Index No: ____________

UNIVERSITI SAINS MALAYSIA

Final Examination
Academic Session 2008/2009

April 2009

# JKE 316E – Quantitative Economics
## *[Ekonomi Kuantitatif]*

Duration : 3 hours
*[Masa : 3 jam]*

INSTRUCTIONS TO CANDIDATES

- The paper consists of **SEVENTEEN** pages, Appendix A (formula) and Appendix B (Table Z, t and F).
- Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.
- Write your answer in the space provided only.

*ARAHAN*

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH BELAS** muka surat yang bercetak, Lampiran A (Formula) dan Lampiran B (Jadual Z, t dan F), sebelum anda memulakan peperiksaan.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

*Tulis jawapan anda di ruangan yang disediakan.*

Angka Giliran: ______________________

Pusat Peperiksaan: ______________________

Tarikh Peperiksaan: ______________________

...2/-

1. Write short notes on:
*(Tulis nota ringkas tentang:)*

(a) Type II error (4 marks)
*(Ralat jenis II)* *(4 markah)*

(b) Describe how Type I error can occur (4 marks)
*(Terangkan bagaimanakah ralat jenis I boleh terjadi)* *(4 markah)*

(c) Cluster sampling (5 marks)
*(Persampelan kluster)* *(5 markah)*

...3/-

(d) Measures of linear relationship (6 marks)
*(Pengukuran hubungan linear)* *(6 markah)*

(e) Normal distribution (6 marks)
*(Taburan normal)* *(6 markah)*

2. (a) Describe the process of conducting One- and Two-Tail Test hypotheses testing.

(10 marks)

*(Jelaskan proses menjalankan ujian hipotesis satu dan dua sisi.)*

*(10 markah)*

...5/-

(b) A tyre manufacturer has been producing car tyres for the last five years. The manufacturer's record showed that the tyre produced has a mean life of 40,000 km and standard deviation of 3,000 km. The introduction of new technology used by the manufacturer may improve the performance of the tyres. A study to determine the performance of new tyres was made on 100 tyres and found that the new tyres have a mean life of 41,200 km. Determine whether the new technology has produced better tyres than present technology. Use 5% significant level.

(15 marks)

*(Sebuah kilang telah mengeluarkan tayar selama 5 tahun. Rekod kilang menunjukkan yang tayar yang telah dikeluarkan selama ini mempunyai min hayat sebanyak 40,000 km dan sisihan piawai 3,000 km. Penggunaan teknologi baru mungkin dapat meningkatkan lagi prestasi tayar. Satu kajian untuk menentukan prestasi tayar telah dilakukan ke atas 100 tayar dan mendapati min hayatnya ialah 41,200 km. Tentukan sama ada teknologi baru telah berjaya mengeluarkan tayar yang lebih baik daripada teknologi yang sedia ada. Gunakan paras keertian 5%.)*

*(15 markah)*

...6/-

3. (a) Complete the following ANOVA table by writing the correct figures in the shaded cells only.

(7 marks)

*(Lengkapkan jadual ANOVA di bawah dengan menulis angka yang betul di petak yang dikelabukan)*

*(7 markah)*

| Source | df | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| Treatments | | | 541.67 | |
| Blocks | 4 | 367.33 | | |
| Error | 8 | | | |
| Total | 14 | 1531.33 | | |

(b) The sample size (n) for the study was ___________. (1 marks)
*(Saiz sampel (n) kajian ialah ________.)* *(1 markah)*

(c) Test to determine whether the treatment means differ. (Use $\alpha = .05$)

(4 marks)

*(Uji sama ada min olahan adalah berbeza. Guna $\alpha = .05$)*

*(4 markah)*

...7/-

(d) Test to determine whether the block means differ. (Use $\alpha = .05$)

(4 marks)

*(Uji sama ada min blok adalah berbeza. Guna $\alpha = .05$)*

*(4 markah)*

(e) Explain the importance of ANOVA in economics analysis. (4 marks)

*(Jelaskan kepentingan ANOVA dalam analisis ekonomi.)* *(4 markah)*

...8/-

4. The estimated relationship between the quantity demanded for food item Y and selected independent variables is shown by this equation:
*(Persamaan di bawah menunjukkan hubungan antara kuantiti barang makanan Y yang diminta dengan pemboleh ubah bebas terpilih.)*

$$Y = 38.5 - 0.16X_1 + 0.02X_2 - 0.05X_3$$

| | | | | |
|---|---|---|---|---|
| Standard error in parenthesis *(Ralat piawai dalam kurungan)* | (11.7) | (0.05) | (3.3) | (0.04) |

$R^2 = 0.88$ F= 38.49 n= 30

Y = Quantity sold or demanded
*(Kuantiti yang dijual atau diminta)*

$X_1$ = Price of Y (in RM)
*(Harga barang Y (RM))*

$X_2$ = Income (in thousands of RM)
*(Pendapatan (ribu RM))*

$X_3$ = Average price of item X (in RM)
*(Harga barang X (RM))*

(a) Compute the quantity demanded for Y when you are given the following values:
*(Hitung jumlah kuantiti Y yang diminta jika anda diberi nilai berikut:)*

$X_1$ = RM 2.00 per pack *(sebungkus)*
$X_2$ = RM 15,000 a year *(setahun)*
$X_3$ = RM 0.80

(3 marks)
*(3 markah)*

(b) Provide interpretation to the $R^2 = 0.88$ (3 marks)
*(Beri tafsiran $R^2 = 0.88$)* *(3 markah)*

(c) Conduct the F test and comment on it. (3 marks)
*(Lakukan ujian F dan beri komen anda.)* *(3 markah)*

(d) Test whether there is enough evidence to infer the existence of linear relationship between quantity of Y sold and: (Use 0.05 level of significance and two tail test)
*(Uji sama ada terdapat bukti menunjukkan wujudnya hubungan linear antara kuantiti Y yang dijual dengan: (Guna paras keertiaan 0.05 dan ujian dua sisi))*

(i) price of Y (2 marks)
*(harga Y)* *(2 markah)*

...10/-

(ii) annual income (2 marks)
*(pendapatan tahunan)* *(2 markah)*

(iii) price of X (2 marks)
*(harga X)* *(2 markah)*

(e) (i) Explain the time series components (8 marks)
*(Jelaskan komponen siri masa)* *(8 markah)*

(ii) One of the simplest ways to reduce random variation is to smooth the time series. Describe the methods available under this techniques.

(7 marks)

*(Salah satu cara yang paling mudah mengurangkan variasi rawak ialah dengan menggunakan teknik smoothing. Huraikan kaedah yang terdapat dibawah teknik ini.)*

*(7 markah)*

**APPENDIX A**

## FORMULAS

Test statistic for μ.

Test statistic $Z = \dfrac{\overline{X}-\mu}{\sigma/\sqrt{n}}$

Test statistic $t = \dfrac{\overline{X}-\mu}{S/\sqrt{n}}$

Sample slope

$$b_1 = \frac{s_{xy}}{s_x^2}$$

Sample $y$-intercept

$$b_0 = \bar{y} - b_1\bar{x}$$

Sum of squares for error

$$\text{SSE} = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

Standard error of estimate

$$s_\varepsilon = \sqrt{\frac{\text{SSE}}{n-2}}$$

Test statistic for the slope

$$t = \frac{b_1 - \beta_1}{s_{b_1}}$$

Standard error of $b_1$

$$s_{b_1} = \frac{s_\varepsilon}{\sqrt{(n-1)s_x^2}}$$

Coefficient of determination

$$R^2 = \frac{s_{xy}^2}{s_x^2 s_y^2} = 1 - \frac{SSE}{\sum(y_i - \bar{y})^2}$$

Prediction interval

$$\hat{y} \pm t_{\alpha/2,n-2}s_\varepsilon\sqrt{1 + \frac{1}{n} + \frac{(x_g - \bar{x})^2}{(n-1)s_x^2}}$$

Confidence interval estimator of the expected value of $y$

$$\hat{y} \pm t_{\alpha/2,n-2}s_\varepsilon\sqrt{\frac{1}{n} + \frac{(x_g - \bar{x})^2}{(n-1)s_x^2}}$$

Sample coefficient of correlation

$$r = \frac{s_{xy}}{s_x s_y}$$

Test statistic for testing $\rho = 0$

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

**Least Squares Line Coefficients**

$$b_1 = \frac{s_{xy}}{s_x^2}$$

$$b_0 = \overline{y} - b_1\overline{x}$$

where

$$s_{xy} = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{n - 1}$$

$$s_x^2 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n - 1}$$

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$\overline{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

FORMULAS

One-way analysis of variance

$$SST = \sum_{j=1}^{k} n_j(\bar{x}_j - \bar{\bar{x}})^2$$

$$SSE = \sum_{j=1}^{k} \sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2$$

$$MST = \frac{SST}{k-1}$$

$$MSE = \frac{SSE}{n-k}$$

$$F = \frac{MST}{MSE}$$

Two-way analysis of variance (randomized block design of experiment)

$$SS(Total) = \sum_{j=1}^{k} \sum_{i=1}^{b} (x_{ij} - \bar{\bar{x}})^2$$

$$SST = \sum_{i=1}^{k} b(\bar{x}[T]_j - \bar{\bar{x}})^2$$

$$SSB = \sum_{i=1}^{b} k(\bar{x}[B]_i - \bar{\bar{x}})^2$$

$$SSE = \sum_{j=1}^{k} \sum_{i=1}^{b} (x_{ij} - \bar{x}[T]_j - \bar{x}[B]_i + \bar{\bar{x}})^2$$

$$MST = \frac{SST}{k-1}$$

$$MSB = \frac{SSB}{b-1}$$

$$MSE = \frac{SSE}{n-k-b+1}$$

$$F = \frac{MST}{MSE}$$

$$F = \frac{MSB}{MSE}$$

Two-factor experiment

$$SS(Total) = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{r} (x_{ijk} - \bar{\bar{x}})^2$$

$$SS(A) = rb \sum_{i=1}^{a} (\bar{x}[A]_i - \bar{\bar{x}})^2$$

$$SS(B) = ra \sum_{j=1}^{b} (\bar{x}[B]_j - \bar{\bar{x}})^2$$

$$SS(AB) = r \sum_{i=1}^{a} \sum_{j=1}^{b} (\bar{x}[AB]_{ij} - \bar{x}[A]_i - \bar{x}[B]_j + \bar{\bar{x}})^2$$

$$SSE = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{r} (x_{ijk} - \bar{x}[AB]_{ij})^2$$

$$MS(A) = \frac{SS(A)}{a-1}$$

$$MS(B) = \frac{SS(B)}{b-1}$$

$$MS(AB) = \frac{SS(AB)}{(a-1)(b-1)}$$

$$F = \frac{MS(A)}{MSE}$$

$$F = \frac{MS(B)}{MSE}$$

$$F = \frac{MS(AB)}{MSE}$$

Least significant difference comparison method

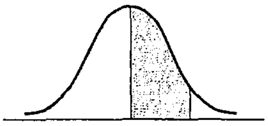
$$LSD = t_{\alpha/2}\sqrt{MSE\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$$

Tukey's multiple comparison method

$$\omega = q_\alpha(k, \nu)\sqrt{\frac{MSE}{n_g}}$$

## APPENDIX B

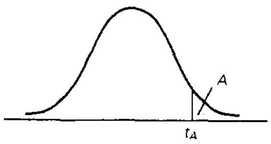
Table 3 Normal Probabilities




| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| 0.7 | .2580 | .2611 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |

SOURCE: Abridged from Table 1 of A. Hald, *Statistical Tables and Formulas* (New York: Wiley & Sons, Inc.), 1952. Reproduced by permission of A. Hald and the publisher, John Wiley & Sons, Inc.

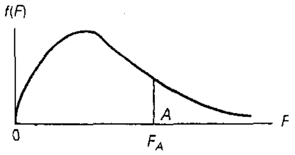
Table 4 Critical Values of $t$




| DEGREES OF FREEDOM | $t_{.100}$ | $t_{.050}$ | $t_{.025}$ | $t_{.010}$ | $t_{.005}$ | DEGREES OF FREEDOM | $t_{.100}$ | $t_{.050}$ | $t_{.025}$ | $t_{.010}$ | $t_{.005}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 2.705 |
| 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 | 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 70 | 1.294 | 1.667 | 1.994 | 2.381 | 2.648 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 80 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 90 | 1.291 | 1.662 | 1.987 | 2.369 | 2.632 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 100 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 120 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 140 | 1.288 | 1.656 | 1.977 | 2.353 | 2.611 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 160 | 1.287 | 1.654 | 1.975 | 2.350 | 2.607 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 180 | 1.286 | 1.653 | 1.973 | 2.347 | 2.603 |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 200 | 1.286 | 1.653 | 1.972 | 2.345 | 2.601 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | ∞ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | | | | | | |

SOURCE: From M. Merrington, "Table of Percentage Points of the $t$-Distribution," *Biometrika* 32 (1941): 300. Reproduced by permission of the Biometrika Trustees.

Table 6(a) Critical Values of $F$: $A = .05$




| $\nu_2$ \ $\nu_1$ | NUMERATOR DEGREES OF FREEDOM 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| DENOMINATOR DEGREES OF FREEDOM 1 | 161.4 | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 |
| 2 | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 |
| 3 | 10.13 | 9.55 | 9.28 | 9.12 | 9.01 | 8.94 | 8.89 | 8.85 | 8.81 |
| 4 | 7.71 | 6.94 | 6.59 | 6.39 | 6.26 | 6.16 | 6.09 | 6.04 | 6.00 |
| 5 | 6.61 | 5.79 | 5.41 | 5.19 | 5.05 | 4.95 | 4.88 | 4.82 | 4.77 |
| 6 | 5.99 | 5.14 | 4.76 | 4.53 | 4.39 | 4.28 | 4.21 | 4.15 | 4.10 |
| 7 | 5.59 | 4.74 | 4.35 | 4.12 | 3.97 | 3.87 | 3.79 | 3.73 | 3.68 |
| 8 | 5.32 | 4.46 | 4.07 | 3.84 | 3.69 | 3.58 | 3.50 | 3.44 | 3.39 |
| 9 | 5.12 | 4.26 | 3.86 | 3.63 | 3.48 | 3.37 | 3.29 | 3.23 | 3.18 |
| 10 | 4.96 | 4.10 | 3.71 | 3.48 | 3.33 | 3.22 | 3.14 | 3.07 | 3.02 |
| 11 | 4.84 | 3.98 | 3.59 | 3.36 | 3.20 | 3.09 | 3.01 | 2.95 | 2.90 |
| 12 | 4.75 | 3.89 | 3.49 | 3.26 | 3.11 | 3.00 | 2.91 | 2.85 | 2.80 |
| 13 | 4.67 | 3.81 | 3.41 | 3.18 | 3.03 | 2.92 | 2.83 | 2.77 | 2.71 |
| 14 | 4.60 | 3.74 | 3.34 | 3.11 | 2.96 | 2.85 | 2.76 | 2.70 | 2.65 |
| 15 | 4.54 | 3.68 | 3.29 | 3.06 | 2.90 | 2.79 | 2.71 | 2.64 | 2.59 |
| 16 | 4.49 | 3.63 | 3.24 | 3.01 | 2.85 | 2.74 | 2.66 | 2.59 | 2.54 |
| 17 | 4.45 | 3.59 | 3.20 | 2.96 | 2.81 | 2.70 | 2.61 | 2.55 | 2.49 |
| 18 | 4.41 | 3.55 | 3.16 | 2.93 | 2.77 | 2.66 | 2.58 | 2.51 | 2.46 |
| 19 | 4.38 | 3.52 | 3.13 | 2.90 | 2.74 | 2.63 | 2.54 | 2.48 | 2.42 |
| 20 | 4.35 | 3.49 | 3.10 | 2.87 | 2.71 | 2.60 | 2.51 | 2.45 | 2.39 |
| 21 | 4.32 | 3.47 | 3.07 | 2.84 | 2.68 | 2.57 | 2.49 | 2.42 | 2.37 |
| 22 | 4.30 | 3.44 | 3.05 | 2.82 | 2.66 | 2.55 | 2.46 | 2.40 | 2.34 |
| 23 | 4.28 | 3.42 | 3.03 | 2.80 | 2.64 | 2.53 | 2.44 | 2.37 | 2.32 |
| 24 | 4.26 | 3.40 | 3.01 | 2.78 | 2.62 | 2.51 | 2.42 | 2.36 | 2.30 |
| 25 | 4.24 | 3.39 | 2.99 | 2.76 | 2.60 | 2.49 | 2.40 | 2.34 | 2.28 |
| 26 | 4.23 | 3.37 | 2.98 | 2.74 | 2.59 | 2.47 | 2.39 | 2.32 | 2.27 |
| 27 | 4.21 | 3.35 | 2.96 | 2.73 | 2.57 | 2.46 | 2.37 | 2.31 | 2.25 |
| 28 | 4.20 | 3.34 | 2.95 | 2.71 | 2.56 | 2.45 | 2.36 | 2.29 | 2.24 |
| 29 | 4.18 | 3.33 | 2.93 | 2.70 | 2.55 | 2.43 | 2.35 | 2.28 | 2.22 |
| 30 | 4.17 | 3.32 | 2.92 | 2.69 | 2.53 | 2.42 | 2.33 | 2.27 | 2.21 |
| 40 | 4.08 | 3.23 | 2.84 | 2.61 | 2.45 | 2.34 | 2.25 | 2.18 | 2.12 |
| 60 | 4.00 | 3.15 | 2.76 | 2.53 | 2.37 | 2.25 | 2.17 | 2.10 | 2.04 |
| 120 | 3.92 | 3.07 | 2.68 | 2.45 | 2.29 | 2.17 | 2.09 | 2.02 | 1.96 |
| $\infty$ | 3.84 | 3.00 | 2.60 | 2.37 | 2.21 | 2.10 | 2.01 | 1.94 | 1.88 |

SOURCE: From M. Merrington and C. M. Thompson, "Tables of Percentage Points of the Inverted Beta ($F$)-Distribution," *Biometrika* 33 (1943): 73–88. Reproduced by permission of the Biometrika Trustees.

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