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ECOM6004 ASSESSMENT 1

1. BINARY MODELS: EXPERIMENTAL ANALYSES

i) The value we get after the split is 0.313 with Bo value of -0.6 where the search range was from -2 to 2 and step size was 0.1. But if we change the range from -3 to 3 and step size to 0.2, we get Bo value of 0.67.

```
Best beta_0: -0.6
Proportion of 1s: 0.313

The value of beta0 that gives approximately 30% 1's is: -0.67
Proportion of 1's in y_final: 0.292
```

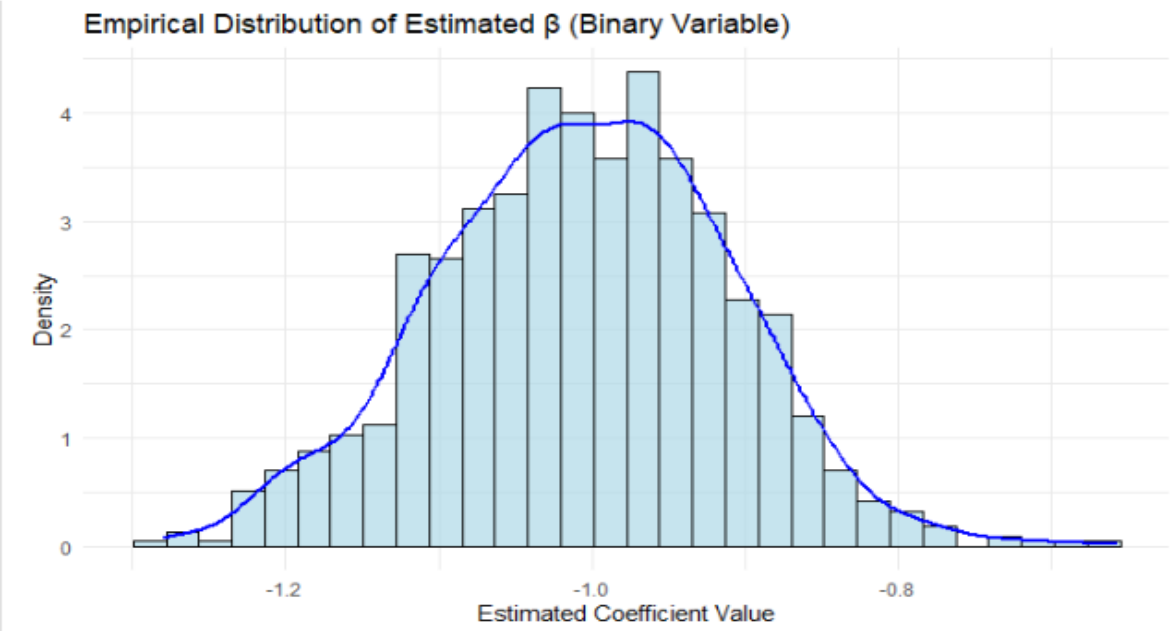
ii)

a) Pick one of the estimated β's and plot its empirical distribution and comment on this.

The average estimated coefficients from re-estimation with new $y_i s$ after 1,000 simulations:

	Intercept	Binary Variable	Normal Variable
Average Estimated Coefficients	-0.60471900	-1.00633421	0.05058127

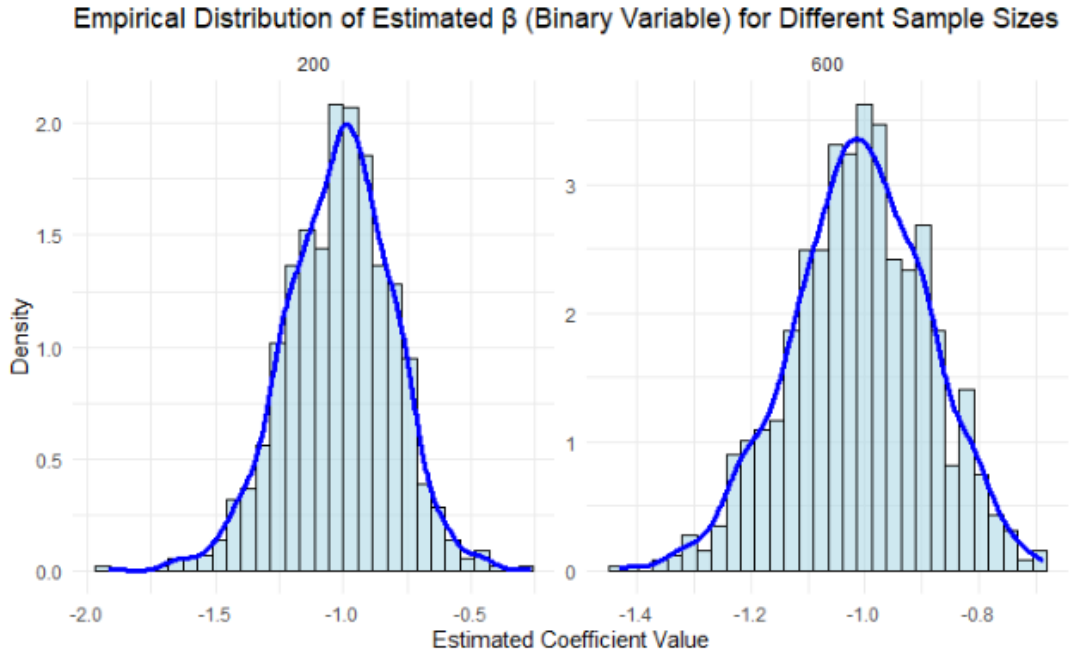
The estimated β taken for plotting is Binary Variable. The sample size used for this distribution is N=1000.



The distribution is normal distribution with most values scattered around -1.0. The average estimated coefficients are close to the B value of -0.6, 1 and -0.5. The intercepts estimates reflect the distribution around the true coefficients. The results suggests that the model correctly captures data and the estimated outcomes under the normal condition of maximum probability estimation.

b) Repeat this exercise experimenting with a few (say 2 or 3) different sample sizes (N) and comment on your findings. In particular relate these findings to any theoretical properties of these estimators.

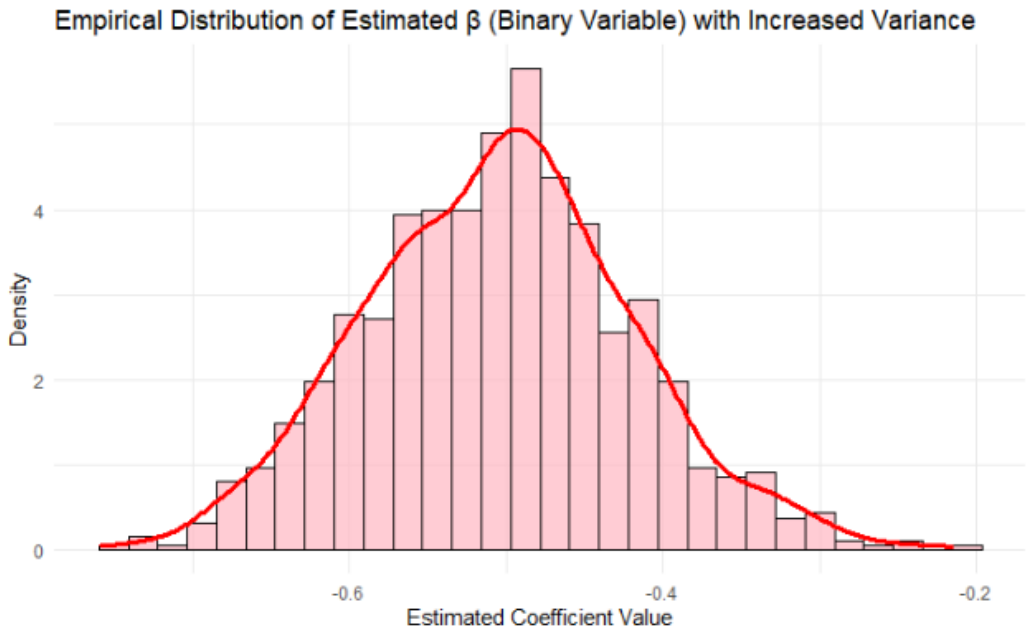
The sample size of N=200 and N =600 was used in two of the distributions.



The histograms shows that as we increase the sample size, the spread of distribution becomes narrow and narrow. It could be implied from this that the variance of the estimator decreases with the increase in sample size. Furthermore, the shape of all histograms appears to be more and more normally distributed as we increase the sample size with most values centred around the true coefficient i.e., -1. The plots suggests that as the sample size increase, the model become more and more consistent to the true parameter values.

c) Pick one value of N you have already considered, and instead of setting σ 2 = 1, set this to a bigger number and re-run your experiment. Focusing on the estimation of β, how does this affect your results and how can you explain this? [5 marks]

To understand the impact of increasing error variance (σ^2) on the estimation of β, we will increase the standard deviation $(\sigma^2) = 4$ instead of (σ^2)=1 in the initial models where N=1000. This increases the error terms spread which leads to more variability in given equation and impact the binary outcome.



Larger empirical distribution of estimated β coefficients can be observed in the new distribution which shows a lower precision and larger standard error in finding the true coefficients. The increasing variance leads to higher uncertainty in coefficients estimations. The reason for this is more noise makes it difficult to find the true relationship between the estimated coefficient and density. The distribution still shows a normal distribution with a little skewness toward to right end, suggesting that, large error variance results in many unobserved factors which influence the outcome variable, and it makes more challenging to precisely estimate the independent variables impact on the dependent variable.

2 BINARY MODELS: EMPIRICAL ANALYSES (20 MARKS IN TOTAL)

i) Choice of Features/Covariates:

Model:

```
Call:
glm(formula = change ~ zlb + size_scaled + gender + chair_scaled +
    exp_scaled + acad_scaled + bank_scaled + govt_scaled + fin_scaled +
    ind_scaled + infg_d_scaled + gapf4_scaled + outsider + kids_scaled,
    family = binomial, data = data_scaled)

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)    1.6536     0.6169   2.681 0.007350 **
zlb           -0.8468     0.1640  -5.162 2.44e-07 ***
size_scaled   -0.2431     0.5037  -0.483 0.629347
gender        -0.9549     0.2168  -4.404 1.06e-05 ***
chair_scaled  -0.3907     0.2335  -1.673 0.094254 .
exp_scaled     0.1731     0.3392   0.510 0.609957
acad_scaled   -0.2096     0.3653  -0.574 0.566073
bank_scaled   -0.7162     0.3738  -1.916 0.055391 .
govt_scaled   -0.4365     0.3794  -1.150 0.249956
fin_scaled    -0.8522     0.4275  -1.994 0.046200 *
ind_scaled     0.4273     0.3180   1.344 0.178985
infg_d_scaled -1.0452     0.4455  -2.346 0.018970 *
gapf4_scaled  -1.9278     0.3157  -6.107 1.01e-09 ***
outsider       0.5427     0.1626   3.338 0.000844 ***
kids_scaled    0.2036     0.2343   0.869 0.384824
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2657.0  on 2182  degrees of freedom
Residual deviance: 2371.3  on 2168  degrees of freedom
AIC: 2401.3

Number of Fisher Scoring iterations: 4
```

The model shows that zlb, gender, gapf4 and outsider are highly significant variables while fin and infg_d shows low significance while chair and bank show very low significance on the dependent variable i.e., change in interest rate decision.

Zero Lower Bound (zlb) is referred to periods when the interest rates are very near to zero which limits the ability of MPC’s to further lower rates. During this period, policy makers are supposed to less likely to make changes and monetary policy is constrained. The committee size must impact dynamics of decision making with large groups facing more difficulty in reaching a consensus. Hence the relationship among voting behaviour and committee size in monetary policy is not well established.

The diversity of gender is increasingly recognized as decision making factor. Female policy makers might adopt more cautions and risk averse approaches in undefined environments which might impact the likelihood of policy changes voting. The MPC chair plays a leadership role and might be more conservative in advocating policy changes. MPC chair may prioritize consensus building or stability over pushing for drastic changes. the MPC member professional background might shape the policy preferences like

- Banking and Finance: finance or banking members background might favour caution and stability.
- Academia: might encourage more experimental or theoretical policy approaches.
- Government: emphasize economic stability or policy continuity.
- Industry: focus on interest rate impact on investment and business

On MPC, outsiders are the external experts whereas insiders are employees of Bank of England. The outsiders might bring latest perspectives and are willing to advocate the changes whereas insiders may more institutionally conservative. GDP growth forecast gap measures the difference among the long run trend and expected GDP growth. The strong growth of economy might reduce the interest rate changes need whereas weak growth might prompt the cuts. Inflation Forecast Gap (infg_d_scaled) measures the difference among target rate and expected inflation which is usually 2%.

The members of MPC are likely to vote for change, when there is a deviation of inflation from target either to prevent deflation or combat high inflation. Kids variable is included for completeness as there is less theoretical reason to expect the dependent children number may impact decisions of monetary policy. It is more considered to be a demographic factor.

ii) Based on the coefficients alone describe and explain your findings.

Variable	Coefficient	P-value
zlb	-0.8468	p < 0.001
size_scaled	-0.2431	p = 0.629
gender	-0.9549	p < 0.001
chair_scaled	-0.3907	p = 0.094
exp_scaled	0.1731	p = 0.610
acad_scaled	-0.2096	p = 0.566
bank_scaled	-0.7162	p = 0.055
govt_scaled	-0.4365	p = 0.250
fin_scaled	-0.8522	p = 0.046
ind_scaled	0.4273	p = 0.179
infg_d_scaled	-1.0452	p = 0.019
gapf4_scaled	-1.9278	p < 0.001
outsider	0.5427	p = 0.001
kids_scaled,	0.2036	p = 0.385

Zero Lower Bound has a coefficient estimate of -0. 8468. The negative coefficient shows that when interest rates reach near Zero Lower Bound (ZLB), the voting for likelihood of change, decreases significantly. Particularly for the periods when interest rates are near to zero and members are less likely to vote the rate change. This shows the difficulty in making more rate cuts, when the policy is already limited by low rates of interest. Size of the Committee coefficient is -0.2431. Negative coefficient shows that large committees may slightly reduce the likelihood of vote for change, but this impact is not significant statistically.

The coefficient of Gender is -0.9549 suggests that the female members are less likely to vote for interest rate change. -0.9549 coefficient shows that female members are risk averse or more cautious when it comes to change in policy. Chair of the Committee value is -0.3907. This implies that the committee chair is less likely to vote for change with relatively negative coefficient significance which suggest that chair might adopt more conservative view which favours monetary policy stability. Experience on the Committee coefficient came out to be 0.1731, suggesting that it has less positive effect on the dependent variable which suggests that more experienced members might slightly be motivated to vote for change, although this impact is not significant statistically.

Professional Background Variables are academic Experience which has a coeffiecient of -0.2096 which suggests that effect is not significant and academic background members

are not less or more likely to vote for change. Banking Experience coefficient is -0.7162. This negative coefficient may suggest that banking experience members are more likely to support stability and avoid changes in policy. Government Experience coefficient has come out to be -0.4365 suggesting that it has no significant impact on the dependent variable. The government experience members may not significantly differ in likelihood of change in vote. Finance Experience has a coefficient of -0.8522. This negative coefficient significantly shows members with finance background are more agreed to avoid changes in policy. Industry Experience coefficient is 0.4273, which shows that it has no significant impact. Industry background members do not show a tendency to vote against or for changes. Inflation Forecast Gap has a coefficient of -1.0452. the negative coefficient shows higher forecast of inflation which decrease the vote for change likelihood. The members might unwill to act until inflation becomes more predictable or stabilizes. GDP Growth Forecast Gap has a coefficient of -1.9278 indicating the negative coefficient and highly significant means that the if growth forecast of GDP exceed the long-term trend, then members are very less likely to vote for interest rate change. The strong economic growth reduces the need perceived for policy intervention. Outsider has a coefficient of 0.5427. This significant and positive coefficient shows that outsiders are more likely to vote for interest rate change in comparison to insiders. Number of Dependent Children has a coefficient of 0.2036, suggesting that the number of children has no significant impact on the members likelihood of vote for interest rate change.

iii) Compute partial/marginal effects for your model, and carefully explain and describe these.

The computed value of partial/marginal effects of model has been shown below:

	factor <chr>	AME <chr>	SE <chr>	z <chr>	p <chr>	lower <chr>	upper <chr>
1	acad_scaled	-0.0382	0.0665	-0.5740	0.5659	-0.1685	0.0922
2	bank_scaled	-0.1304	0.0678	-1.9229	0.0545	-0.2634	0.0025
3	chair_scaled	-0.0711	0.0424	-1.6761	0.0937	-0.1543	0.0120
4	exp_scaled	0.0315	0.0618	0.5101	0.6100	-0.0896	0.1526
5	fin_scaled	-0.1552	0.0775	-2.0016	0.0453	-0.3072	-0.0032
6	gapf4_scaled	-0.3511	0.0559	-6.2789	0.0000	-0.4607	-0.2415
7	gender	-0.1739	0.0389	-4.4681	0.0000	-0.2502	-0.0976
8	govt_scaled	-0.0795	0.0690	-1.1518	0.2494	-0.2148	0.0558
9	ind_scaled	0.0778	0.0579	1.3448	0.1787	-0.0356	0.1913
10	infg_d_scaled	-0.1904	0.0807	-2.3583	0.0184	-0.3486	-0.0322
11	kids_scaled	0.0371	0.0426	0.8701	0.3842	-0.0465	0.1206
12	outsider	0.0988	0.0294	3.3636	0.0008	0.0412	0.1564
13	size_scaled	-0.0443	0.0917	-0.4827	0.6293	-0.2241	0.1355
14	zlb	-0.1542	0.0293	-5.2597	0.0000	-0.2117	-0.0968

14 rows

Academic Experience has an AME value of -0.0382. This indicates a non-significant negative marginal impact with p value of 0.5659, which suggests that the work experience has no meaningful effect on likelihood of voting for interest rate change. Banking Experience has a AME value of -0.1304 suggesting Negative significant marginal impact of p=0.0545, which is close to conventional threshold significance of 0.05, indicating that the members who have a

banking background are less likely to support changes in rate which reflects a thoughtful approach in understanding the banking sector. Chair of the Committee has a AME value of -0.0711. The negative impact with p equals 0.0937 shows that the chair committee is less likely to vote for changes in rate which could be due to policy stability or joint decision. Experience on the Committee has an AME value of 0.0315. This value indicates that there is no statistical significance of positive impact, implying that committee experience does not significantly impact decision to rate changes. Finance Experience has an AME value of -0.1552. Negative impact significance shows that finance experience members are less likely to vote for interest rate change which is due to more risk averse nature in concern to financial stability. GDP Growth Forecast Gap has an AME = -0.3511 suggesting a negative impact on the growth of high GDP forecast which reduces the likelihood of vote in rate change and suggest confidence in condition of current economy without need of adjustment. Gender has AME = -0.1739 and significantly high negative impact with $p<0.002$ shows that female gender is less likely to vote for rate changes which reflects more conservative approach in monetary changes in policy.
Government Experience has AME value of -0.0795 shows that experience of government is not significantly affect decisions of rate change.
Industry Experience with the AME value of 0.0778 suggests a positive effect on dependent variable with p value of 0.1787 shows that the experience of industry must not influence the decisions of rate changes. Inflation Forecast Gap AME value is -0.1904. This shows a negative impact with p value of 0.0184 shows that high forecast of inflation relative to target lessen the likelihood of vote for change in rate which suggests a wait and see approach in inflation uncertainties. Kids has an AME value of 0.0371 showing a positive impact of members with children who are more dependent do not influence the rate changes decisions.
Outsider Status has a AME value of 0.0988 showing a positive significant impact with p of 0.0008 indicating that the outsiders who are more likely to vote for changes in rate which is due to less bias in maintaining the quo status. Size of the Committee AME has a value of -0.0443. A negative non-significant effect with p value of 0.6293, shows that the committee size does not meaningfully impact the decision-making process related to rate changes.
Zero Lower Bound AME is -0.1542 implying that the negative high significant impact with $p< 0.001$ shows that members are less likely to vote for changes in rate when the rates are near or at the zero, which is due to limited effectiveness of more reductions in rate.

iv) Report any summary model evaluation measures that you feel appropriate, and on the basis of these comment on the applicability of your model

For summary model evaluation, model like confusion matrix and coefficient significance can show meaningful insights on the predictability and strengths of the model.

a. **Confusion matrix:**

```
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0 1413  471
         1  121  178

               Accuracy : 0.7288
                 95% CI : (0.7096, 0.7474)
    No Information Rate : 0.7027
    P-Value [Acc > NIR] : 0.003841

                  Kappa : 0.2314

 Mcnemar's Test P-Value : < 2.2e-16

            Sensitivity : 0.27427
            Specificity : 0.92112
         Pos Pred Value : 0.59532
         Neg Pred Value : 0.75000
             Prevalence : 0.29730
         Detection Rate : 0.08154
   Detection Prevalence : 0.13697
      Balanced Accuracy : 0.59769

       'Positive' Class : 1
```

The results could be classified into:

- **True Negatives (TN)**: no change was predicted 1413 times by the model indicating the reliability of the outcome.
- **False Positives (FP)**: There were 471 instances where the model prediction of change was incorrect. This indicates the tendency of this model to overestimate the change occurrence.
- **False Negatives (FN)**: The opportunity to detect true changes was missed 121 times by the model, indicating that the model failed to identify the changes many times.
- **True Positives (TP)**: the correct prediction was made by the model 178 times, showing the strength of model in identifying changes.

The model indicates the accuracy of 72.8% indicating that almost 73 out of 100 prediction that were made by the model were accurate. 95% Confidence Interval (CI) for Accuracy of 70% and 74 %. This gives a range where the model true accuracy is likely to fall with 95% certainty indicating the model's stability. The model has a no Information rate of 0.7027. This is the accuracy which is achieved through predicting the more frequent class instead of just relying on guessing. This model is slightly better than the baseline. The model has Kappa value of 0.2314. it indicates and measures the fair agreement between the actual and predicted values, which are corrected for chance. It also shows the fair agreement which suggests the effectiveness of model and shows room for improvements. Furthermore, Mcnemar's Test has P-Value of < 2.2e-16. The vary small p value suggests significant imbalance among the errors of type I and type II.

Sensitivity (Recall) of 0.27427 indicates the ability of model to correctly find the actual changes. The value is low as model misses a significant amount of change events. Specificity of 0.92112 indicates the ability of the model to correctly find the no change event is relatively high which shows the effective model in finding the majority classes.
Positive Predictive Value (Precision) of 0.59532 indicates that the predictions made by model are nearly 59.53% correct. Negative Predictive Value of 0.75000 indicates that 75% were correct in all the no change prediction which are made by model. The model has a Balanced Accuracy of 0.59769. Specificity and sensitivity average gives more balanced measure of

performance of model across the class, mainly when there are imbalanced classes. This shows the less effectiveness of model in finding the minority class.

b. Coefficient significance

Coefficient significance indicates the stars in summary of models. The coefficient significance shows that respective predictors are playing the meaningful role in outcomes of model. Coefficients for predictors like fin_scaled, zlb, gender, infg_d_scaled, outsider and gapf4_scaled are significant, which indicates that they have substantial effect on the likelihood of voting for a change in rate.

3 MULTINOMIAL MODELS: EMPIRICAL ANALYSES (15 MARKS IN TOTAL)

i) Using your specification from Part 2 go back to your original definition of your dependent variable (up/down/no –chang e) and this time estimate an appropriate unordered choice model. What model do you estimate, and briefly comment on the results.

Multinomial Logistic Regression model would be used for that purpose. The model is used to handle dependent variables, it extends binary logistic regression with more than two categories and models the log odds of every outcome category as compared to reference category, usually chosen as most frequent or base category, as linear combination for predictor variables. The analysis is shown in the figure below.

```
# weights:  48 (30 variable)
initial  value 2398.270626
iter  10 value 1515.062879
iter  20 value 1396.511634
iter  30 value 1388.563589
final  value 1388.185205
converged
Call:
multinom(formula = vote_all ~ zlb + size_scaled + gender + chair_scaled +
    exp_scaled + acad_scaled + bank_scaled + govt_scaled + fin_scaled +
    ind_scaled + infg_d_scaled + gapf4_scaled + outsider + kids_scaled,
    data = data_scaled)

Coefficients:
  (Intercept)        zlb size_scaled        gender chair_scaled exp_scaled acad_scaled bank_scaled govt_scaled
1   5.7264320  0.8087063   -7.564642 -0.0008050422     2.066254  -2.716189   0.5389135  1.18462268   1.1632395
2  -0.2103231 -0.6658491   -8.885709 -1.8280883290     1.340987  -4.023961  -0.1979587  0.05491698   0.6704935
  fin_scaled ind_scaled infg_d_scaled gapf4_scaled   outsider kids_scaled
1  1.6269794   2.025117       2.38578     3.201944 -0.6370420  -0.6432571
2  0.4190386   3.290278      11.81924     4.259650 -0.1551408  -0.6318602

Std. Errors:
  (Intercept)       zlb size_scaled    gender chair_scaled exp_scaled acad_scaled bank_scaled govt_scaled fin_scaled
1    2.372562 0.2196283    2.323048 0.2943632    0.3636474  0.5282745   0.4828937   0.4997302   0.5480362  0.6403375
2    2.578357 0.3429207    2.360688 0.4105289    0.5081894  0.6873939   0.6548901   0.6671118   0.7145113  0.8041872
  ind_scaled infg_d_scaled gapf4_scaled  outsider kids_scaled
1  0.5747203     0.5877384    0.4381277 0.2202508   0.3287860
2  0.6704401     1.2824507    0.6358252 0.2902463   0.4292801

Residual Deviance: 2776.37
AIC: 2836.37
```

The model highlights the complex interactions among economic forecasts, member characteristics and professional backgrounds in decision-making. The significance of

predictors such as economic forecasts and gender show extended role in influencing decision-rate, aligns with economic theory for policy response to growth expectations and inflation.

- **Zero Lower Bound (zlb):**
    - For “Down”, the coefficient of = -0.2102331, shows that a decrease in likelihood of voting at ZLB to lower rates, aligns with the expectations as further lowering in rates when the interest rates are already near zero is less feasible.
    - For “Up”, Coefficient of 5.7264320, indicates a strong likelihood of voting when it is not at ZLB to raise rates is quite contrary, to what may be expected. This may show other dynamics at modelling anomaly or at play.
- **Gender(gender):**
    - It indicates that females decrease the likelihood of voting in raising the rates and significantly for lowering the rates, which might show a more conservative stance on rate changes between female members.
- **gapf4_scaled:**
    - “Down” Coefficient of -0.635471, also indicate decrease likelihood in lowering the rates, which is due to economic optimism or similar reasons.
    - "up" Coefficient of -2.58778, a forecast of higher GDP gap reduces the likelihood of voting in raising rates due to sufficient perceived economic growth.
- **infg_d_scaled:**
    - "down" Coefficient of -3.158090, indicates a strong likelihood in lowering rates when the inflation is lesser than target, to probably stimulate economic activity.
    - "up" Coefficient of 2.539475: shows an increasing likelihood of raising rates when forecasted the inflation to differ significantly from the target, which aligns to combat inflation with traditional monetary policy.
- **bank_scaled, fin_scaled:**
    - Finance (fin_scaled) and Banking (bank_scaled) backgrounds both show various effects based on the category of decision which reflects complex influences on decisions of rates, since professional experiences.

ii) Conduct a test for the Independence of (from) Irrelevant Alternatives and explain your findings; and in-light of your findings comment on the suitability of your model. [5 marks]

One of the common ways of testing the independence of irrelevant alternatives is by using Hausman-McFadden test. This involves modelling all variables and calculating the coefficients of the complete model and then comparing it with the coefficients of reduced model, where one choice is omitted. It tests the coefficients significance and makes assumptions based on that significance. The results of Hausman-McFadden test are as follow:

	Chi- square	Degree of Freedom	p-value
Hausman-Mcfadden Test	-664.76	15	1

Independence of irrelevant alternatives assumption are done using the hausman-McFadden test in multinomial logit model. The Ho of the test is that the relative chance of choosing between two alternatives is independent of the chance of presence or absence of another alternative. The test shows that the p-value has come out to be 1, which indicates that their no significant statistical evidence to reject the null hypothesis. The Chi square value is -664.76. The negative chi square can happen when the model is perfect multicollinear.

iii) Following the suggestion in the lecture notes, allow for nonlinearity in the effects of one of your continuous variables on the response probabilities (hint: include one, if you don't have one already following your Part 2 findings, for the purposes of this question). Does this appear to be an appropriate relationship or not? Explain. Report a single partial/marginal effect for this variable across all three outcomes.

A quadratic term has been introduced into the experience of the member (exp_scaled) variable to allow and capture the nonlinearity effect. The coefficient of exp_scaled is 3.396229 for outcome 1 and 1.007465 for outcome 2. The coefficient for both outcomes is positive indicating that the probabilities of the outcomes will gradually rise as the exp_scaled increases. On the other hand, the coefficient of the new variable exp_scaled_sq is -5.76993 for outcome 1 and -4.66709 for output 2. Both coeffiecients of the exp_scaled_sq are negative for both outcomes, incidating that the gradual increase in the exp_scaled will result in decrease in the probabilities of both outcomes. The test suggests that the relationship has been explored in a way where in the start the experience raises the probability of outcomes but beyond a certain point, the additional experience results in the reduction of probabilities.

Outcomes	Exp_scaled	Exp_scaled_sq
Reduce(0)	3.396229	-5.769937
No Change (1)	1.007465	-4.667096

On the other hand, Marginal effects indicate the influence on the outcomes as exp_scaled changes could be stated as,

Outcome 0(reduce): The marginal effect has come out to be -0.335422 indicating that the increase in exp_scaled will result in decreasing the probability of member choosing to reduce interest rate.
Outcome 1(no change): The marginal effect has come out to be 0.5081675 indicating that the increase in exp_scaled will result in increasing the probability of members voting the keep the interest rate unchanged.
Outcome 2(raise): The marginal effect has come out to be -0.1727565, indicating that the increase in exp_scaled will result in decreasing the probability of members voting to raise interest rates.

Outcomes	Marginal Effect
Reduce (0)	-0.3354110
No change(1)	0.5081675
Raise(2)	-0.1727565

Some of the predicted probabilities to demonstrate the how the model predicts the likelihood of each outcome:

Observation	Probability of Reduce(0)	Probability of no change(1)	Probability of raise(2)
1	1.503437e-05	0.3603749	0.6396101
2	1.830369e-03	0.4954035	0.5027662
3	2.085665e-03	0.5135882	0.4843262

Thus, the non-linearity of exp_scaled is significant in predicting the probability of rate cuts.