

Homework 4

Alexander Brandt
STAT 215A

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1 Classification

7.B.1

a

True: since from the definition of the CDF/PDF relationship:

$$\frac{\partial \Phi(x)}{\partial x} = \phi(x)$$

b

True: again, this is a basic CDF/PDF relationship:

$$\int_{-\infty}^x \phi(z) dz = \Phi(x)$$

c

False: this is a basic calculus definition:

$$\int_x^x \phi(z) dz = 0$$

d

True: From above, and part e:

$$\int_x^x \phi(z) dz + \int_{-\infty}^x \phi(z) dz = 0 + \Phi(x)$$

e

True: Basic CDF/PDF relationship:

$$\int_{-\infty}^x \phi(z) dz = \Phi(x)$$

f

True: Given CDF/PDF relationship:

$$\begin{aligned} P(x < Z < x + h) &= \lim_{x \rightarrow h} \int_x^{x+h} \phi(z) dz \\ &= \Phi(x + h) - \Phi(x) \end{aligned}$$

And basic calculus:

$$\lim_{x \rightarrow h} \frac{\Phi(x + h) - \Phi(x)}{h} = \phi(x)$$

Thus:

$$P(x < Z < x + h) = h\phi(x)$$

7.B.2

a

X_i is a column vector of 1 (the intercept), the educational level in years of school the individual has attended, the income level of the individual in dollars, and the gender of the individual (1 for male, 0 for female). β_i is a column vector of the weights associated with for the probit model.

b

Random and Latent

c

U_i is i.i.d. $N(0, 1)$, and independent of the prediction variables.

d

The log likelihood function is a sum with one term for each subject.

1.1

False.

$$\begin{aligned} \text{Difference} &= \Phi(X'_{Harry}\beta) - \Phi(X'_{George}\beta) \\ &= \Phi(.29) - \Phi(.19) \\ &= 3.87\% \end{aligned}$$

7.B.3

I think I will be using x_i in the opposite orientation that the authors of the paper do.

Proof of 5.1

Given $(X'_i X_i)^{-1} = (X'X - x_i x'_i)^{-1}$, and the Sherman Morrison formula:

$$\begin{aligned} (X'_i X_i)^{-1} &= (X'X)^{-1} + \frac{(X'X)^{-1} x_i x'_i (X'X)^{-1}}{1 - x'_i X^{-1} x_i} \\ &= (X'X)^{-1} + \frac{(X'X)^{-1} x_i x'_i (X'X)^{-1}}{1 - h_i} \end{aligned}$$

Proof of 5.5

Continuing from above:

$$\begin{aligned}
\hat{\beta}_i &= (X'_i X_i)^{-1} (X'Y - x_i y_i) \\
&= \left[(X'X)^{-1} + \frac{(X'X)^{-1} x_i x'_i (X'X)^{-1}}{1 - h_i} \right] (X'Y - x_i y_i) \\
&= (X'X)^{-1} X'Y - (X'X)^{-1} x_i y_i + \frac{(X'X)^{-1} x_i x'_i X'Y}{1 - h_i} - \frac{(X'X)^{-1} x_i x'_i x_i y_i}{1 - h_i} \\
&= \hat{\beta} - \frac{(X'X)^{-1} x_i}{1 - h_i} \left[y_i(1 - h_i) - x'_i \hat{\beta} + h_i y_i \right] \\
&= \hat{\beta} - \frac{(X'X)^{-1} x_i}{1 - h_i} \left[y_i - x'_i \hat{\beta} \right] \\
&= \hat{\beta} - \frac{(X'X)^{-1} x_i r_i}{1 - h_i} \\
\hat{\beta} - \hat{\beta}_i &= \frac{(X'X)^{-1} x_i r_i}{1 - h_i}
\end{aligned}$$

I found this proof to be tricky, so I spent a lot of time reading through linear algebra/linear regression texts. In particular Linear Regression Analysis by Seber and Lee (2003), especially Chapter 10, were really helpful in helping me complete these proofs.