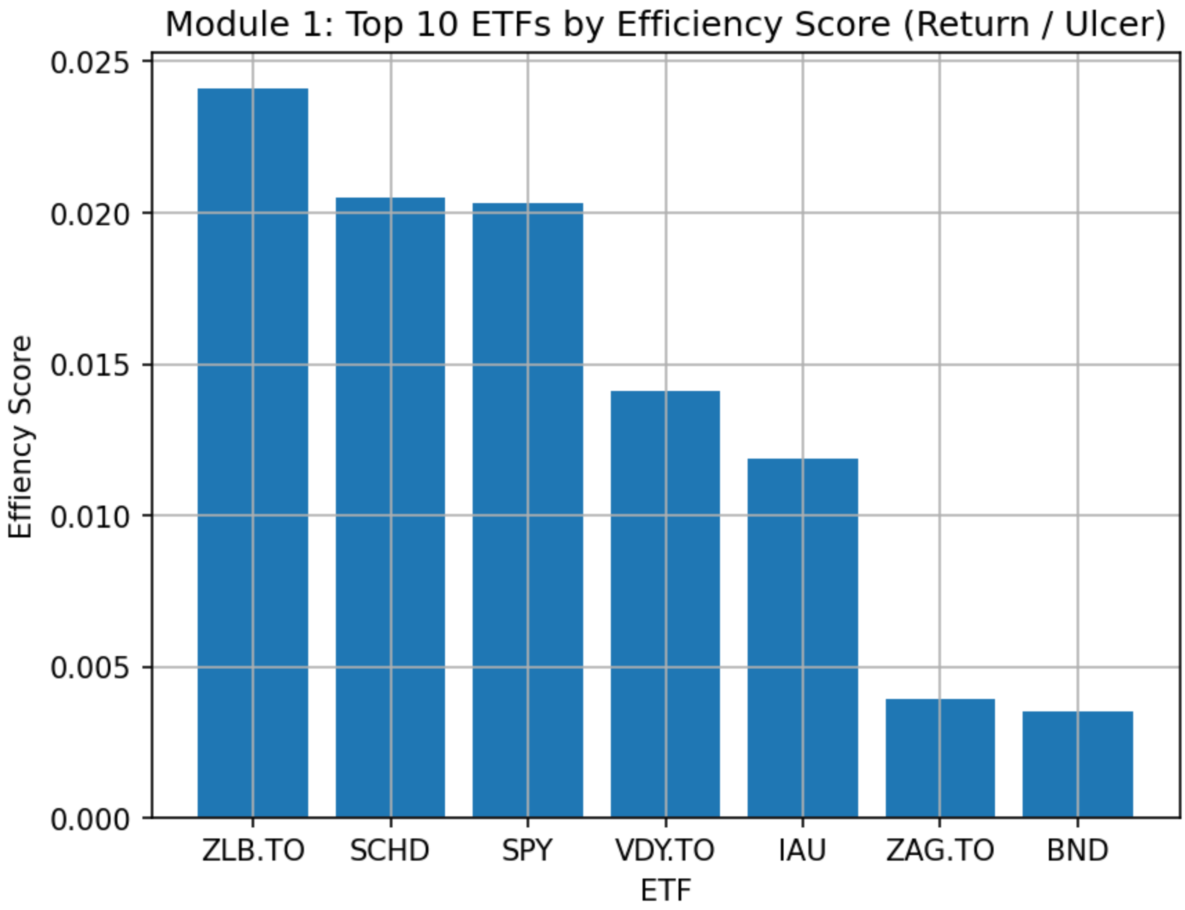
```
plt.show()
```



Cell 17: ■ Code

```
top10 = metrics_df.sort_values("Efficiency Score", ascending=False).head(10)
```

```
plt.figure()
plt.bar(top10.index, top10["Efficiency Score"])
plt.title("Module 1: Top 10 ETFs by Efficiency Score (Return / Ulcer)")
plt.xlabel("ETF")
plt.ylabel("Effiency Score")
plt.grid(True)
plt.show()
```

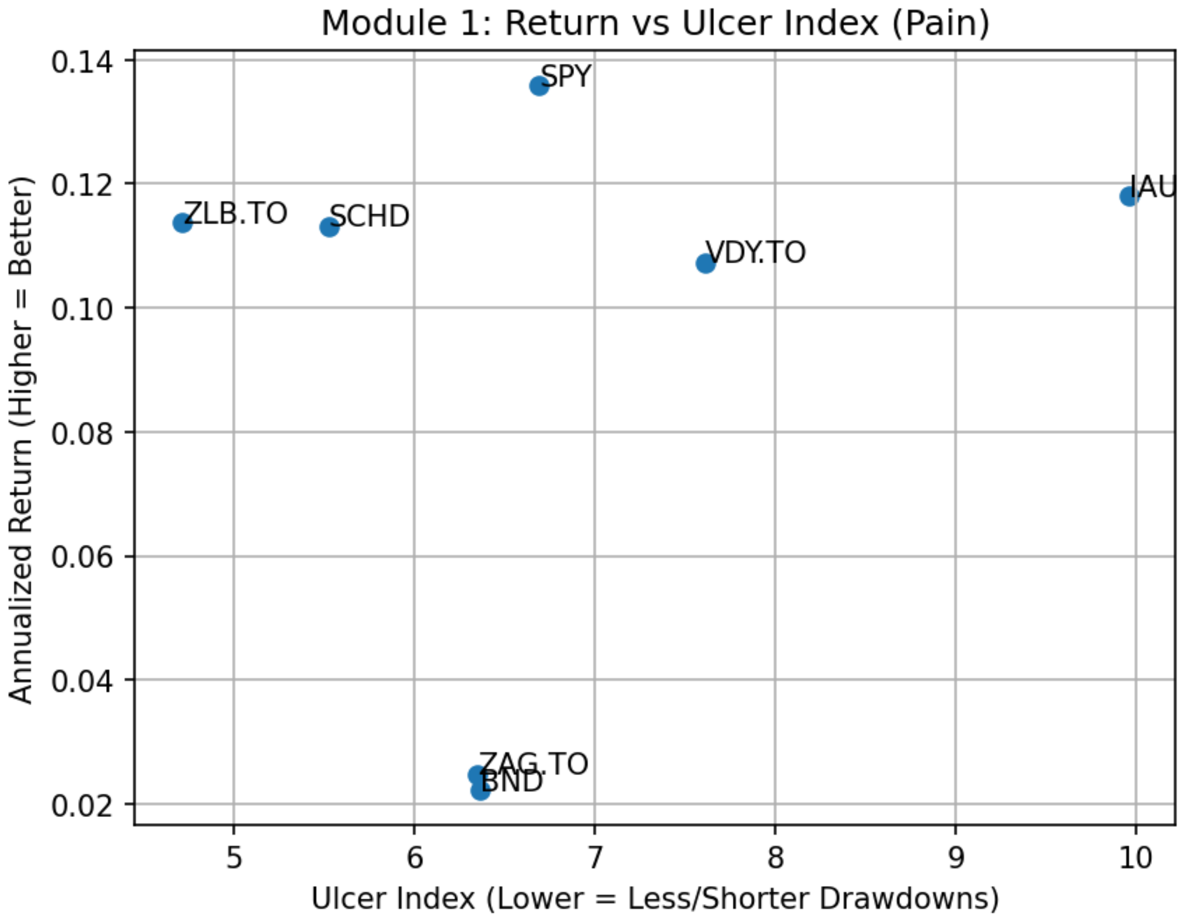


Cell 18: ■ Code

```
plt.figure()
x = metrics_df["Ulcer Index"]
y = metrics_df["Annualized Return"]
plt.scatter(x, y)
```

```
for etf in metrics_df.index:
plt.text(x.loc[etf], y.loc[etf], etf)
```

```
plt.title("Module 1: Return vs Ulcer Index (Pain)")
plt.xlabel("Ulcer Index (Lower = Less/Shorter Drawdowns)")
plt.ylabel("Annualized Return (Higher = Better)")
plt.grid(True)
plt.show()
```



Cell 19: ■ Markdown

- Left = less pain, up = more reward

- Best ETFs sit upper left

- thats why return/ulcer is a clean effiency score

The Story:

- SPY (Top Right): Makes the most money, but sits far to the right. It is "High Stress."

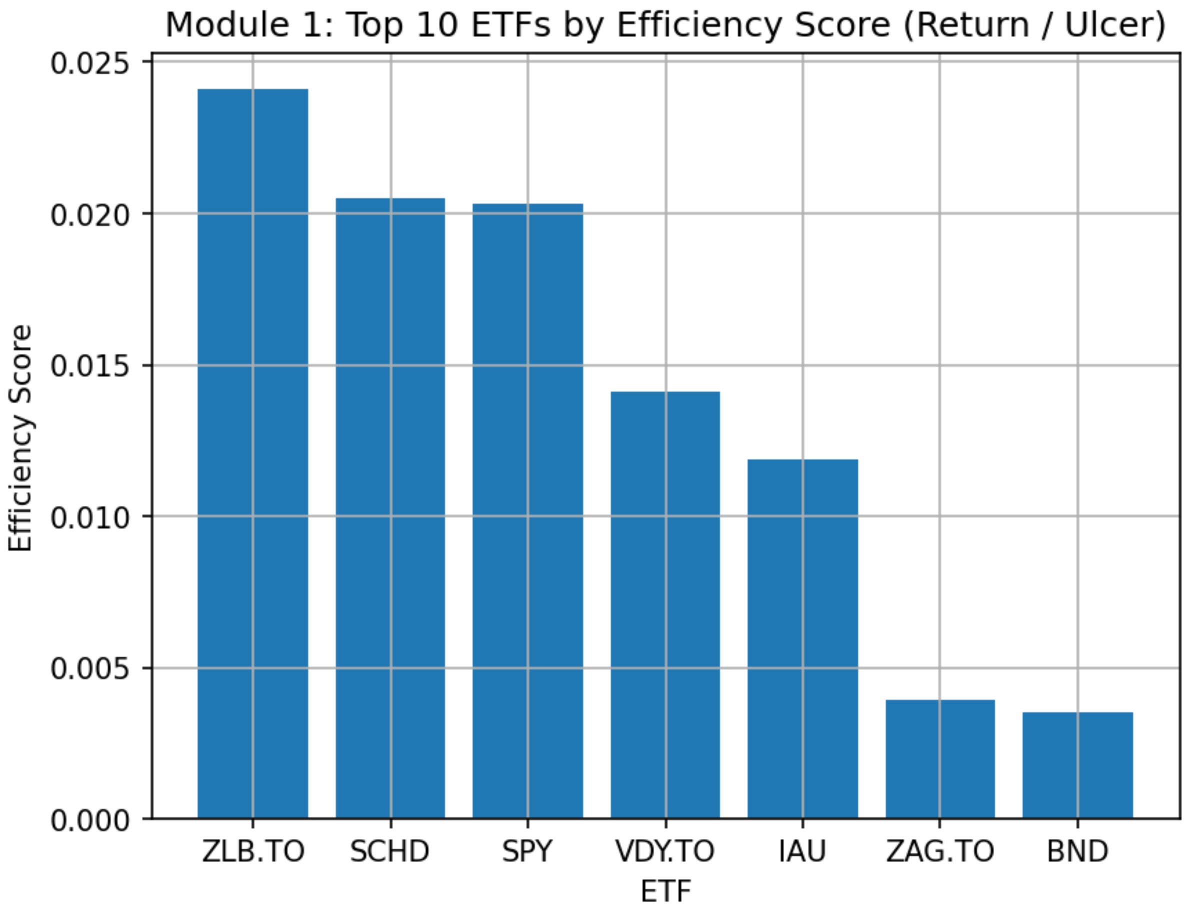
- SCHD (Top Left-ish): This is your Winner. It is nearly as high up as SPY (good return) but significantly to the left (less pain). It is the "Efficient" choice.

- BND (Bottom): Low return and, surprisingly, historically high pain recently. It is currently the "Worst of both worlds."

Cell 20: ■ Code

```
top10 = metrics_df.sort_values("Efficiency Score", ascending=False).head(10)
```

```
plt.figure()
plt.bar(top10.index, top10["Efficiency Score"])
plt.title("Module 1: Top 10 ETFs by Efficiency Score (Return / Ulcer)")
plt.xlabel("ETF")
plt.ylabel("Efficiency Score")
plt.grid(True)
plt.show()
```



Cell 21: ■ Markdown

divide "Return" by "Pain." A taller bar means you are getting a better deal.

Cell 22: ■ Code

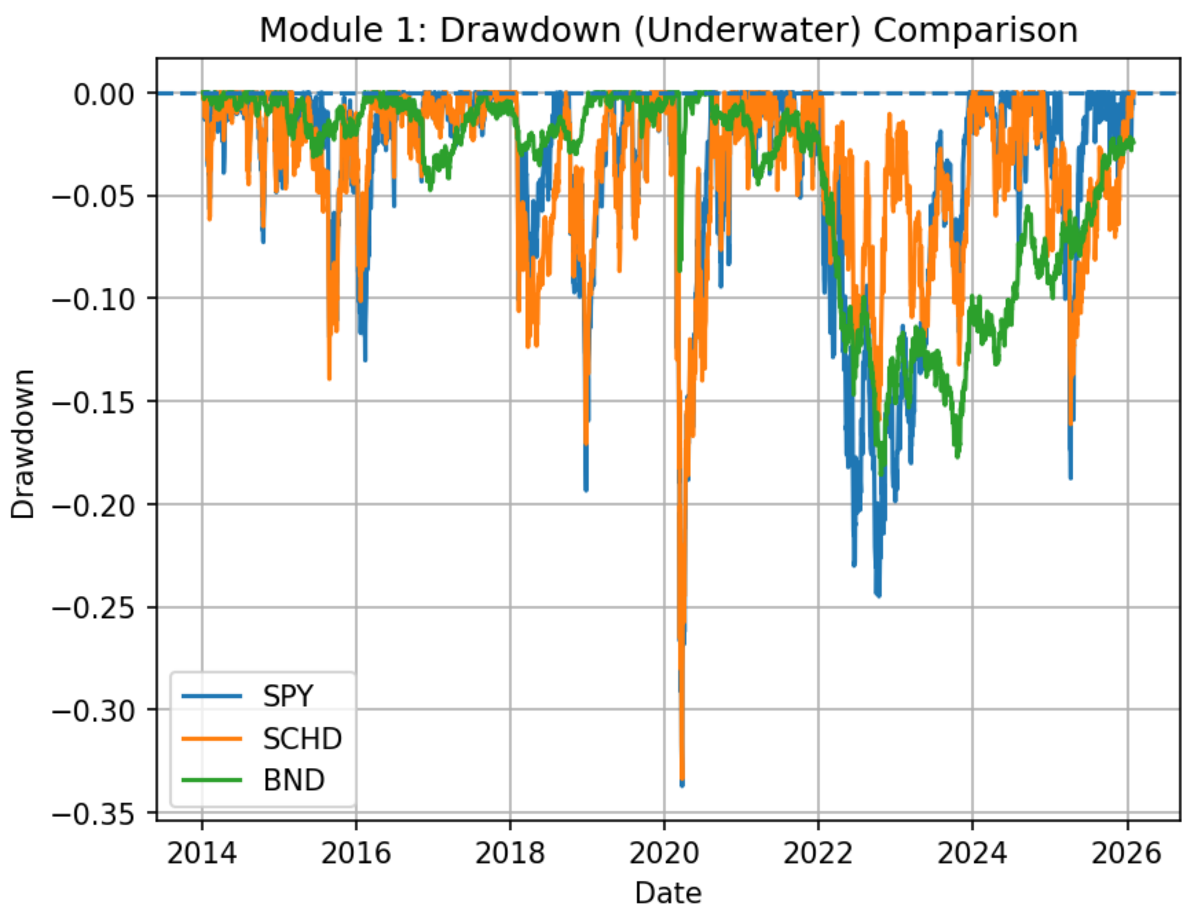
```
def drawdown_series(r):
eq = (1 + r.fillna(0)).cumprod()
peak = eq.cummax()
```

```
return (eq / peak - 1)
```

```
compare = [t for t in ["SPY","SCHD","USMV","QUAL","BND"] if t in
returns_wide.columns]
```

```
plt.figure()
for t in compare:
plt.plot(drawdown_series(returns_wide[t]), label=t)
```

```
plt.axhline(0, linestyle="--")
plt.title("Module 1: Drawdown (Underwater) Comparison")
plt.xlabel("Date")
plt.ylabel("Drawdown")
plt.legend()
plt.grid(True)
plt.show()
```



Cell 23: ■ Markdown

- Blue Line (SPY): Deep dives. It goes down fast and hard.

- Orange Line (SCHD): Notice that in many crashes, the Orange line doesn't go as deep as the Blue line. It is a "life jacket"—you still get wet, but you don't drown.

- Green Line (BND): Look at the right side (2022-present). It went deep underwater and stayed there. It hasn't recovered. This scares passive investors.

Cell 24: ■ Code

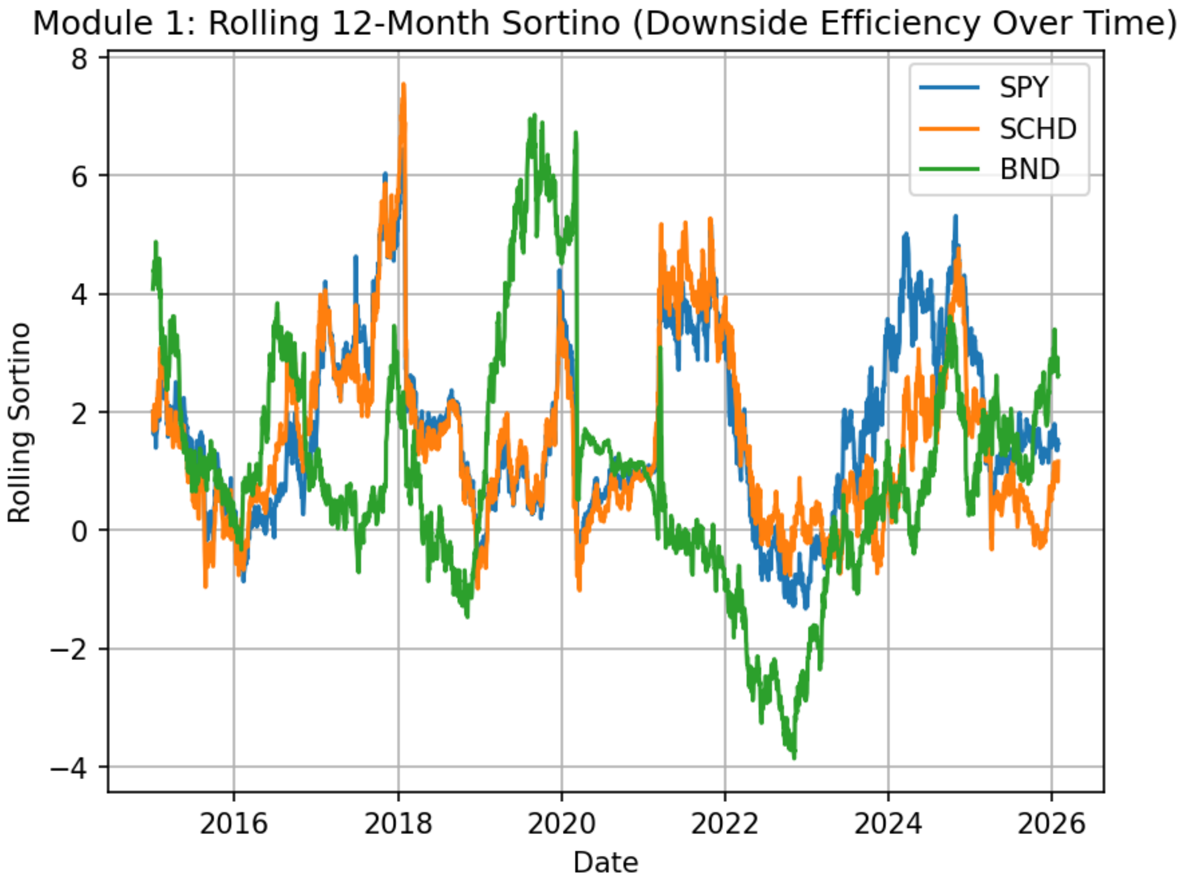
```
TRADING_DAYS = 252
```

```
def rolling_sortino(r, window=252, mar_annual=0.0):
mar_daily = (1 + mar_annual)**(1/TRADING_DAYS) - 1
out = []
idx = r.dropna().index
r = r.dropna()
for i in range(window, len(r)+1):
chunk = r.iloc[i-window:i]
downside = np.minimum(chunk - mar_daily, 0.0)
downside_dev = downside.std(ddof=0) * np.sqrt(TRADING_DAYS)
ann_excess = (chunk.mean() - mar_daily) * TRADING_DAYS
out.append(ann_excess / downside_dev if downside_dev != 0 else np.nan)
return pd.Series(out, index=idx[window-1:])
```

```
winners = [t for t in ["SPY","SCHD","BND"] if t in returns_wide.columns]
```

```
plt.figure()
for t in winners:
rs = rolling_sortino(returns_wide[t], window=252)
plt.plot(rs, label=t)
```

```
plt.title("Module 1: Rolling 12-Month Sortino (Downside Efficiency Over Time)")
plt.xlabel("Date")
plt.ylabel("Rolling Sortino")
plt.legend()
plt.grid(True)
plt.show()
```



Cell 25: ■ Markdown

- this shows if the etf stay efficient consistenly, not only on average

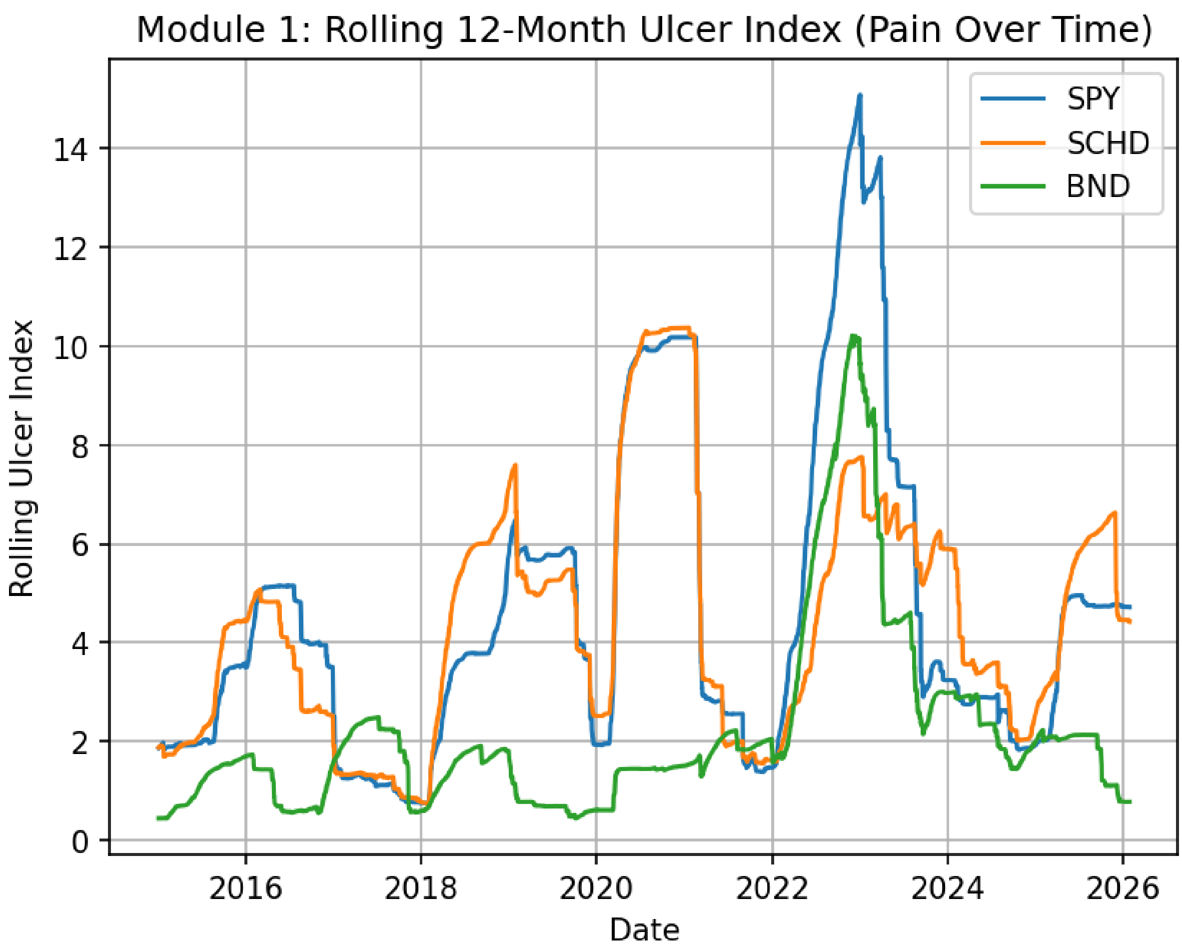
Cell 26: ■ Code

```
def rolling_ulcer(r, window=252):
r = r.dropna()
out = []
idx = r.index
for i in range(window, len(r)+1):
chunk = r.iloc[i-window:i]
eq = (1 + chunk).cumprod()
peak = eq.cummax()
dd_pct = (eq / peak - 1) * 100.0
out.append(np.sqrt(np.mean(dd_pct**2)))
```

```
return pd.Series(out, index=idx[window-1:])
```

```
plt.figure()
for t in [x for x in ["SPY","SCHD","USMV","BND"] if x in returns_wide.columns]:
ru = rolling_ulcer(returns_wide[t], window=252)
plt.plot(ru, label=t)
```

```
plt.title("Module 1: Rolling 12-Month Ulcer Index (Pain Over Time)")
plt.xlabel("Date")
plt.ylabel("Rolling Ulcer Index")
plt.legend()
plt.grid(True)
plt.show()
```



Cell 27: ■ Code

```
ru_spy = rolling_ulcer(returns_wide["SPY"], window=252)
print("First rolling date:", ru_spy.index.min())
print("Original data start:", returns_wide.index.min())
```

Output:

```
First rolling date: 2015-01-02 00:00:00
Original data start: 2014-01-03 00:00:00
```

Cell 28: ■ Code