probit

November 10, 2025

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from fredapi import Fred
import yfinance as yf
from dotenv import load_dotenv
import os
```

[2]:
```
fred =Fred(os.getenv("fred_api"))
```

[3]:
```
def series_fred(fred, series_dict):
    data= pd.DataFrame()
    for code, name in series_dict.items():
        data[name] = fred.get_series(code, frequency = 'm')
    return data
```

[4]:
```
series={'SAHMCURRENT':'sahm_rule',
        'VIXCLS':'vix',
        'T10Y2Y':'T10Y2Y',
        'T10Y3M':'T10Y3M',
        'INDPRO':'INDPRO',
        'CPIAUCSL':'CPI',
        'PCE':'PCE'
        }
```

[5]:
```
sp_500 = yf.download(tickers='^GSPC', start='1990-01-01', end='2025-10-05',␣
 ↪interval='1mo', auto_adjust=True)['Close']
sp_500 = sp_500.round(4)
```

```
[**********************100%**********************]  1 of 1 completed
```

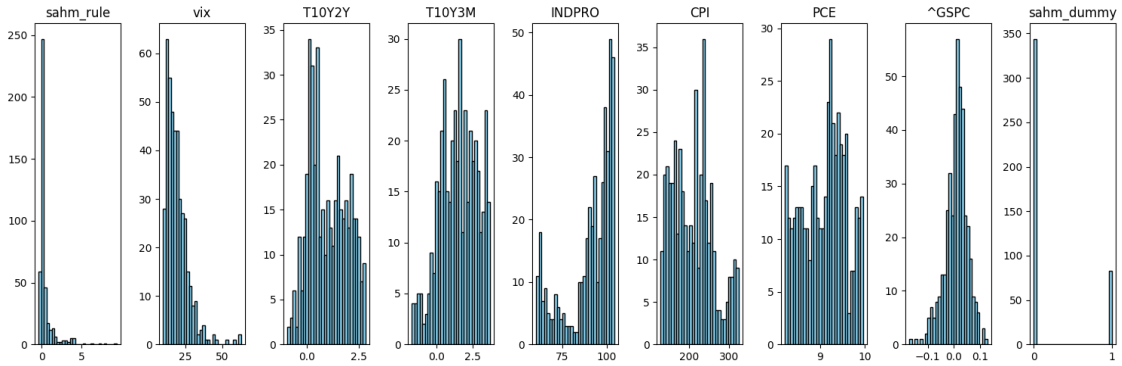
[6]:
```
data = series_fred(fred, series)
data = pd.merge(data, sp_500, left_index=True, right_index=True, how='left')
data['sahm_dummy'] = (data['sahm_rule'] > 0.5).astype(int)
data['PCE'] = np.log(data['PCE'])
data['^GSPC'] = data['^GSPC'].pct_change()
```

```
data = data.dropna(axis=0)
#data = data.loc['2007-12-01':'2009-06-06']
data
```

[6]:
```
            sahm_rule    vix  T10Y2Y  T10Y3M    INDPRO      CPI       PCE  \
1990-02-01       0.23  23.26    0.10    0.47   62.1951  128.000  8.223681
1990-03-01       0.17  20.06   -0.04    0.42   62.4916  128.600  8.230817
1990-04-01       0.17  21.40    0.06    0.75   62.3511  128.900  8.234830
1990-05-01       0.20  18.10    0.12    0.75   62.5353  129.100  8.236368
1990-06-01       0.10  16.82    0.13    0.49   62.7479  129.900  8.243940
…                 …     …       …       …        …        …        …
2025-04-01       0.27  31.97    0.50   -0.04  103.6224  320.321  9.940128
2025-05-01       0.27  20.46    0.50    0.06  103.6570  320.580  9.940542
2025-06-01       0.17  18.40    0.49   -0.04  104.2115  321.500  9.945991
2025-07-01       0.10  16.38    0.51   -0.02  103.8194  322.132  9.951454
2025-08-01       0.13  15.75    0.56   -0.04  103.9203  323.364  9.957592

                ^GSPC  sahm_dummy
1990-02-01   0.008539           0
1990-03-01   0.024255           0
1990-04-01  -0.026887           0
1990-05-01   0.091989           0
1990-06-01  -0.008886           0
…                 …          …
2025-04-01  -0.007625           0
2025-05-01   0.061524           0
2025-06-01   0.049607           0
2025-07-01   0.021667           0
2025-08-01   0.019066           0

[427 rows x 9 columns]
```

[7]:
```
variables = data.columns
n =  len(variables)
```

[8]:
```
fig, axes = plt.subplots(1, n, figsize=(15,5))

for i, col in enumerate(variables):
    axes[i].hist(data[col], bins=30, color="skyblue", edgecolor="black")
    axes[i].set_title(f"{col}")

plt.tight_layout()
plt.show()
```



[9]:
```
#Modelo Probit
x = data.iloc[:,1:-1]
#x = sm.add_constant(x)
y = data.iloc[:,-1]
probit_model = sm.Probit(y, x)
res = probit_model.fit()
```

```
Optimization terminated successfully.
         Current function value: 0.297852
         Iterations 7
```

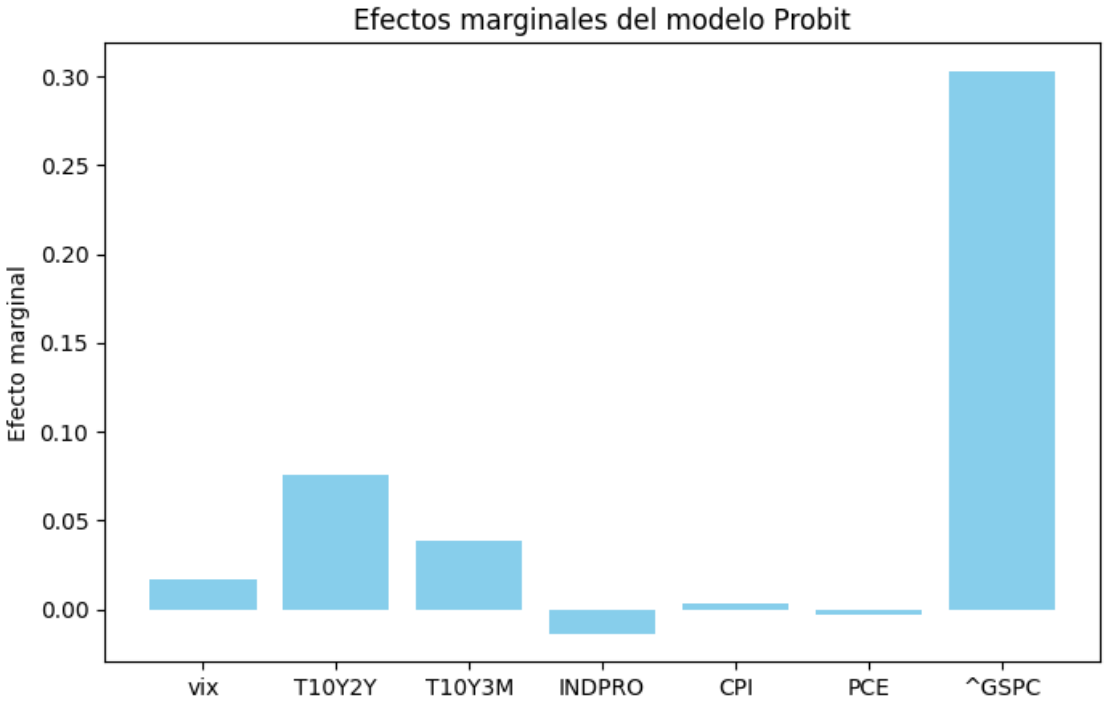
[10]:
```
print(res.summary())
```

```
                          Probit Regression Results
==============================================================================
Dep. Variable:             sahm_dummy   No. Observations:                  427
Model:                         Probit   Df Residuals:                      420
Method:                           MLE   Df Model:                            6
Date:                Mon, 10 Nov 2025   Pseudo R-squ.:                  0.3952
Time:                        11:54:07   Log-Likelihood:                -127.18
converged:                       True   LL-Null:                       -210.30
Covariance Type:            nonrobust   LLR p-value:                2.822e-33
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
vix            0.1009      0.014      7.238      0.000       0.074       0.128
T10Y2Y         0.4549      0.266      1.713      0.087      -0.065       0.975
T10Y3M         0.2308      0.212      1.091      0.275      -0.184       0.645
INDPRO        -0.0829      0.014     -5.965      0.000      -0.110      -0.056
CPI            0.0169      0.004      4.416      0.000       0.009       0.024
PCE           -0.0172      0.109     -0.158      0.874      -0.231       0.197
^GSPC          1.8226      2.053      0.888      0.375      -2.200       5.846
==============================================================================
```

[11]:
```
margeff = res.get_margeff()
print(margeff.summary())
```

```
       Probit Marginal Effects
=====================================
Dep. Variable:             sahm_dummy
Method:                          dydx
At:                           overall
================================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------
vix             0.0168      0.002      8.678      0.000       0.013       0.021
T10Y2Y          0.0756      0.043      1.746      0.081      -0.009       0.161
T10Y3M          0.0384      0.035      1.089      0.276      -0.031       0.107
INDPRO         -0.0138      0.002     -6.772      0.000      -0.018      -0.010
CPI             0.0028      0.001      4.693      0.000       0.002       0.004
PCE            -0.0029      0.018     -0.158      0.875      -0.038       0.033
^GSPC           0.3030      0.341      0.890      0.374      -0.365       0.971
================================================================================
```

[12]:
```
effects = margeff.margeff
variables = x.columns
plt.figure(figsize=(8,5))
plt.bar(variables, effects, color='skyblue')
plt.ylabel("Efecto marginal")
plt.title("Efectos marginales del modelo Probit")
plt.show()
```



[13]:
```
#estadistica descriptiba

describe_stats = data.describe().T.round(4)
```

[14]:
```
#modelo logit

x_logit = data.iloc[:,1:-1]
x_logit = sm.add_constant(x)
y_logit = data.iloc[:,-1]
```

[15]:
```
logit_model = sm.Logit(y,x)
res_logit = logit_model.fit()
print(res_logit.summary())
```

```
Optimization terminated successfully.
         Current function value: 0.296588
         Iterations 8
                           Logit Regression Results
==============================================================================
Dep. Variable:              sahm_dummy   No. Observations:                  427
Model:                           Logit   Df Residuals:                      420
Method:                            MLE   Df Model:                            6
Date:                 Mon, 10 Nov 2025   Pseudo R-squ.:                 0.3978
Time:                         11:54:07   Log-Likelihood:                -126.64
converged:                       True   LL-Null:                       -210.30
Covariance Type:            nonrobust   LLR p-value:                 1.666e-33
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
vix            0.1897      0.028      6.759      0.000       0.135       0.245
T10Y2Y         0.6170      0.471      1.309      0.190      -0.307       1.541
T10Y3M         0.5784      0.394      1.470      0.142      -0.193       1.350
INDPRO        -0.1497      0.026     -5.648      0.000      -0.202      -0.098
CPI            0.0308      0.007      4.326      0.000       0.017       0.045
PCE           -0.0564      0.194     -0.291      0.771      -0.437       0.324
^GSPC          3.4670      3.747      0.925      0.355      -3.877      10.811
==============================================================================
```

[16]:
```
#Resultados log_odds

odds_ratio_logit = np.exp(res_logit.params)
print(odds_ratio_logit)
```

```
vix        1.208912
T10Y2Y     1.853312
T10Y3M     1.783140
```

```
INDPRO     0.861008
CPI        1.031304
PCE        0.945124
^GSPC     32.040863
dtype: float64
```

[17]:
```
#Efectos marginales logit

marginal_logit = res_logit.get_margeff()
print(marginal_logit.summary())
```

```
        Logit Marginal Effects
=====================================
Dep. Variable:             sahm_dummy
Method:                          dydx
At:                           overall
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
vix             0.0173      0.002      8.680      0.000       0.013       0.021
T10Y2Y          0.0564      0.043      1.326      0.185      -0.027       0.140
T10Y3M          0.0529      0.036      1.474      0.141      -0.017       0.123
INDPRO         -0.0137      0.002     -6.661      0.000      -0.018      -0.010
CPI             0.0028      0.001      4.680      0.000       0.002       0.004
PCE            -0.0052      0.018     -0.290      0.772      -0.040       0.030
^GSPC           0.3170      0.342      0.927      0.354      -0.353       0.987
==============================================================================
```

[ ]: