Question 4

(a)

```
import pandas as pd
import statsmodels.api as sm
import statsmodels.formula.api as smf

df = pd.read_csv("treaty.csv")

covariates = [
    "shift_left", "flexible", "regnorm", "gdpgrow", "resgdp", "bopgdp",
    "useimfcr", "surveil", "univers", "resvol", "totvol", "tradedep",
    "military", "termlim", "parli", "lastrest", "lastrest2", "lastrest3"
]

formula = "restrict ~ art8 + " + " + ".join(covariates)
model = smf.logit(formula=formula, data=df)
result = model.fit()

print(result.summary())

import numpy as np
odds_ratio = np.exp(result.params['art8'])
print(f"\nOdds ratio for art8: {odds_ratio:.3f}")
```

```
Optimization terminated successfully.
         Current function value: 0.259201
         Iterations 8
                           Logit Regression Results
==============================================================================
Dep. Variable:               restrict   No. Observations:                 4362
Model:                          Logit   Df Residuals:                     4342
Method:                           MLE   Df Model:                           19
Date:                Sun, 04 May 2025   Pseudo R-squ.:                  0.6240
Time:                        15:12:24   Log-Likelihood:                -1130.6
converged:                       True   LL-Null:                       -3006.8
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.2730      0.601      0.454      0.650      -0.905       1.451
art8          -1.6956      0.162    -10.458      0.000      -2.013      -1.378
shift_left     0.6228      0.247      2.521      0.012       0.139       1.107
flexible      -0.5891      0.147     -4.021      0.000      -0.876      -0.302
regnorm        0.0046      0.002      1.945      0.052   -3.58e-05       0.009
gdpgrow       -0.0101      0.005     -1.854      0.064      -0.021       0.001
resgdp        -0.4410      0.395     -1.117      0.264      -1.215       0.333
bopgdp        -0.0032      0.005     -0.591      0.554      -0.014       0.007
useimfcr       0.9478      0.128      7.393      0.000       0.697       1.199
surveil        0.4333      0.158      2.735      0.006       0.123       0.744
univers        0.0362      0.006      5.691      0.000       0.024       0.049
resvol         0.1399      0.110      1.268      0.205      -0.076       0.356
totvol         0.3662      0.097      3.788      0.000       0.177       0.556
tradedep      -0.0063      0.001     -4.719      0.000      -0.009      -0.004
military      -0.3204      0.140     -2.288      0.022      -0.595      -0.046
termlim        0.0484      0.149      0.325      0.745      -0.243       0.340
parli         -0.0765      0.153     -0.501      0.617      -0.376       0.223
lastrest      -1.6723      0.075    -22.406      0.000      -1.819      -1.526
lastrest2      0.1345      0.009     15.066      0.000       0.117       0.152
lastrest3     -0.0030      0.000    -11.174      0.000      -0.004      -0.003
==============================================================================

Odds ratio for art8: 0.183
```

The logistic regression shows a negative and statistically significant coefficient for art8, with an odds ratio less than 1. This suggests that, after adjusting for other covariates, countries that signed Article VIII were less likely to impose foreign exchange restrictions. While the result indicates a strong association, causal interpretation should be made with caution due to the observational nature of the data.

(b)

```
import pandas as pd
import statsmodels.api as sm
import statsmodels.formula.api as smf
import numpy as np
```

```
# 1. Load the data
df = pd.read_csv("treaty.csv")

# 2. Drop any missing clusters (if any)
df = df.dropna(subset=["imf_ccode"])

# 3. Define covariates
covariates = [
    "shift_left", "flexible", "regnorm", "gdpgrow", "resgdp", "bopgdp",
    "useimfcr", "surveil", "univers", "resvol", "totvol", "tradedep",
    "military", "termlim", "parli", "lastrest", "lastrest2", "lastrest3"
]

# 4. Construct formula
formula = "restrict ~ art8 + " + " + ".join(covariates)

# 5. Fit logistic regression with clustered standard errors
model = smf.logit(formula=formula, data=df)
result = model.fit(
    cov_type="cluster",
    cov_kwds={"groups": df["imf_ccode"]},
    disp=0
)

# 6. Show the results
print(result.summary())

# 7. Odds ratio for art8
odds_ratio = np.exp(result.params['art8'])
print(f"\nClustered odds ratio for art8: {odds_ratio:.3f}")
```

```
                           Logit Regression Results
==============================================================================
Dep. Variable:               restrict   No. Observations:                 4362
Model:                          Logit   Df Residuals:                     4342
Method:                          MLE   Df Model:                           19
Date:                Sun, 04 May 2025   Pseudo R-squ.:                0.6240
Time:                        15:12:25   Log-Likelihood:                -1130.6
converged:                       True   LL-Null:                       -3006.8
Covariance Type:             cluster   LLR p-value:                     0.000
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.2730      0.834      0.328      0.743      -1.361       1.907
art8          -1.6956      0.248     -6.841      0.000      -2.181      -1.210
shift_left     0.6228      0.218      2.860      0.004       0.196       1.050
flexible      -0.5891      0.185     -3.189      0.001      -0.951      -0.227
regnorm        0.0046      0.004      1.249      0.212      -0.003       0.012
gdpgrow       -0.0101      0.006     -1.685      0.092      -0.022       0.002
resgdp        -0.4410      0.737     -0.599      0.549      -1.885       1.003
bopgdp        -0.0032      0.005     -0.621      0.535      -0.013       0.007
useimfcr       0.9478      0.168      5.629      0.000       0.618       1.278
surveil        0.4333      0.214      2.028      0.043       0.014       0.852
univers        0.0362      0.010      3.793      0.000       0.018       0.055
resvol         0.1399      0.160      0.872      0.383      -0.175       0.454
totvol         0.3662      0.119      3.072      0.002       0.133       0.600
tradedep      -0.0063      0.002     -3.590      0.000      -0.010      -0.003
military      -0.3204      0.151     -2.115      0.034      -0.617      -0.023
termlim        0.0484      0.181      0.267      0.790      -0.307       0.404
parli         -0.0765      0.166     -0.462      0.644      -0.401       0.248
lastrest      -1.6723      0.104    -16.057      0.000      -1.876      -1.468
lastrest2      0.1345      0.016      8.316      0.000       0.103       0.166
lastrest3     -0.0030      0.001     -5.413      0.000      -0.004      -0.002
==============================================================================

Clustered odds ratio for art8: 0.183
```

After refitting the logistic regression with clustered standard errors by country (imf_ccode), the coefficient for art8 remains negative and statistically significant. This suggests that the association between signing Article VIII and a lower likelihood of imposing foreign exchange restrictions is robust to within-country correlation. Our conclusion from part (a) remains unchanged.

(c)

Using a ridge penalty may help reduce overfitting due to the large number of covariates relative to the number of observations per country. However, the primary goal here is to interpret the effect of art8, and ridge regression shrinks coefficients toward zero, making interpretation less straightforward. Since our logistic model yields a significant and stable estimate for art8 even with clustered standard errors, adding a ridge penalty is not necessary in this case.