Student: ____________________ **Date:** ____________________	**Instructor:** Richeng Piao **Course:** ECON 2560 - Applied Econometrics	**Assignment:** Practice Problem Set 11

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______________________________ Signature ______________________________ Date

1. Suppose that the linear probability model yields a predicted value of Y that is equal to 1.3. Explain why this is nonsensical.

   - **A.** The predicted value of Y is too low.
   - **B.** The predicted value of Y is not an integer.
   - **C.** The predicted value of Y must be between 0 and 1.
   - **D.** The predicted value of Y is a positive number.

   Answer: C. The predicted value of Y must be between 0 and 1.

   ID: Review Concept 11.1

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2. One of your friends is using data on individuals to study the determinants of smoking at your university. She is particularly concerned with estimating marginal effects on the probability of smoking at the extremes. She asks you whether she should use a probit, logit, or linear probability model. What advice do you give her?

   - **A.** She should use the linear probability model or probit, but not the logit.
   - **B.** It doesn't make a difference which model she uses.
   - **C.** She should use the logit or probit, but not the linear probability model.
   - **D.** She should use the linear probability model or logit, but not the probit.

   Answer: C. She should use the logit or probit, but not the linear probability model.

   ID: Review Concept 11.3

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3. The linear probability model is:

   - **A.** an example of probit estimation.
   - **B.** the application of the linear multiple regression model to a binary dependent variable.
   - **C.** another word for logit estimation.
   - **D.** the application of the multiple regression model with a continuous left-hand side variable and a binary variable as at least one of the regressors.

   Answer: B. the application of the linear multiple regression model to a binary dependent variable.

   ID: Test A Ex 11.1.1

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4. A researcher wants to study the factors affecting a person's decision to buy a car. For his study, he selects a random sample of 100 people from a city and estimates the following regression equation:

$$\hat{C} = -7.35 + 0.18I + 0.36M - 0.27P,$$

where C is a binary dependent variable which denotes the decision to buy the car (C equals 1 if the person decides to buy the car, and 0 otherwise), I denotes the monthly income of the person (I equals 1 if the income exceeds \$5,000 and 0 otherwise), M denotes the car's mileage (measured in miles per gallon) and P denotes the price of the car (in thousand dollars).

The researcher wants to test the hypothesis that the coefficient on I, β_1, and the coefficient on M, β_2, are jointly zero, against the hypothesis that at least one of these coefficients is non-zero. The test statistics for testing the null hypotheses $\beta_1 = 0$ and $\beta_2 = 0$ are calculated to be 2.15 and 1.25, respectively. Suppose that these test statistics are uncorrelated.

The F-statistic associated with the above test will be [ ].

(*Round your answer to two decimal places.*)

At the 5% significance level, the value of the F-statistic suggests that the researcher will (1) ________ the joint null hypothesis.

Suppose the standard error of $\hat{\beta}_1$ is 0.87.

The 95% confidence interval for the slope coefficient β_1, keeping the other variables constant, will be ([ ], [ ]).

(*Round your answers to two decimal places.*)

(1) ○ fail to reject
○ reject

Answers 3.09

(1) reject

−1.53

1.89

ID: Concept Exercise 11.1.1

5. Suppose a linear probability model (LPM) with two regressors is of the form:

$$\Pr\left(Y = 1 | X_1, X_2\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2,$$

where the dependent variable Y is binary, taking the value 1 when a certain event occurs and 0 otherwise; X_1 and X_2 are the regressors and β_0, β_1, and β_2 are the intercept and the coefficients on X_1 and X_2 respectively.

Which of the following statements is not true about linear probability models?

- **A.** The regression coefficients of LPM cannot be estimated using OLS.
- **B.** The regression coefficient β_1 is the change in the probability that $Y = 1$ associated with a unit change in X_1, holding the other regressor constant.
- **C.** In linear probability models, the predicted probability that $Y = 1$, may take values less than 0 or greater than 1.
- **D.** The expected value of Y given X_1 and X_2 is interpreted as the probability that Y takes the value 1, given X_1 and X_2.

The errors of a linear probability model are (1) ____________ heteroskedastic.

Which of the following statements is true?

- **A.** The R^2 cannot be used to measure the goodness of fit when the dependent variable and the regressors, both are binary.
- **B.** The R^2 cannot be used to measure the goodness of fit when the dependent variable is continuous and the regressors are binary.
- **C.** The R^2 cannot be used to measure the goodness of fit when the dependent variable is binary and the regressors are continuous.
- **D.** The R^2 cannot be used to measure the goodness of fit when the dependent variable and the regressors, both are continuous.

(1)
- always
- sometimes
- never

Answers A. The regression coefficients of LPM cannot be estimated using OLS.

(1) always

C.

The R^2 cannot be used to measure the goodness of fit when the dependent variable is binary and the regressors are continuous.

ID: Concept Exercise 11.1.2

6. Andy is trying to understand the factors which affect cigarette smoking among teenagers. He collects data from 500 randomly selected teenagers and asks them whether they smoke (*Smoker* = 1) or not (*Smoker* = 0), whether at least one of their parents smokes (*Parent* = 1) or neither of their parents smoke (*Parent* = 0), whether at least one of their friends smokes (*Friend* = 1) or none of them smoke (*Friend* = 0), and their monthly family income (*FamilyInc*, in dollars). The estimated linear probability model is:

$$\widehat{\Pr\left(Smoker = 1\right)} = \underset{(0.0157)}{-0.0302} + \underset{(0.0175)}{0.2864}Parent + \underset{(0.0374)}{0.1358}Friend - \underset{(0.00026)}{0.0005}FamilyInc.$$

Standard errors are given in parentheses. Suppose Drew's monthly family income is \$400. Her mother smokes but her father does not; and, none of her friends smoke.

The predicted probability that Drew would smoke is ____ %.

(*Round your answer to two decimal places.*)

Andy wishes to test whether or not annual family income has a significant impact on the probability that a teenager takes up smoking.

The test statistic associated with the test Andy wishes to conduct is ____.

(*Round your answer to two decimal places. Enter a minus sign if your answer is negative.*)

At the 5% significance level, Andy will (1) ____ the hypothesis that monthly family income does not have a significant impact on the probability that a teenager takes up smoking.

If Drew's monthly family income increases to \$1,800, the predicted probability that Drew would smoke would now be ____ %.

(*Round your answer to two decimal places. Enter a minus sign if your answer is negative.*)

This probability value (2) ____ as it (3) ____.

(1) ○ fail to reject
○ reject

(2) ○ is nonsensical
○ makes sense

(3) ○ is greater than 1
○ is less than 0
○ lies between 0 and 1

Answers 5.62

– 1.92

(1) fail to reject

– 64.38

(2) is nonsensical

(3) is less than 0

ID: Concept Exercise 11.1.3

7. In the expression $\widehat{\Pr\left(deny = 1 \middle| P/I\ ratio,\ black\right)} = \Phi(-2.26 + 2.74\ P/I\ ratio + 0.71\ black)$, the effect of increasing the *P*/*I* ratio from 0.3 to 0.4 for a black person *(Assume a probit model)*:

- **A.** is 9.4 percentage points.
- **B.** is 2.74 percentage points.
- **C.** is 0.274 percentage points.
- **D.** should not be interpreted without knowledge of the regression R^2.

Answer: A. is 9.4 percentage points.

ID: Test A Ex 11.2.2

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8. Your textbook plots the estimated regression function produced by the probit regression of *deny* on *P/I ratio*. The estimated probit regression function has a stretched "S" shape given that the coefficient on the *P/I ratio* is positive. Consider a probit regression function with a negative coefficient.

The shape would:

- **A.** would have to be estimated with a logit function.
- **B.** not exist since probabilities cannot be negative.
- **C.** remain the "S" shape as with a positive slope coefficient.
- **D.** resemble an inverted "S" shape (for low values of *X*, the predicted probability of *Y* would approach 1).

Answer: D. resemble an inverted "S" shape (for low values of *X*, the predicted probability of *Y* would approach 1).

ID: Test A Ex 11.2.3

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9. *F*-statistics computed using maximum likelihood estimators:

- **A.** are not meaningful since the entire regression R^2 concept is hard to apply in this situation.
- **B.** can be used to test joint hypotheses.
- **C.** cannot be used to test joint hypotheses.
- **D.** do not follow the standard *F* distribution.

Answer: B. can be used to test joint hypotheses.

ID: Test A Ex 11.2.4

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10. The probit model:

- A. forces the predicted values to lie between 0 and 1.
- B. always gives the same fit for the predicted values as the linear probability model for values between 0.1 and 0.9.
- C. should not be used since it is too complicated.
- D. is the same as the logit model.

Answer: A. forces the predicted values to lie between 0 and 1.

ID: Test B Ex 11.2.1

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11. In the probit regression, the coefficient β_1 indicates:

- A. the change in the probability of $Y = 1$ given a unit change in X.
- B. the change in the z-value associated with a unit change in X.
- C. the change in the probability of $Y = 1$ given a percent change in X.
- D. none of the above.

Answer: B. the change in the z-value associated with a unit change in X.

ID: Test B Ex 11.2.2

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12. Probit coefficients are typically estimated using:

- A. the OLS method.
- B. nonlinear least squares (NLLS).
- C. the method of maximum likelihood.
- D. by transforming the estimates from the linear probability model.

Answer: C. the method of maximum likelihood.

ID: Test B Ex 11.2.3

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13. A researcher studies a sample of 7,500 individuals who considered going on a trip to Eastern Europe last year; some individuals did go on the trip while some did not. The average cost of a trip to Eastern Europe is $120 a day, per individual. Let *C*/*S* denote an individual's cost to savings ratio and let *Y* be a binary variable that takes the value 1 if the individual goes on a trip to Eastern Europe, and 0 otherwise. The researcher estimates the probability that an individual goes on a trip through the following regression equation:

$$\widehat{\Pr[Y=1|(C/S)]} = \underset{(0.73)}{\Phi[2.8} - \underset{(0.93)}{4.2(C/S)]}.$$

Standard errors are given in parentheses. Jack, who has savings of $3,200, is considering going backpacking through Eastern Europe for 15 days.

The probability that Jack will go backpacking through Eastern Europe is [ ] %.

(*Round your answer to two decimal places.*)

The researcher adds another regressor to his regression equation - whether or not a friend accompanies an individual planning to go backpacking through Eastern Europe.

The new regression equation estimated by the researcher is:

$$\widehat{\Pr\left[Y=1|(C/S)_P\right]} = \Phi\left[\underset{(0.73)}{2.8} - \underset{(0.93)}{4.2(C/S)_P} + \underset{(0.60)}{1.68F}\right],$$

where $(C/S)_P$ is the ratio of total cost to total pooled savings of the two individuals for this trip and *F* is a binary variable that takes the value 1 when a friend agrees to accompany and pool their resources with the individual planning the trip, and 0 otherwise. Standard errors are given in parentheses.

Suppose Jack plans to invite his friend Daniel to join him on the 15 day trip. Daniel has savings of $5,000. If Daniel agrees to accompany Jack, they could use a total of $4,200 from their combined savings for this trip.

The probability that Jack goes backpacking through Eastern Europe when he is accompanied by Daniel is [ ] %.

(*Round your answer to two decimal places.*)

The probability that Jack goes on the trip when Daniel accompanies him is (1) ______ than the probability that Jack goes on the trip alone.

The difference in the probability is [ ] percentage points.

(*Round your answer to two decimal places.*)

(1) ○ greater
○ less

Answers 66.91

81.06

(1) greater

14.15

ID: Concept Exercise 11.2.1

14. A private institute named Allen Coaching which provides tutoring for the SAT exam is preparing a report on the performance of its students in the SAT exam held for the year 2017-18. They want to check whether the students who receive tutoring from their institution have a higher probability of scoring above the 90^{th} percentile in the SAT exam, in comparison with students who obtain instruction elsewhere. They collected data from 2,000 randomly selected individuals who took the SAT exam. Let *IQ* denote the intellegence quotient of the student, let *days* denote the number of days they studied for the exam and let *Allen* denote whether the student is tutored by Allen Coaching (*Allen* = 1) or not (*Allen* = 0). The following is the estimated probit model:

$$\widehat{\Pr\left(SAT_{90} = 1 | IQ,\ days,\ Allen\right)} = \Phi(\underset{(0.78)}{2.14} + \underset{(1.11)}{1.11}IQ + \underset{(0.85)}{1.12}days + \underset{(0.71)}{1.03}Allen).$$

The standard errors are given in parentheses. The binary dependent variable, SAT_{90} denotes the probability of a student scoring above the 90^{th} percentile in the SAT exam, keeping *IQ*, *days*, and *Allen* constant.

Let β_3 be the slope coefficient on *Allen*.

The value of the *t*-statistic associated with test H_0: $\beta_3 = 0$ vs. H_1: $\beta_3 > 0$ is ______.

(*Round your answer to two decimal places.*)

Based on the value of the *t*-statistic, it can be concluded that a student who is tutored by Allen Coaching has (1) ______ probability of scoring above the 90^{th} percentile in the SAT exam as compared to a student who obtains tutoring elsewhere, keeping *IQ* and *days* constant.

(1) ○ the same
○ a higher

Answers 1.45

(1) the same

ID: Concept Exercise 11.2.2

15. A researcher is interested in finding out the factors affecting the probability that a candidate contesting the U.S general elections wins or not. Let *Money* denote the amount of money spent on campaigning (measured in million dollars) and let the binary variable *candidate* denote whether the candidate is a Democrat (*candidate* = 1) or a Republican (*candidate* = 0). The researcher collects a random sample of 250 individuals out of those who contested for the U.S general election in the year 2016, and estimates the following regression equation:

$$\widehat{\Pr(Win = 1 \mid Money, candidate)} = \Phi(\underset{(0.75)}{0.51} + \underset{(1.12)}{0.79}Money - \underset{(1.11)}{0.82}candidate).$$

The standard errors are given in parentheses. The binary dependent variable *Win* takes the value 1 if a candidate wins the election, and 0 otherwise, keeping *Money* and *candidate* constant. Φ is the cumulative standard normal distribution function.

The change in the predicted probability of a candidate winning when the amount of money spent on the election campaign increases from \$1mn to \$2mn, given that the candidate is a Democrat is ______.

(*Round your answer to four decimal places*.)

The change in the predicted probability of a candidate winning when the amount of money spent on the election campaign increases from \$2mn to \$3mn, given that the candidate is a Democrat, is ______.

(*Round your answer to four decimal places*.)

The change in the predicted probability of a candidate winning when *Money* increases from \$2mn to \$3mn is (1) ______ than the change when *Money* increases from \$1mn to \$2mn, given that the candidate is a Democrat.

(1) ○ smaller
○ larger

Answers 0.2136

0.0823

(1) smaller

ID: Concept Exercise 11.2.3

16. A researcher wants to find the factors affecting the probability that a person suffers from heart diseases. Let *Age* denote the age of the person, let *BMI* denote whether the BMI of the preson is above 30 (*BMI* = 1) or below 30 (*BMI* = 0), and let *smoker* denote whether the person is a smoker (*smoker* = 1) or not (*smoker* = 0). She collects a random sample of 2,500 individuals from the general population and estimates the following logit regression:

$$\widehat{\Pr(\textit{Heart disease}|\ \textit{Age}, \textit{BMI}, \textit{Smoker})} = F(\underset{(0.81)}{2.42} + \underset{(1.02)}{0.05}\textit{Age} + \underset{(1.23)}{0.02}\textit{BMI} + \underset{(1.23)}{0.02}\textit{Smoker}).$$

Standard errors are given in parentheses. The binary dependent variable, *Heart disease* denotes the probability of a person suffering from heart disease keeping *Age*, *BMI*, and *smoker* constant.

The predicted probability that Henry who is currently aged 53, whose BMI is above 30, and is a smoker, will suffer from a heart disease is ______.

(*Round your answer to four decimal places.*)

The predicted probability that a 53 year old Emily whose BMI is below 30 and is a non-smoker will suffer from a heart disease is ______.

(*Round your answer to four decimal places.*)

The difference in predicted probability of suffering from heart disease between Henry and Emily is ______.

(*Round your answer to four decimal places.*)

Answers 0.9940

0.9938

0.0002

ID: Concept Exercise 11.2.4

17. A student has studied a sample of 125,000 recently released convicts from 500 medium security penitentiaries across all the 50 states in the U.S., in the last year. These convicts had similar income levels and living conditions prior to their incarcerations, some of them were re-incarcerated within a year while some were not. The dependent variable *reinc* is a binary variable which takes the value 1 if a recently released convict is re-incarcerated within a year, and 0 otherwise. The student wants to measure the probability that a recently released convict is re-incarcerated within a year, Pr[*reinc* = 1], given the number of prior incarcerations (*PI*, measured by the number of times a convict was incarcerated prior to the recent release). The researcher estimates the following logit regression model:

$$\widehat{\Pr[reinc = 1|PI]} = F[-1.09 + 0.63PI].$$
$$(0.91)\ (0.11)$$

Standard errors are given in parentheses. Given that the sample consists of recently released convicts, any random individual from the sample has at least one prior incarceration.

The estimated difference in the probability that a single recently released convict will be re-incarcerated within a year, of a change in the number of prior incarcerations from 1 to 2, is ______%.

(*Round your answer to two decimal places.*)

The 95% confidence interval of the coefficient on *PI* ranges from ______ to ______.

(*Round your answers to two decimal places*).

At the 5% significance level, the student will (1) ______ the hypothesis that the number of prior incarcerations have no effect on the probability that a recently released convict is re-incarcerated within a year.

(1) ○ reject
○ fail to reject

Answers 15.54

0.41

0.85

(1) reject

ID: Concept Exercise 11.2.5

18. Researchers Amber and Baker choose a sample of 100,000 undergraduate students applying for graduate courses in Ivy League schools from across all the 50 states in the U.S. They want to study the probability that an undergraduate student is accepted into any one of these schools, [Pr(*Accept* = 1)], given the student's SAT scores (*SAT*, scaled down by a factor of 1000), and the student's performance in an undergraduate course (*UG*, measured by GPA on a 4 point scale).

Amber estimates the following probit regression model:

$$\widehat{\Pr[Accept = 1 | SAT,\ UG]} = \Phi[\underset{(0.8)}{-1.26} + \underset{(0.8)}{0.52}SAT + \underset{(0.8)}{0.32}UG],$$

where Φ is the cumulative standard normal distribution function, and standard errors are given in parentheses. Mike, an undergraduate student has a SAT score of 1500, and his GPA in an undergraduate course is 3.25.

Mike's probability of getting accepted into an Ivy League school, as calculated by Amber, is ______%.

(*Round your answer to two decimal places.*)

Baker estimates the following logit regression model:

$$\widehat{\Pr[Accept = 1 | SAT,\ UG]} = F[\underset{(0.8)}{-1.19} + \underset{(0.8)}{0.58}SAT + \underset{(0.8)}{0.36}UG],$$

Mike's probability of getting accepted into an Ivy League school, as calculated by Baker, is ______%.

(*Round your answer to two decimal places.*)

The probability that Mike is accepted into an Ivy League school as measured by Amber is (1) ______ than the probability that Mike is accepted into an Ivy League school as measured by Baker.

The difference in probability is ______%.

(*Round your answer to two decimal places.*)

(1) ○ less
○ greater

Answers 71.23

70.06

(1) greater

1.17

ID: Concept Exercise 11.2.6

19. Which of the given statements most accurately describes the effect on the probability that a binary dependent variable equals 1, of a change in the value of the regressor, in the probit regression model?

- **A.** The effect of a change in the value of the regressor depends on the difference between the values of the regressor.
- **B.** The effect of a change in the value of the regressor depends on the starting value of the regressor.
- **C.** The effect of a change in the value of the regressor remains constant across all regressors.
- **D.** The effect of a change in the value of the regressor depends on the changed value of the regressor.

The linear probability model (1) ______________ an adequate approximation to the nonlinear population regression function when the regressors take few extreme values.

The coefficients of the logit and probit models are estimated using (2) ______________.

(1) does not provide / provides

(2) OLS estimation / maximum likelihood estimation

Answers B. The effect of a change in the value of the regressor depends on the starting value of the regressor.

(1) provides

(2) maximum likelihood estimation

ID: Concept Exercise 11.2.7

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20. Why are the coefficients of probit and logit models estimated by maximum likelihood instead of OLS?

- **A.** OLS cannot be used because it will yield results that are biased upward.
- **B.** OLS cannot be used because the regression function is not a linear function of the regression coefficients.
- **C.** OLS cannot be used because it will yield results that are biased downward.
- **D.** Maximum likelihood is easier to implement than OLS.

Answer: B. OLS cannot be used because the regression function is not a linear function of the regression coefficients.

ID: Review Concept 11.4

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21. Four hundred driver's license applicants were randomly selected and asked whether they passed their driving test ($Pass_i = 1$) or failed their test ($Pass_i = 0$); data were also located on their gender ($Male_i = 1$ if male and $= 0$ if female) and their years of driving experience ($Experience_i$, in years). The following table summarizes the results from several probit, logit and linear probability models.

Dependent variable: Pass.							
Regression Model Regressor	**Probit (1)**	**Logit (2)**	**LPM (3)**	**Probit (4)**	**Logit (5)**	**LPM (6)**	**Probit (7)**
Experience	0.038 (0.005)	0.042 (0.018)	0.005 (0.004)				0.044 (0.159)
Male				− 0.338 (0.162)	− 0.628 (0.307)	− 0.073 (0.036)	− 0.174 (0.259)
Male × Experience							− 0.015 (0.021)
Constant	0.712 (0.129)	1.059 (0.224)	0.776 (0.036)	1.285 (0.125)	2.195 (0.245)	0.906 (0.026)	0.808 (0.203)

Use the results in column (1) to answer the following questions.

Is the coefficient on *Experience* significant at any reasonable level?

- **A.** The coefficient on *Experience* is significant at the 10%, but not at the 5% or 1% significance level.
- **B.** The coefficient on *Experience* is significant at the 5%, but not at the 1% significance level.
- **C.** The coefficient on *Experience* is not significant at any reasonable level.
- **D.** The coefficient on *Experience* is significant at the 1% significance level.

Matthew has 18 years of driving experience. What is the predicted probability that he will pass the test?

The predicted probability that Matthew will pass the test is ______

(*Round your response to three decimal places*)

Christopher is a new driver (zero years of experience). What is the predicted probability that he will pass the test?

The predicted probability that Christopher will pass the test is ______

(*Round your response to three decimal places*)

The sample included values of *Experience* between 0 and 40 years, and only four people in the sample had more than 30 years of driving experience. Jed is 95 years old and has been driving since he was 17. What is the model's prediction for the probability that Jed will pass the test?

The predicted probability that Jed will pass the test is ______

(*Round your response to three decimal places*)

Do you think the previous prediction is reliable?

- **A.** Yes.
- **B.** No.

Answers D. The coefficient on *Experience* is significant at the 1% significance level.

0.919

0.762

1.000

B. No.

ID: Exercise 11.1

22. Four hundred driver's license applicants were randomly selected and asked whether they passed their driving test ($Pass_i = 1$) or failed their test ($Pass_i = 0$); data were also located on their gender ($Male_i = 1$ if male and = 0 if female) and their years of driving experience ($Experience_i$, in years). The following table summarizes the results from several probit, logit and linear probability models.

Dependent variable: Pass.							
Regression Model Regressor	**Probit (1)**	**Logit (2)**	**LPM (3)**	**Probit (4)**	**Logit (5)**	**LPM (6)**	**Probit (7)**
Experience	0.035 (0.006)	0.041 (0.013)	0.008 (0.004)				0.043 (0.156)
Male				− 0.334 (0.164)	− 0.621 (0.305)	− 0.079 (0.035)	− 0.174 (0.261)
Male × Experience							− 0.013 (0.023)
Constant	0.713 (0.129)	1.053 (0.222)	0.778 (0.036)	1.283 (0.126)	2.196 (0.244)	0.908 (0.023)	0.807 (0.202)

Use the results in column (2) to answer the following questions.

Is the coefficient on *Experience* significant at any reasonable level?

- **A.** The coefficient on *Experience* is significant at the 5%, but not at the 1% significance level.
- **B.** The coefficient on *Experience* is not significant at any reasonable level.
- **C.** The coefficient on *Experience* is significant at the 1% significance level.
- **D.** The coefficient on *Experience* is significant at the 10%, but not at the 5% or 1% significance level.

John has 15 years of driving experience. What is the predicted probability that he will pass the test?

The predicted probability that John will pass the test is ______

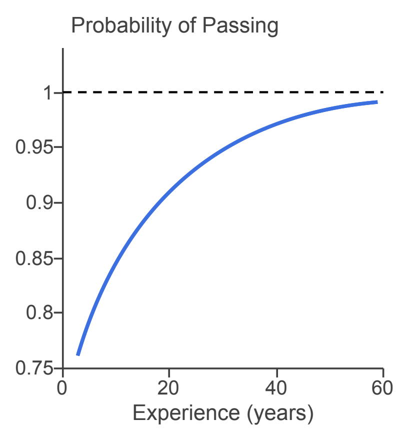
(*Round your response to three decimal places*)

Katherine is a new driver (zero years of experience). What is the predicted probability that she will pass the test?

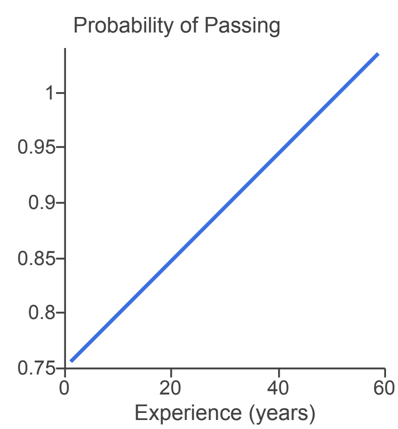
The predicted probability that Katherine will pass the test is ______

(*Round your response to three decimal places*)

Which of the figures below is more likely to show predicted probabilities from the logit model?



(A)



(B)

- **A.** Figure (A).
- **B.** Figure (B).

Answers C. The coefficient on *Experience* is significant at the 1% significance level.

0.841

0.741

A. Figure (A).

ID: Exercise 11.2

23. Four hundred driver's license applicants were randomly selected and asked whether they passed their driving test ($Pass_i = 1$) or failed their test ($Pass_i = 0$); data were also located on their gender ($Male_i = 1$ if male and $= 0$ if female) and their years of driving experience ($Experience_i$, in years). The following table summarizes the results from several probit, logit and linear probability models.

Dependent variable: Pass.							
Regression Model Regressor	**Probit (1)**	**Logit (2)**	**LPM (3)**	**Probit (4)**	**Logit (5)**	**LPM (6)**	**Probit (7)**
Experience	0.039 (0.005)	0.048 (0.014)	0.007 (0.001)				0.045 (0.158)
Male				−0.331 (0.164)	−0.623 (0.304)	−0.076 (0.036)	−0.176 (0.261)
Male × Experience							−0.015 (0.021)
Constant	0.719 (0.129)	1.059 (0.224)	0.772 (0.035)	1.285 (0.125)	2.191 (0.244)	0.908 (0.024)	0.801 (0.202)

Use the results in column (3) to answer the following questions.

Is the coefficient on *Experience* significant at any reasonable level?

- **A.** The coefficient on *Experience* is significant at the 10%, but not at the 5% or 1% significance level.
- **B.** The coefficient on *Experience* is significant at the 1% significance level.
- **C.** The coefficient on *Experience* is significant at the 5%, but not at the 1% significance level.
- **D.** The coefficient on *Experience* is not significant at any reasonable level.

Courtney has 11 years of driving experience. What is the predicted probability that she will pass the test?

The predicted probability that Courtney will pass the test is ______

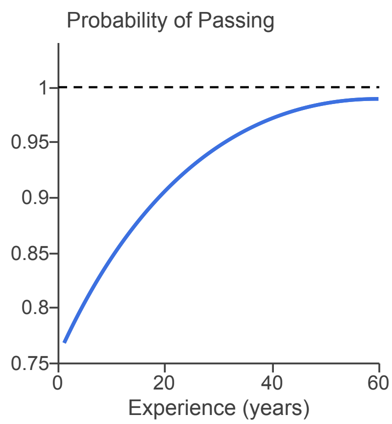
(*Round your response to three decimal places*)

Jason is a new driver (zero years of experience). What is the predicted probability that he will pass the test?

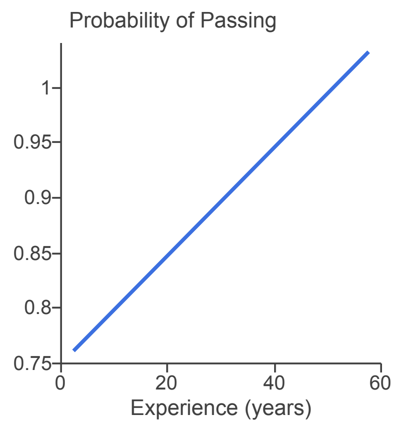
The predicted probability that Jason will pass the test is ______

(*Round your response to three decimal places*)

Which of the figures below is more likely to show predicted probabilities from the linear probability model?



(A)



(B)

- **A.** Figure (A).
- **B.** Figure (B).

Answers B. The coefficient on *Experience* is significant at the 1% significance level.

0.849

0.772

B. Figure (B).

ID: Exercise 11.3

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24. Four hundred driver's license applicants were randomly selected and asked whether they passed their driving test ($Pass_i = 1$) or failed their test ($Pass_i = 0$); data were also located on their gender ($Male_i = 1$ if male and $= 0$ if female) and their years of driving experience ($Experience_i$, in years). The following table summarizes the results from several probit, logit and linear probability models.

Dependent variable: Pass.							
Regression Model Regressor	**Probit (1)**	**Logit (2)**	**LPM (3)**	**Probit (4)**	**Logit (5)**	**LPM (6)**	**Probit (7)**
Experience	0.036 (0.007)	0.049 (0.011)	0.007 (0.001)				0.047 (0.156)
Male				−0.332 (0.164)	−0.628 (0.304)	−0.072 (0.036)	−0.179 (0.261)
Male × Experience							−0.018 (0.021)
Constant	0.716 (0.128)	1.058 (0.224)	0.774 (0.037)	1.281 (0.127)	2.191 (0.245)	0.903 (0.025)	0.808 (0.203)

Use the results in columns (4) through (6) to answer the following questions.

Compute the estimated probability of passing the test for men and for women.

Group	**Probit (4)**	**Logit (5)**	**LPM (6)**
Men			0.831
Women		0.899	

(*Round your responses to three decimal places*)

Why are the estimated probabilities from models (4) through (6) nearly identical?

- **A.** The similarity between estimates from models (4) through (6) is simply coincidence.
- **B.** Because the estimated probability curve is the same for the three models.
- **C.** Because there is only one binary regressor (*Male*).
- **D.** Because the distributional assumptions are the same for the three models.

Answers 0.829

0.827

0.900

0.903

C. Because there is only one binary regressor (*Male*).

ID: Exercise 11.4

25. Four hundred driver's license applicants were randomly selected and asked whether they passed their driving test ($Pass_i = 1$) or failed their test ($Pass_i = 0$); data were also located on their gender ($Male_i = 1$ if male and $= 0$ if female) and their years of driving experience ($Experience_i$, in years). The following table summarizes the results from several probit, logit and linear probability models.

Dependent variable: Pass.							
Regression Model Regressor	**Probit (1)**	**Logit (2)**	**LPM (3)**	**Probit (4)**	**Logit (5)**	**LPM (6)**	**Probit (7)**
Experience	0.031 (0.008)	0.043 (0.019)	0.005 (0.003)				0.042 (0.156)
Male				−0.337 (0.161)	−0.628 (0.304)	−0.075 (0.037)	−0.177 (0.261)
Male × Experience							−0.017 (0.022)
Constant	0.711 (0.129)	1.059 (0.224)	0.778 (0.037)	1.282 (0.126)	2.195 (0.246)	0.905 (0.024)	0.808 (0.203)

Use the results in column (7) to answer the following questions.

Akira is a man with 18 years of driving experience. What is the predicted probability that he will pass the test?

The predicted probability that Akira will pass the test is

(*Round your response to three decimal places*)

Jane is a woman with 7 years of driving experience. What is the predicted probability that she will pass the test?

The predicted probability that Jane will pass the test is

(*Round your response to three decimal places*)

Does the effect of experience on test performance depend on gender?

- **A.** No, the interaction term is not statistically significant at any reasonable level.
- **B.** This is unclear with the give information.
- **C.** Yes, the interaction term is statistically significant at the 1% significance level.
- **D.** Yes, the interaction term is statistically significant at the 5% significance level.

Answers 0.860

0.865

A. No, the interaction term is not statistically significant at any reasonable level.

ID: Exercise 11.5

26. The equation below estimates the effect of race on the probability of mortgage denial, holding constant the payment-to-income ratio.

$$\Pr\left(deny = 1 \middle| P/I\ ratio,\ black\right) = \underset{(0.18)}{\Phi(-2.23} + \underset{(0.46)}{2.73} P/I\ ratio + \underset{(0.085)}{0.73} black)$$

A black mortgage applicant has a *P/I ratio* of 0.38. What is the predicted probability that his application will be denied?

The predicted probability that his application will be denied is ______%.

(*Express your response as a percentage and round to two decimal places*)

Suppose that the applicant reduced this ratio to 0.33. What effect would this have on his predicted probability of being denied a mortgage?

The predicted probability of being denied a mortgage would (1) ______ by ______ percentage points.

(*Round your response to two decimal places*)

A white mortgage applicant has a *P/I ratio* of 0.39. What is the predicted probability that his application will be denied?

The predicted probability that his application will be denied is ______%.

(*Express your response as a percentage and round to two decimal places*)

Suppose that the applicant reduced this ratio to 0.28. What effect would this have on his predicted probability of being denied a mortgage?

The predicted probability of being denied a mortgage would (2) ______ by ______ percentage points.

(*Round your response to two decimal places*)

Does the marginal effect of the *P/I ratio* on the probability of mortgage denial depend on race?

- **A.** Yes.
- **B.** No.

(1) decrease / increase   (2) decrease / increase

Answers 32.18

(1) decrease

4.72

12.19

(2) decrease

5.05

A. Yes.

ID: Exercise 11.6

27. The population logit model of the binary dependent variable Y with multiple regressors is

$$\Pr\left(Y=1 \middle| X_1, X_2, \ldots, X_k\right) = F\left(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k\right) = \frac{1}{1+e^{-\left(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k\right)}}$$

Where $X_1, X_2, \ldots, X_k$ are regressors.

The equation below estimates the effect of race on the probability of mortgage denial, holding constant the payment-to-income ratio.

$$\Pr\left(deny = 1 \middle| P/I\ ratio,\ black\right) = F(\underset{(0.19)}{-2.27} + \underset{(0.46)}{2.71} P/I\ ratio + \underset{(0.086)}{0.78} black)$$

A black mortgage applicant has a *P/I ratio* of 0.41. What is the predicted probability that his application will be denied?

The predicted probability that his application will be denied is ____%.

(*Express your response as a percentage and round to two decimal places*)

Suppose that the applicant reduced this ratio to 0.28. What effect would this have on his predicted probability of being denied a mortgage?

The predicted probability of being denied a mortgage would (1) ____ by ____ percentage points.

(*Round your response to two decimal places*)

A white mortgage applicant has a *P/I ratio* of 0.45. What is the predicted probability that his application will be denied?

The predicted probability that his application will be denied is ____%.

(*Express your response as a percentage and round to two decimal places*)

Suppose that the applicant reduced this ratio to 0.26. What effect would this have on his predicted probability of being denied a mortgage?

The predicted probability of being denied a mortgage would (2) ____ by ____ percentage points.

(*Round your response to two decimal places*)

Does the marginal effect of the *P/I ratio* on the probability of mortgage denial depend on race?

- **A.** Yes.
- **B.** No.

(1) decrease / increase (2) decrease / increase

Answers 40.64

(1) decrease

8.15

25.91

(2) decrease

8.62

A. Yes.

ID: Exercise 11.7

28. The Boston HMDA data set was collected by researchers at the Federal Reserve Bank of Boston. The data set combines information from mortgage applications and a follow-up-survey of the banks and other lending institutions that received these mortgage applications. The data pertain to mortgage applications made in 1990 in the greater Boston metropolitan area. The full data set has 2925 observations, consisting of all mortgage applications by blacks and Hispanics plus a random sample of mortgage applications by whites.

Morgan denial regressions using the Boston HMDA Data

Dependent variable: deny = 1 if mortgage application is denied, = 0 if accepted; 2380 observations.						
Regression Model **Regressor**	**LPM** **(1)**	**Logit** **(2)**	**Probit** **(3)**	**Probit** **(4)**	**Probit** **(5)**	**Probit** **(6)**
Black	0.089** (0.027)	0.688** (0.182)	0.389** (0.098)	0.371** (0.099)	0.363** (0.100)	0.246 (0.448)
P/I ratio	0.449** (0.114)	4.76** (1.33)	2.44** (0.61)	2.46** (0.60)	2.62** (0.61)	2.57** (0.66)
Housing expense-to-income ratio	-0.048 (.110)	-0.11 (1.29)	-0.18 (0.68)	-0.30 (0.68)	-0.50 (0.70)	-0.54 (0.74)
Medium loan-to-value ratio (0.80 ≤ loan-value ratio ≤ 0.95)	0.031* (0.013)	0.46** (0.16)	0.21** (0.08)	0.22** (0.08)	0.22** (0.08)	0.22** (0.08)
High loan-to-value ratio (loan-value ratio > 0.95)	0.189** (0.050)	1.49** (0.32)	0.79** (0.18)	0.79** (0.18)	0.84** (0.18)	0.79** (0.18)
Consumer credit score	0.031** (0.005)	0.29** (0.04)	0.15** (0.02)	0.16** (0.02)	0.34** (0.11)	0.16** (0.02)
Mortgage credit score	0.021 (0.011)	0.28* (0.14)	0.15* (0.07)	0.11 (0.08)	0.16 (0.10)	0.11 (0.08)
Public bad credit record	0.197** (0.035)	1.23** (0.20)	0.70** (0.12)	0.70** (0.12)	0.72** (0.12)	0.70** (0.12)
Denied mortgage insurance	0.702** (0.045)	4.55** (0.57)	2.56** (0.30)	2.59** (0.29)	2.59** (0.30)	2.59** (0.29)
Self-employed	0.060** (0.021)	0.67** (0.21)	0.36** (0.11)	0.35** (0.11)	0.34** (0.11)	0.35** (0.11)
Single				0.23** (0.08)	0.23** (0.08)	0.23** (0.08)
High school diploma				-0.61** (0.23)	-0.60* (0.24)	-0.62** (0.23)
Unemploymenr rate				0.03 (0.02)	0.03 (0.02)	0.03 (0.02)
Condominium					-0.05 (0.09)	
Black × P/I ratio						-0.58 (1.47)
Black × housing expense-to-income ratio						1.23 (1.69)
Additional credit rating indicator variables	no	no	no	no	yes	no
Constant	-0.183** (0.028)	-5.71** (0.48)	-3.04** (0.23)	-2.57** (0.34)	-2.90** (0.39)	-2.54** (0.35)
***F*-Statistics and *p*-Values Testing Exclusion of Groups of Variables**						
Applicant single; high school diploma; industry unemployment rate				5.85 (<0.001)	5.22 (0.001)	5.79 (<0.001)
Additional credit rating indicator variables					1.22 (0.291)	
Race interactions and black						4.96 (0.002)
Race interactions only						0.27 (0.766)
Difference in predicted probability of denial, white vs. black (percentage points)	8.4%	6.0%	7.1%	6.6%	6.3%	6.5%

These regressions were estimated using the n = 2380 observations in the Boston HMDA data set. The linear probability model was estimated by OLS, and probit and logit regressions were estimated by maximum likelihood. Standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The change in predicted probability in the final row was computed for a hypothetical applicant whose values of the regressors, other than race, equal the sample mean. Individual coefficients are statistically significant at the *5% or **1% level.

Use the estimated linear probability model shown in column (1) of the table above to answer the following questions.

Two applicants, one white and one black, apply for a mortgage. They have the same values for all the regressors other than race. How mu
more likely is the black applicant to be denied a mortgage?

The denial probability is [ ] percentage points higher for the black applicant.

(*Express your response in percentage points and round to two decimal places*)

The denial probability is 8.90 percentage points higher for the black applicant. Construct a 95% confidence interval for this estimate.

The 95% confidence interval is [[ ], [ ]] percentage points.

(*Express your response in percentage points and round to two decimal places*)

Suppose that blacks obtain less education than whites, and that educational attainment is negatively related the probability of being denied
mortgage. What is the likely direction of the bias as result of omitting a measure of education from the regression?

The estimated probability is likely to be biased (1) __________.

(1) ○ upward
○ downward

Answers 8.90

3.61

14.19

(1) upward

ID: Exercise 11.9

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29. To measure the fit of the probit model, you should:

- ○ **A.** use the "fraction correctly predicted" or the "pseudo R^2."
- ○ **B.** use the log of the likelihood function and compare it to the value of the likelihood function.
- ○ **C.** plot the predicted values and see how closely they match the actual values.
- ○ **D.** use the regression R^2.

Answer: A. use the "fraction correctly predicted" or the "pseudo R^2."

ID: Test A Ex 11.3.5

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30. Nonlinear least squares:

- A. gives you the same results as maximum likelihood estimation.
- B. should always be used when you have nonlinear equations.
- C. solves the minimization of the sum of squared predictive mistakes through sophisticated mathematical routines, essentially by trial-and-error methods.
- D. is another name for sophisticated least squares.

Answer: C.
solves the minimization of the sum of squared predictive mistakes through sophisticated mathematical routines, essentially by trial-and-error methods.

ID: Test B Ex 11.3.4

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31. When testing joint hypotheses, you can use:

- A. the chi-squared statistic.
- B. either the F-statistic or the chi-squared statistic.
- C. the F-statistic.
- D. none of the above.

Answer: B. either the F-statistic or the chi-squared statistic.

ID: Test B Ex 11.3.5

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32. Let R be the possibility of rain the next day, where $R = 0$ indicates that it does not rain tomorrow and $R = 1$ indicates that it does rain tomorrow. Let the probability that it does rain tomorrow be p. Suppose Barry collects a random sample consisting of 85 i.i.d observations on the dependent variable R (with no regressors) and finds that on 49 instances, there was no rain the next day.

The maximum likelihood estimate of p, $\hat{p}$, is ______.

(*Round your answer to two decimal places.*)

A randomly selected group of 200 individuals was asked whether they had gone to college (*College* = 1) or not (*College* = 0); data was also collected on whether their mothers were educated (*Mother* = 1 if she was educated and *Mother* = 0 if she was not educated), their family income (*FamilyInc*, in thousand dollars), their race (*Race* = 1 if they are non-White and *Race* = 0 if they are White), and the inflation level in the economy in the year (*Infl*) they graduated from high school.

A probit regression of *College* against *Mother*, *FamilyInc*, *Race*, and *Infl* was estimated using maximum likelihood. Suppose the *F*-statistic associated with the hypothesis that *Mother*, *Race*, and *Infl* have no significant effect on *College* once we control for *FamilyInc*, is 1.85.

The chi-squared statistic associated with the given hypothesis will be ______.

(*Round your answer to two decimal places.*)

At the 5% significance level, we would (1) ______ the hypothesis that *Mother*, *Race*, and *Infl* have no significant effect on *College* once we control for *FamilyInc*.

(1) ○ fail to reject
○ reject

Answers 0.42

5.55

(1) fail to reject

ID: Concept Exercise 11.3.1

33. Which of the following statements are true in describing the methods used for the estimation of probit and logit regression functions? (*Check all that apply*.)

- [ ] **A.** Like OLS, nonlinear least squares finds the values of the parameters that minimize the sum of squared prediction mistakes produced by the model.
- [ ] **B.** The nonlinear least squares estimator is consistent, efficient, and is normally distributed in large samples.
- [ ] **C.** The probit/logit coefficients $\beta_0, \beta_1, \ldots, \beta_k$ cannot be estimated by OLS as the population regression function is a nonlinear function of these coefficients.
- [ ] **D.** In practice, the use of the nonlinear least squares estimator of the probit/logit coefficients is preferred over the use of the maximum likelihood estimator.

Which of the following statements are true in describing the measures of fit used for models with binary dependent variables? (*Check all that apply*.)

- [ ] **A.** An advantage of the fraction correctly predicted measure is that it reflects the quality of the prediction.
- [ ] **B.** The pseudo-R^2 measures the quality of fit of such models by comparing values of the maximized likelihood function with all the regressors to the value of the likelihood with none.
- [ ] **C.** According to the fraction correctly predicted measure, Y_i is said to be correctly predicted if $Y_i = 1$ and the predicted probability exceeds 50% or if $Y_i = 0$ and the predicted probability is less than 50%.
- [ ] **D.** The "fraction correctly predicted", the R^2, and the pseudo-R^2 are the three measures of fit for these models.

Answers A.

Like OLS, nonlinear least squares finds the values of the parameters that minimize the sum of squared prediction mistakes produced by the model.

, C.

The probit/logit coefficients $\beta_0, \beta_1, \ldots, \beta_k$ cannot be estimated by OLS as the population regression function is a nonlinear function of these coefficients.

B.

The pseudo-R^2 measures the quality of fit of such models by comparing values of the maximized likelihood function with all the regressors to the value of the likelihood with none.

, C.

According to the fraction correctly predicted measure, Y_i is said to be correctly predicted if $Y_i = 1$ and the predicted probability exceeds 50% or if $Y_i = 0$ and the predicted probability is less than 50%.

ID: Concept Exercise 11.3.2

34. The Boston HMDA data set was collected by researchers at the Federal Reserve Bank of Boston. The data set combines information from mortgage applications and a follow-up-survey of the banks and other lending institutions that received these mortgage applications. The data pertain to mortgage applications made in 1990 in the greater Boston metropolitan area. The full data set has 2925 observations, consisting of all mortgage applications by blacks and Hispanics plus a random sample of mortgage applications by whites.

Morgan denial regressions using the Boston HMDA Data

Dependent variable: deny = 1 if mortgage application is denied, = 0 if accepted; 2380 observations.						
Regression Model Regressor	**LPM (1)**	**Logit (2)**	**Probit (3)**	**Probit (4)**	**Probit (5)**	**Probit (6)**
Black	0.084** (0.023)	0.688** (0.182)	0.389** (0.098)	0.371** (0.099)	0.363** (0.100)	0.246 (0.448)
P/I ratio	0.449** (0.114)	4.76** (1.33)	2.44** (0.61)	2.46** (0.60)	2.62** (0.61)	2.57** (0.66)
Housing expense-to-income ratio	-0.048 (.110)	-0.11 (1.29)	-0.18 (0.68)	-0.30 (0.68)	-0.50 (0.70)	-0.54 (0.74)
Medium loan-to-value ratio (0.80 ≤ loan-value ratio ≤ 0.95)	0.031* (0.013)	0.46** (0.16)	0.21** (0.08)	0.22** (0.08)	0.22** (0.08)	0.22** (0.08)
High loan-to-value ratio (loan-value ratio > 0.95)	0.189** (0.050)	1.49** (0.32)	0.79** (0.18)	0.79** (0.18)	0.84** (0.18)	0.79** (0.18)
Consumer credit score	0.031** (0.005)	0.29** (0.04)	0.15** (0.02)	0.16** (0.02)	0.34** (0.11)	0.16** (0.02)
Mortgage credit score	0.021 (0.011)	0.28* (0.14)	0.15* (0.07)	0.11 (0.08)	0.16 (0.10)	0.11 (0.08)
Public bad credit record	0.197** (0.035)	1.23** (0.20)	0.70** (0.12)	0.70** (0.12)	0.72** (0.12)	0.70** (0.12)
Denied mortgage insurance	0.702** (0.045)	4.55** (0.57)	2.56** (0.30)	2.59** (0.29)	2.59** (0.30)	2.59** (0.29)
Self-employed	0.060** (0.021)	0.67** (0.21)	0.36** (0.11)	0.35** (0.11)	0.34** (0.11)	0.35** (0.11)
Single				0.23** (0.08)	0.23** (0.08)	0.23** (0.08)
High school diploma				-0.61** (0.23)	-0.60* (0.24)	-0.62** (0.23)
Unemploymenr rate				0.03 (0.02)	0.03 (0.02)	0.03 (0.02)
Condominium					-0.05 (0.09)	
Black × P/I ratio						-0.58 (1.47)
Black × housing expense-to-income ratio						1.23 (1.69)
Additional credit rating indicator variables	no	no	no	no	yes	no
Constant	-0.183** (0.028)	-5.71** (0.48)	-3.04** (0.23)	-2.57** (0.34)	-2.90** (0.39)	-2.54** (0.35)
***F*-Statistics and *p*-Values Testing Exclusion of Groups of Variables**						
Applicant single; high school diploma; industry unemployment rate				5.85 (<0.001)	5.22 (0.001)	5.79 (<0.001)
Additional credit rating indicator variables					1.22 (0.291)	
Race interactions and black						4.96 (0.002)
Race interactions only						0.27 (0.766)
Difference in predicted probability of denial, white vs. black (percentage points)	8.4%	6.0%	7.1%	6.6%	6.3%	6.5%

These regressions were estimated using the n = 2380 observations in the Boston HMDA data set. The linear probability model was estimated by OLS, and probit and logit regressions were estimated by maximum likelihood. Standard errors are given in parentheses under the coefficients, and p-values are given in parentheses under the F-statistics. The change in predicted probability in the final row was computed for a hypothetical applicant whose values of the regressors, other than race, equal the sample mean. Individual coefficients are statistically significant at the *5% or **1% level.

In the table above the estimated coefficient on *black* is 0.084 in column (1), 0.688 in column (2), and 0.389 in column (3). In spite of these large differences, all three models yield similar estimates of the marginal effect of race on the probability of mortgage denial. How can this l

- **A.** The marginal effect in column (2) is the estimated coefficient, whereas the marginal effects in columns (1) and (3) are not the estimated coefficients directly.
- **B.** The marginal effects in columns (1), (2) and (3) are similar, but cannot be derived from the estimated coefficients.
- **C.** The marginal effect in column (1) is the estimated coefficient, whereas the marginal effects in columns (2) and (3) are not the estimated coefficients directly.
- **D.** The marginal effect in column (3) is the estimated coefficient, whereas the marginal effects in columns (1) and (2) are not the estimated coefficients directly.

Answer: C.

The marginal effect in column (1) is the estimated coefficient, whereas the marginal effects in columns (2) and (3) are not the estimated coefficients directly.

ID: Review Concept 11.2