

### *Solution for Assignment #4*

(1) The intent of this problem was to create a situation in which the Bonferroni rule *is* correct to apply. We had spent so much time “criticizing” the use of Bonferroni in stepwise regression that I thought it useful to remind you that it does do the “right” thing when it’s correctly applied. It’s right to use Bonferroni here because *you* pick the 20 variables in advance of looking at the data; that is, the data do not generate the list of 20 coefficients to test, you do.

(a) Only about 5% of the models fit in the class should pass the usual F-test.

(b) You expect one coefficient to be significant (i.e., have p-value less than 0.05) by chance alone when there is no real relationship between the predictors and the response (i.e., when the population slopes are all really zero). Thus, even if all of the twenty population slopes are zero, you can expect to find one significant in your model, simply by chance alone.

(c) Here the use of Bonferroni is correct. None of the p-values should be less than its threshold  $0.05/20$  (assuming I am correct to believe that there really is no signal here to find).

(2) There were unfortunate differences in how JMP implements stepwise. Different version of JMP gave different answers. To clarify what I hoped you would find, I’ll show you my results.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	0.03000488	0.004286	6.7318
Error	39	0.02483285	0.000637	<b>Prob&gt;F</b>
C Total	46	0.05483773		<.0001

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.0082	0.003782	2.16	0.0371
US-ITALY	0.0000	0.000019	2.22	0.0325
US-UK	0.0000	0.000015	1.91	0.0635
CONST-COMM&INDU	-0.0019	0.000726	-2.60	0.0130
UNEMP-PART	0.0233	0.012612	1.85	0.0725
MONEY-EURO	-0.0033	0.001667	-1.97	0.0560
MONEY-COM	0.0041	0.001384	2.97	0.0051
CPI-ENERGY	-0.0086	0.002174	-3.96	0.0003

(a) With the default stepwise settings, (.25 to enter, .10 to leave), here’s the fit produced by using the “Make Model” button. The F stat = 6.7 is very significant, though the  $R^2 = .55$  is not so impressive. The RMSE = .025. Two of the fitted slopes pass the naïve, incorrect Bonferroni threshold of  $0.05/7 = .007$ .

(b) “Opening the door” just a bit changes things dramatically (at least for my JMP). With p-to-enter increased to 0.45 (and p-to-leave kept at 0.1), here are my results.

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob>F
Model	21	0.044	0.0021	4.8703	
Error	25	0.011	0.0004		
C Total	46	0.055			0.0001

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.0237	0.009644	2.46	0.0211
US-JAP	-0.0000	0.000008	-2.41	0.0235
US-UK	0.0000	0.000015	1.77	0.0890
US-AUTO	-0.0000	0.000008	-3.78	0.0009
CONST-COMM	0.0000	0.000002	2.49	0.0196
CONST-COMM&INDU	-0.0044	0.000785	-5.66	<.0001
CONST-EDUC	-0.0000	0.000014	-3.32	0.0027
CONST-FED	0.0000	0.000004	4.03	0.0005
CONST-HOTEL	-0.0007	0.000179	-4.02	0.0005
CONST-HOTEL2	0.0007	0.00018	4.06	0.0004
UNEMP-FULL	0.1643	0.040916	4.02	0.0005
UNEMP-WOMEN	-0.0267	0.009976	-2.68	0.0128
UNEMP-SPOUSE	-0.1233	0.039466	-3.12	0.0045
MONEY-SAVE1	0.0052	0.001656	3.11	0.0046
MONEY-SAVE3	-0.0127	0.003562	-3.56	0.0015
MONEY-EURO	-0.0058	0.002011	-2.87	0.0083
MONEY-COM	0.0052	0.001418	3.68	0.0011
MONEY-TREAS	-0.0014	0.000477	-2.96	0.0066
PERSAVERATE	0.0193	0.005288	3.65	0.0012
CPI-ALLURBAN	0.0728	0.026547	2.74	0.0111
CPI-URBAN-SA	-0.1257	0.031164	-4.04	0.0005
CPI-FOOD	0.0182	0.007904	2.30	0.0302

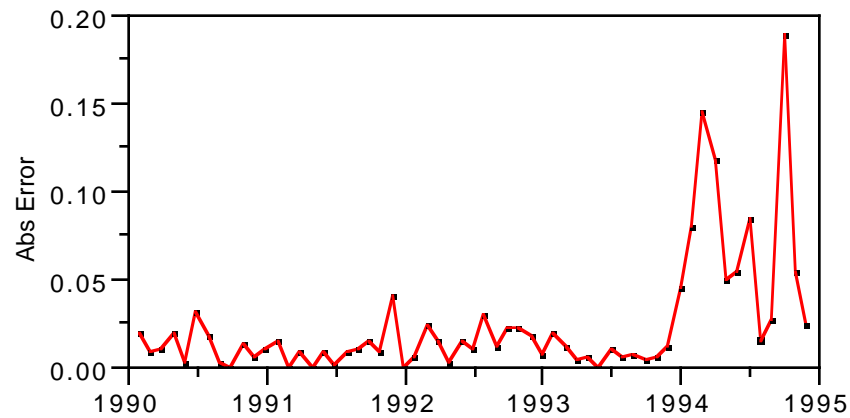
With the lower barrier to entry, the model ends up with 21 rather than 7 predictors. Again, the overall  $F=4.87$  is significant. This time the  $R^2$  rises to about 80% with smaller  $RMSE = .00208$ . Many (ten!) of the coefficients pass the improper Bonferroni threshold, here  $0.05/21 = .0024$ .

(c) Open the door allows the model to “pull in” many inappropriate predictors and find special combinations of them that work much better than when we had a higher initial threshold. By allowing more variables to enter the model, I provide the stepwise procedure the freedom to find by chance alone many more significant effects. It also increases the bias in the estimate of  $RMSE$ ; the estimate from this model is too small and contributes to the number of significant effects found.

(3) Use your imagination. Since the predictors convey some attribute of the economy, we can say that this factor is essential in predicting the movements

of the stock market. For example from this fit, it looks like construction activity is very important to the stock market.

- (4) The predictions of 1994 are not so accurate as the residuals from the fitting period would suggest. Here you can see that the absolute errors are fairly small during the estimation period (1990-1993), but then get much larger in the forecast period.



In terms of the variability in the predictions, the model's claimed RMSE = 0.0208, but the SD of these 12 prediction errors is 2.5 times this size. The predictions are also biased, being on average too large. You'd expect them to average around zero.

Mean	0.0748
Std Dev	0.0529
Std Error Mean	0.0153
Upper 95% Mean	0.1084
Lower 95% Mean	0.0412
N	12.0000

- (5) If you set p-to-enter large enough, the stepwise procedure will “fail” in the sense that it fits a saturated model, one that fits the data perfectly using n-1 slopes and a constant to reproduce n observations. That's not much of a summary!