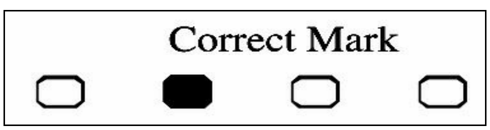
Instructor: Prof. Murdock (Sections L0301 and L0401 ONLY)
Duration: 120 minutes. You must stay in the test room for the entire time.
Part I: 20 multiple choice questions worth 2.5 points each
Part II: 3 problems
Total Points: 100 possible points total: 50 from Part I and 50 from Part II
Allowed Aids: A non-programmable calculator

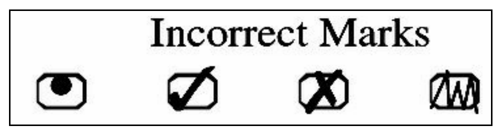
<u>INSTRUCTIONS (for Part 1)</u>:

Do NOT write your answers to the multiple choice questions on these test papers
ONLY those answers correctly marked on the SCANTRON form can earn marks
You MAY do scratch work on these pages

- Use <u>only</u> a pencil or blue or black ball point pen

- **<u>Pencil strongly recommended</u>**, it can be erased if a mistake is made
- Make dark solid marks that fill the bubble completely





- Select the <u>one</u> best alternative
  - Questions with more than one answer selected will be scored incorrect
- Erase completely any marks you want to change
  - Do <u>not</u> use correction fluid
- Do <u>not</u> make stray marks on the form
- Answer every question: there is no penalty for guessing

1st : Print your **LAST NAME** and **INITIALS** in boxes provided
- Use exact name you are <u>officially registered</u> under
- Darken each letter in the corresponding bracket <u>below each box</u>

2nd : Print your 9 digit **STUDENT NUMBER** in the boxes provided
- Fill in zeros in front of the number if less than 9 digits
- Darken each number in the corresponding bracket <u>below each box</u>

3rd : Print 2 digit **FORM** number in the boxes provided
- Your FORM number is **01**
- Darken each number in the corresponding bracket <u>below each box</u>

4th : Sign your name in the **SIGNATURE** box

For the 20 questions, choose the most correct answer and mark it on the SCANTRON form.

(1) Which could be used to describe a linear relationship between variables?

(A) A scatter diagram
(B) The coefficient of correlation
(C) The least squares method
(D) All of the above
(E) None of the above

(2) Which is a random variable?

(A) The population mean: μ
(B) The sample mean: X-bar
(C) The population variance: σ^2
(D) All of the above
(E) None of the above

► For Questions **(3) – (5)**, Consider a survey that asks whether a respondent's home is 1, 2 or 3 stories tall (i.e. how many floors). The variable X records the answer. In the population, suppose 10% have a 1 story home, 50% have a 2 story home, and 40% have a 3 story home.

(3) What is the shape of the population?

(A) Binomial
(B) Poisson
(C) Uniform
(D) Normal
(E) None of the above

(4) After speaking with 3 respondents, what is the chance that you receive three different answers: one lives in a 1 story home, one lives in a 2 story home, and one lives in a 3 story home?

(A) 0.08
(B) 0.10
(C) 0.12
(D) 0.54
(E) 0.66

(5) After speaking with 300 respondents, what is the chance that more than 40% live in 3 story homes?

(A) 0.30
(B) 0.33
(C) 0.35
(D) 0.40
(E) 0.50

(6) For a small retail outlet suppose the standard deviation of annual sales is \$25,200. What is the standard deviation of monthly sales?

(A) \$175
(B) \$2,100
(C) \$2,520
(D) \$302,400
(E) None of the above

(7) For a normal population, suppose that to find the $P(X < 10)$ you standardize to obtain $P(Z < -1.4)$. What is the interpretation of 10 and -1.4?

(A) 10 is within 1.4 standard deviations of the mean of X
(B) 10 is 1.4 standard deviations below the mean of X
(C) 10 is the mean of X and -1.4 is the mean of Z
(D) $(10)^2$ is the variance of X and $(-1.4)^2$ is the variance of Z
(E) There is about a 68.3% chance that 10 plus or minus 1.4 includes the population mean

(8) In general, which of the following is a true statement about the population distribution and a sampling distribution of the sample mean?

(A) They have the same shape but different parameter values
(B) They are exactly the same if the population is perfectly bell shaped
(C) They are exactly the same if the sample size is equal to one
(D) They are exactly the same if the sample size is equal to the population size
(E) They are approximately the same if you have a sufficiently large sample size

► For Questions **(9) – (10)**, consider a Uniform population with lower bound 0 and upper bound 100: $X \sim U[0, 100]$.

(9) What is the probability that X is greater than 55?

(A) 0.05
(B) 0.15
(C) 0.25
(D) 0.35
(E) 0.45

(10) For a sample size of 36, what is the probability that X-bar is greater than 55?

(A) 0.05
(B) 0.15
(C) 0.25
(D) 0.35
(E) 0.45

(11) If X is normally distributed with mean 10 and standard deviation 2, what is the probability that X is less than 5?

(A) 0.00
(B) 0.01
(C) 0.02
(D) 0.03
(E) 0.04

(12) Consider a normal population with mean 65 and standard deviation 12: Y ~ N(65, 144). What is the population 99^{th} percentile?

(A) 92.96
(B) 95.90
(C) 99.00
(D) 101.00
(E) 807.96

► For Question **(13)**, suppose a researcher conducts a Monte Carlo simulation where a sample of 5 observations is taken from a known population and computes the sample median. This sampling experiment is repeated 100,000 times and the simulation results are summarized below.

```
                         Sample Median
-------------------------------------------------------------
      Percentiles      Smallest
 1%            1              1
 5%            1              1
10%            1              1       Obs              100000
25%            2              1       Sum of Wgt.      100000

50%            4                      Mean            3.49393
                        Largest       Std. Dev.      1.766685
75%            5              9
90%            5              9       Variance       3.121174
95%            7              9       Skewness       .4481188
99%            7              9       Kurtosis       2.533736
```

(13) About 95% of the time the sample median will be in which interval?

(A) (-1.82, 8.80)
(B) (0.03, 6.96)
(C) (0.54, 7.46)
(D) (1.00, 7.00)
(E) (1.12, 5.86)

(14) When is the sample mean approximately normally distributed?

- **(A)** When the sample size is at least 30
- **(B)** When the population mean is sufficiently large
- **(C)** When its expected value plus or minus three standard deviations is between 0 and 1
- **(D)** When its expected value plus or minus three standard deviations is between 0 and n
- **(E)** It never is approximately normal

(15) When is the sample proportion approximately normally distributed?

- **(A)** When the sample size is at least 30
- **(B)** When the population proportion is sufficiently large
- **(C)** When its expected value plus or minus three standard deviations is between 0 and 1
- **(D)** When its expected value plus or minus three standard deviations is between 0 and n
- **(E)** It never is approximately normal

(16) Considering a Uniform population, which of the following properties does the sample range have as an estimator of the population range?

- **(A)** It is unbiased and consistent
- **(B)** It is biased and consistent
- **(C)** It is unbiased and not consistent
- **(D)** It is biased and not consistent
- **(E)** E[sample range] = population range

(17) For which of the following populations is the sample mean an unbiased estimator of the population mean?

- **(A)** Uniform distribution
- **(B)** Normal distribution
- **(C)** A very skewed population
- **(D)** All of the above
- **(E)** None of the above

(18) Which of the following would cause a 95% confidence interval estimator of the mean to exclude the population mean more than 5% of the time?

- **(A)** Sampling error
- **(B)** Non-sampling errors
- **(C)** Population is non-normal
- **(D)** Population variance is unknown
- **(E)** All of the above

(19) Which of the following probability statements regarding a Standard Normal random variable and Student t random variable is true?

(A) P(Z > -1) = P(t > -1)
(B) P(Z > 0) = P(t > 0)
(C) P(Z > 1) = P(t > 1)
(D) All of the above
(E) None of the above

(20) For a small sample (less than 30 observations) taken from a normal population, which of the following statements about the interval estimator of the mean (μ) is true?

(A) If σ^2 is known it will tend to be more narrow than if σ^2 is unknown
(B) If σ^2 is known it will tend to be wider than if σ^2 is unknown
(C) Whether σ^2 is known or unknown does not affect the width
(D) It cannot be calculated because there is not a sufficiently large sample size
(E) It will be useless for inference because of the bias caused by sampling error

Population Mean: $\mu = \dfrac{\sum_{i=1}^{N} x_i}{N}$

Sample Mean: $\overline{X} = \dfrac{\sum_{i=1}^{n} x_i}{n}$

Population Variance: $\sigma^2 = \dfrac{\sum_{i=1}^{N}(x_i - \mu)^2}{N}$

Sample Variance: $s^2 = \dfrac{\sum_{i=1}^{n}(x_i - \overline{X})^2}{n-1} = \dfrac{1}{n-1}\left[\sum_{i=1}^{n} x_i^2 - \dfrac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}\right]$

Population s.d.: $\sigma = \sqrt{\sigma^2}$

Sample s.d.: $s = \sqrt{s^2}$

Population coefficient of variation: $CV = \dfrac{\sigma}{\mu}$

Sample coefficient of variation: $cv = \dfrac{s}{\overline{X}}$

Population covariance: $\sigma_{XY} = \dfrac{\sum_{i=1}^{N}(x_i - \mu_X)(y_i - \mu_Y)}{N}$

Sample covariance: $s_{XY} = \dfrac{\sum_{i=1}^{n}(x_i - \overline{X})(y_i - \overline{Y})}{n-1}$

Population coefficient of correlation: $\rho = \dfrac{\sigma_{XY}}{\sigma_X \sigma_Y}$

Sample covariance (shortcut): $s_{XY} = \dfrac{1}{n-1}\left[\sum_{i=1}^{n} x_i y_i - \dfrac{\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n}\right]$

Sample coefficient of correlation: $r = \dfrac{s_{XY}}{s_X s_Y}$

Coefficients of Least Squares line (y = b_0 + b_1x): $b_1 = \dfrac{s_{XY}}{s_X^2}$ $\quad b_0 = \overline{Y} - b_1\overline{X}$

Conditional Probability:

$$P(A \mid B) = \frac{P(A \text{ and } B)}{P(B)}$$

Complement Rules:

$$P(A^C) = 1 - P(A) \qquad P(A^C \mid B) = 1 - P(A \mid B)$$

Multiplication Rule: $P(A \text{ and } B) = P(A \mid B)P(B)$

Addition Rule: $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$

Bayes Law: $P(A \mid B) = \dfrac{P(B \mid A)P(A)}{P(B)}$

Expected Value: $E[X] = \mu = \sum_{all\ \mathrm{x}} xp(x)$

Variance: $V[X] = E[(X-\mu)^2] = \sigma^2 = \sum_{all\ x} (x-\mu)^2 p(x)$

Covariance: $E[(X-\mu_X)(Y-\mu_Y)] = \sigma_{XY} = \sum_{all\ x}\sum_{all\ y}(x-\mu_X)(y-\mu_Y)p(x,y)$

Laws of Expected Value:
E[c] = c
E[X+c] = E[X] + c
E[cX] = cE[X]
E[a+bX+cY] = a + bE[X] + cE[Y]

Laws of Variance:
V[c] = 0
V[X+c] = V[X]
V[cX] = c^2V[X]
V[a+bX+cY] = b^2V[X] + c^2V[Y] + 2bcCOV[X,Y]

Laws of Covariance:
COV[X, c] = 0
COV[a+bX, c+dY] = bdCOV[X,Y]

Combinatorial formula: $$C_x^n = \frac{n!}{x!(n-x)!}$$

Binomial probability: $$p(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{n-x}$$ $$for\ x = 0, 1, 2, \ldots, \mathrm{n}$$

Mean of Binomial: np **Variance of Binomial:** $np(1-p)$

Poisson probability: $$p(x) = \frac{e^{-\lambda}\lambda^x}{x!} \quad for\ x = 0, 1, 2, \ldots$$

Mean of Poisson: λ **Variance of Poisson:** λ

Uniform density function: $$f(x) = \frac{1}{b-a} \quad where\ \ a \le x \le b$$

Mean of Uniform: $\frac{a+b}{2}$ **Variance of Uniform:** $\frac{(b-a)^2}{12}$

Sample Mean:

$$\mu_{\bar{X}} = E[\bar{X}] = \mu_X$$

$$\sigma_{\bar{X}}^2 = V[\bar{X}] = \frac{\sigma_X^2}{n}$$

$$\sigma_{\bar{X}} = \frac{\sigma_X}{\sqrt{n}}$$

Sample Proportion:

$$E[\hat{P}] = p$$

$$\sigma_{\hat{P}}^2 = V[\hat{P}] = \frac{p(1-p)}{n}$$

$$\sigma_{\hat{P}} = \sqrt{\frac{p(1-p)}{n}}$$

Difference Between Two Sample Means:

$$\mu_{\bar{X}_1 - \bar{X}_2} = E[\bar{X}_1 - \bar{X}_2] = \mu_1 - \mu_2$$

$$\sigma_{\bar{X}_1 - \bar{X}_2}^2 = V[\bar{X}_1 - \bar{X}_2] = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}$$

$$\sigma_{\bar{X}_1 - \bar{X}_2} = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

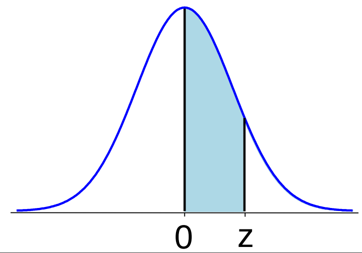
z statistic: $$z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$$

Confidence interval estimator of μ when σ^2 is known: $$\bar{X} \pm z_{\alpha/2}\frac{\sigma}{\sqrt{n}}$$

Sample size to estimate $\mu \pm \tau$ when σ^2 is known: $$n = \left(\frac{z_{\alpha/2}\sigma}{\tau}\right)^2$$

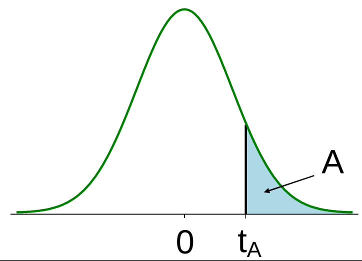
t statistic: $$t = \frac{\bar{X} - \mu}{s/\sqrt{n}}$$

Confidence interval estimator of μ when σ^2 is unknown: $$\bar{X} \pm t_{\alpha/2}\frac{s}{\sqrt{n}}$$



Normal Probabilities:

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990



Critical Values of t:

ν	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$	ν	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$
1	3.078	6.314	12.706	31.821	63.657	24	1.318	1.711	2.064	2.492	2.797
2	1.886	2.920	4.303	6.965	9.925	25	1.316	1.708	2.060	2.485	2.787
3	1.638	2.353	3.182	4.541	5.841	26	1.315	1.706	2.056	2.479	2.779
4	1.533	2.132	2.776	3.747	4.604	27	1.314	1.703	2.052	2.473	2.771
5	1.476	2.015	2.571	3.365	4.032	28	1.313	1.701	2.048	2.467	2.763
6	1.440	1.943	2.447	3.143	3.707	29	1.311	1.699	2.045	2.462	2.756
7	1.415	1.895	2.365	2.998	3.499	30	1.310	1.697	2.042	2.457	2.750
8	1.397	1.860	2.306	2.896	3.355	35	1.306	1.690	2.030	2.438	2.724
9	1.383	1.833	2.262	2.821	3.250	40	1.303	1.684	2.021	2.423	2.704
10	1.372	1.812	2.228	2.764	3.169	45	1.301	1.679	2.014	2.412	2.690
11	1.363	1.796	2.201	2.718	3.106	50	1.299	1.676	2.009	2.403	2.678
12	1.356	1.782	2.179	2.681	3.055	55	1.297	1.673	2.004	2.396	2.668
13	1.350	1.771	2.160	2.650	3.012	60	1.296	1.671	2.000	2.390	2.660
14	1.345	1.761	2.145	2.624	2.977	70	1.294	1.667	1.994	2.381	2.648
15	1.341	1.753	2.131	2.602	2.947	80	1.292	1.664	1.990	2.374	2.639
16	1.337	1.746	2.120	2.583	2.921	90	1.291	1.662	1.987	2.368	2.632
17	1.333	1.740	2.110	2.567	2.898	100	1.290	1.660	1.984	2.364	2.626
18	1.330	1.734	2.101	2.552	2.878	120	1.289	1.658	1.980	2.358	2.617
19	1.328	1.729	2.093	2.539	2.861	140	1.288	1.656	1.977	2.353	2.611
20	1.325	1.725	2.086	2.528	2.845	160	1.287	1.654	1.975	2.350	2.607
21	1.323	1.721	2.080	2.518	2.831	180	1.286	1.653	1.973	2.347	2.603
22	1.321	1.717	2.074	2.508	2.819	200	1.286	1.653	1.972	2.345	2.601
23	1.319	1.714	2.069	2.500	2.807	∞	1.282	1.645	1.960	2.326	2.576

Degrees of freedom: ν

Student ID #:

Last Name:

First Name:

Instructor: Prof. Murdock
Duration: 120 minutes. You must stay in the test room for the entire time.
Part I: 20 multiple choice questions worth 2.5 points each
Part II: 3 problems
Total Points: 100 possible points total: 50 from Part I and 50 from Part II
Allowed Aids: A non-programmable calculator

<u>INSTRUCTIONS (for Part II)</u>:

Write your answers clearly, concisely, and completely on these test papers.

You must show ALL work.

If you run out of room you may continue your answers on pages 7 and 8, but indicate you have done so and clearly label your additional responses (for example: “Question (1) (b) continued:”).

DO NOT WRITE IN THIS TABLE:

Marks	Q1	Q2	Q3	Total (Part II)
Maximum possible	*18*	*16*	*16*	*50*
Marks earned				

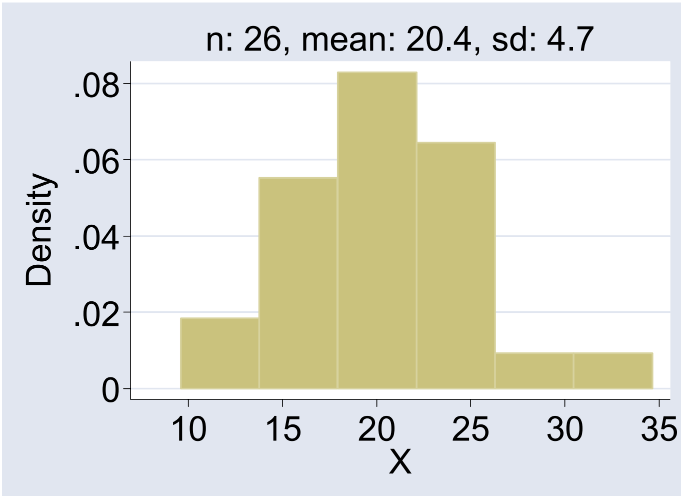
(1) [18 points] Preview the questions in parts **(a)** – **(c)** and then read the attached article "The Price of Climate Change" by Stephen Dubner and Steven Levitt. The ENTIRETY of your answers to these question must be in YOUR OWN WORDS. Anything copied from the article will earn a mark of 0.

(a) [4 points] Economists have used weather and new laws (legislation) to try to address some research questions. In the article, weather is argued to be useful because it is which kind of variable: endogenous or exogenous? What about new laws? Explain.

(b) [6 points] Give three different research questions discussed in the article.

(c) [8 points] Which kind of data does this article discuss to address these questions: observational, experimental, or natural experiment? Using one research questions as an example, explain.

(2) [16 points] Consider the following description of a sample.



(a) [8 points] What is the 99% confidence interval estimator of the mean? (Round answer to nearest tenth.) Interpretation?

(b) [8 points] If you learned that the response rate for the survey that generated this sample is quite low, how would that affect your inference? Explain.

(3) [16 points] Consider a box containing 8000 black balls and 2000 white balls. The random variable P-hat is defined as the proportion of black balls obtained in 4 draws with replacement. Find the sampling distribution of P-hat and graph it.

Extra Space: If you use this space, clearly indicate for which question(s).

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The Price of Climate Change

By STEPHEN J. DUBNER and STEVEN D. LEVITT

The famous old quip about the weather — everyone talks about it but nobody does anything about it — is not as true as it once was. Alarmed by the threat of global warming, lots of people are actively trying to change human behaviors in order to change the weather.

Even economists are getting into the weather business. Olivier Deschênes of the University of California at Santa Barbara and Michael Greenstone of the Massachusetts Institute of Technology have written a pair of papers that assess some effects of climate change. In the first, they use long-run climatological models — year-by-year temperature and precipitation predictions from 2070 to 2099 — to examine the future of agriculture in the United States. Their findings? The expected rises in temperature and precipitation would actually increase annual agricultural production, and therefore agricultural profits, by about 4 percent, or $1.3 billion. This hardly fulfills the doomsday fears conjured by most conversations about global warming.

For other economists, meanwhile, the weather itself has proved useful in measuring wholly unrelated human behaviors. From an economist's perspective, the great thing about the weather is that there is nothing humans can do to affect it (at least until recently). Contrast this with social changes that people enact: a new set of laws, for instance. Very often, new laws come about when there is a perception that a big social problem — think violent crime or corporate fraud — is growing worse. After a while, and after the laws have been enacted, the problem diminishes. So did the new laws fix the problem, or would it have improved on its own? Politicians will surely claim that it was their laws that fixed the problem, but it's hard to know for sure.

The weather, however, is different; the beauty of weather is that it does its own thing, and whether the weather is good or bad, you can be pretty sure that it didn't come about in response to some human desire to fix a problem. Weather is a pure shock to the system, which means that it is a valuable tool to help economists make sense of the world.

Consider 19th-century Bavaria. The problem there was rain — too much of it. As Halvor Mehlum, Edward Miguel and Ragnar Torvik explained in a recent paper, excessive rain damaged the rye crop by interfering with the planting and the harvest. Using a historical rainfall database from the United Nations, they found that the price of rye was significantly higher in rainy years, and since rye was a major staple of the Bavarian diet, food prices across the board were considerably higher in those years, too. This was a big problem, since a poor family at the time would have been likely to spend as much as 80 percent of its money on food. The economists went looking for other effects of this weather shock. It turns out that Bavaria kept remarkably comprehensive crime statistics — the most meticulous in all of Germany — and when laid out one atop the other, there was a startlingly robust correlation between the amount of rain, the price of rye and the rate of property crime: they rose and fell together in lockstep. Rain raised food prices, and those prices, in turn, led hungry families to steal in order to feed themselves.

But violent crime fell during the rainy years, at the same time property crimes were on the rise. Why should that be? Because, the economists contend, rye was also used to make beer. "Ten percent of Bavarian household income went to beer purchases alone," they write. So as a price spike in rye led to a price spike in beer, there was less beer consumed — which in turn led to fewer assaults and murders.

It turns out that rainfall often has a surprisingly strong effect on violence. In a paper on the economic aftermath of the hundreds of riots in American cities during the 1960's, William Collins and Robert Margo used rainfall as a variable to compare the cities where riots took place with cities where riots probably would have taken place had it not rained. Few things can dampen a rioter's spirit more than a soaking rain, they learned. After two days of rioting in Miami in the summer of 1968 were finally quelled by rain, they write, the Dade County sheriff joked to The New York Times that he had ordered his off-duty officers to pray for more rain.

The economists Edward Miguel, Shanker Satyanath and Ernest Sergenti have written a paper that uses rainfall to explore the issue of civil war in Africa. Twenty-nine of 43 countries in sub-Saharan Africa, they note, experienced some kind of civil war during the 1980's or 1990's. The causes of any war are of course incredibly complex — or are they? The economists discovered that one of the most reliable predictors of civil war is lack of rain. Using monthly rainfall data from many different African countries (most of which, significantly, are largely agricultural), they found that a shortage of rain in a given growing season led inevitably to a short-term economic decline and that short-term economic declines led all too easily to civil war. The causal effect of a drought, they argue, was frighteningly strong: "a 5-percentage-point negative growth shock" — a drop in the economy, that is — "increases the likelihood of civil war the following year by nearly one-half."

Since the weather yields such interesting findings about the past, it makes sense that economists are also tempted to use it to anticipate the future. In their second paper on the potential effects of global warming, Deschênes and Greenstone try to predict mortality rates in the U.S. in the last quarter of the current century.

Unlike in their paper on agriculture, the news in this one isn't good. They estimate, using one of the latest (and most dire) climatological models, that the predicted rise in temperature will increase the death rate for American men by 1.7 percent (about 21,000 extra fatalities per year) and for American women by 0.4 percent (about 8,000 deaths a year). Most of these excess deaths, they write, will be caused by hot weather that worsens cardiovascular and respiratory conditions. These deaths will translate into an economic loss of roughly $31 billion per year. Deschênes and Greenstone caution that their paper is in a preliminary stage and hasn't yet been peer-reviewed and that the increased mortality rate may well be offset by such simple (if costly) measures as migration to the Northern states — a repopulation that, even a decade ago, might have seemed unimaginable.

Their paper on agriculture also has some wrinkles. While arguing that global warming would produce a net agricultural gain in the United States, they specify which states would be the big winners and which ones would be the big losers. What's most intriguing is that winners' and losers' lists are a true blend of red states and blue states: New York, along with Georgia and South Dakota, are among the winners; Nebraska and North Carolina would lose out, but the biggest loser of all would be California. Which suggests that in this most toxic of election seasons, when there seems not a single issue that can unite blue and red staters (or at least the politicians thereof), global warming could turn out to be just the thing to bring us all together.

Stephen J. Dubner and Stephen D. Levitt are the authors of "Freakonomics." More information on the research behind this column is at www.freakonomics.com.