Continuous Assessment in Applied Econometrics – 2 hours

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Mock exam 2

Answer the questions in order. All answers must be justified. Calculators are allowed. Throughout, log denotes the natural logarithm. Critical values are read from the tables at the end of the paper. When the number of degrees of freedom is not printed, use the closest lower row, and use the row ∞ above 120. The marking scheme is indicative.

Referee report: "Does childcare free up mothers' time?" ***(20 points)***

An applied economics journal asks you to referee a working paper. Its authors study $N = 2{,}400$ mothers living in France with at least one child under 3. For each mother i, they observe h_i, her weekly hours of work (0 if not employed), x_{1i}, the number of childcare places per 100 children under 3 in her municipality, x_{2i}, equal to 1 if she has at least two children, x_{3i}, her years of education, x_{4i}, her partner's monthly income (in thousands of euros), and x_{5i}, the household's other monthly non-labour income (benefits, capital income, in thousands of euros). They set $x_{6i} = x_{1i}x_{2i}$. Column (3) of Table 2 estimates

$$h_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{5i} + \beta_6 x_{6i} + u_i$$

column (2) omits x_6, and column (4) is presented by the authors as "the income-pooling model".

The abstract of the working paper makes four claims.

(i) "Ten additional places per 100 children raise mothers' labour supply by 1.37 hours per week, an effect significant at the 1% level ($t = 13.4$, column (2))."

(ii) "This effect is halved for mothers of two or more children (column (3))."

(iii) "Household income is pooled: equality of the effects of the partner's income and of other income is not rejected ($\hat\beta_4 - \hat\beta_5 = -0.830$, standard error 0.463, $t = -1.79$), which justifies column (4)."

(iv) "Income pooling also holds in Île-de-France (Appendix Table A2, same regressors as column (2)): $\hat\beta_4 - \hat\beta_5 = -1.741$ (standard error 0.594, computed this time with the covariance)." The number of observations of Table A2 is not reported.

Part A – Auditing the table ***(4 points)***

A1. Check the two numbers in claim (i) and the significance level it states.

A2. The authors write that column (4) "fits almost as well as column (2)". Is the ordering of the R^2s of columns (2) and (4) consistent with what the algebra of OLS imposes? Justify.

A3. In a first version of the paper, column (2) also contained a dummy equal to 1 for mothers of exactly one child, together with the constant. The software then dropped one of the variables. Explain why, justifying your answer with $X'X$, and state how the coefficient on "Two or more children" in column (2) must be read.

A4. One of the covariances in the note to the table is impossible. Identify it, justifying your answer with a property of the estimated variance matrix $\hat\sigma^2(X'X)^{-1}$, and suggest a plausible explanation for the error.

Part B – Assessing the results ***(5 points)***

Working paper, Table 2 – Childcare places and mothers' hours of work

Dependent variable	(1) h	(2) h	(3) h	(4) h
Childcare places (per 100 children)	0.1394	0.1366	0.1743	0.1367
	(0.0115)	(0.0102)	(0.0137)	(0.0102)
Two or more children		−7.611	−4.122	−7.440
		(0.377)	(0.932)	(0.371)
Education (years)		1.116	1.118	1.093
		(0.084)	(0.084)	(0.084)
Partner's income (k€/month)		−1.255	−1.261	
		(0.192)	(0.191)	
Other income (k€/month)		−0.425	−0.421	
		(0.421)	(0.419)	
Places × two or more children			−0.0837	
			(0.0205)	
Sum $x_4 + x_5$				−1.354
				(0.188)
Constant	16.54	8.83	7.24	9.88
	(0.52)	(1.34)	(1.39)	(1.27)
N	2,400	2,400	2,400	2,400
R^2	0.0580	0.2558	0.2610	0.2539
$\hat{\sigma}$	10.135	9.016	8.986	9.025
F (overall significance)	147.7	164.6	140.8	203.8

Notes: standard errors in parentheses. OLS. Dependent variable: weekly hours worked (0 if not employed). Estimated covariances: column (2), $\widehat{\mathrm{Cov}}(\hat{\beta}_1, \hat{\beta}_3) = 0.0021$ and $\widehat{\mathrm{Cov}}(\hat{\beta}_4, \hat{\beta}_5) = 0.0502$; column (3), $\widehat{\mathrm{Cov}}(\hat{\beta}_1, \hat{\beta}_6) = -1.881 \times 10^{-4}$.

B1. Using column (3), compute the effect of ten additional places per 100 children on the hours worked by a mother of one child, then by a mother of two or more children. Interpret both numbers.

B2. Interpret $\hat{\beta}_4$ in column (2).

B3. Using the R^2s, test at the 5% level the joint significance of the four regressors added between columns (1) and (2). Then compare the coefficient on places in these two columns and state in two lines what its stability suggests.

B4. The authors use the usual OLS standard errors. Yet the variance of hours worked is much larger among mothers of two or more children. State, in three lines at most, which claims in the abstract become fragile and why.

Part C – Income pooling *(5 points)*

C1. Translate the income-pooling hypothesis of claim (iii) into a null hypothesis on the parameters of column (2). State in one sentence why a household maximising a single utility function under a single budget constraint satisfies it.

C2. Recover the standard error published in claim (iii) from the table and identify the authors' mistake. Redo the test at the 5% level against a two-sided alternative and give the 95% confidence interval for $\beta_4 - \beta_5$.

C3. Explain how column (4) imposes the hypothesis of C1. Compute the F statistic for this hypothesis from columns (2) and (4), and show that it settles the disagreement between your calculation in C2 and the authors' one.

C4. Does the conclusion of the 5% test of $\beta_4 = \beta_5$ on Table A2 depend on its unknown number of observations? Find the smallest number of observations for which the hypothesis is rejected, and conclude on claim (iv).

Part D – What the referee asks for ***(6 points)***

D1. In a first round, another referee asked the authors to add z_i, the commuting time (in minutes), to the regressors of column (2). The authors did not publish the new column, but they report having regressed x_1 on a constant, x_2, x_3, x_4, x_5 and z, and obtained residuals $\hat{r}_i$ such that

$$\sum_{i=1}^{N} \hat{r}_i \, h_i = 113{,}478.5 \qquad \text{and} \qquad \sum_{i=1}^{N} \hat{r}_i^2 = 680{,}920$$

Compute the coefficient on places in the regression augmented with z. Interpret it for ten additional places.

D2. In this augmented regression, the coefficient on z is -0.141 (standard error 0.018). Deduce the coefficient of x_1 in the regression of z on a constant, x_1, x_2, x_3, x_4 and x_5. Interpret its sign and state the direction and size of the bias of the coefficient on places in column (2).

D3. Let ρ denote the ratio of the effect of places for a mother of two or more children to the effect for a mother of one child (column (3)). Estimate ρ, compute its standard error by the delta method and a 95% confidence interval based on the normal approximation. Is claim (ii) supported by the data? Is the hypothesis of an identical effect for all mothers?

D4. Write, in three lines at most, your recommendation to the editor (accept, major revision or reject), citing the two corrections you consider most urgent.

TABLE G.2 Critical Values of the *t* Distribution

		Significance Level				
1-Tailed:		.10	.05	.025	.01	.005
2-Tailed:		.20	.10	.05	.02	.01
Degrees of Freedom	1	3.078	6.314	12.706	31.821	63.657
	2	1.886	2.920	4.303	6.965	9.925
	3	1.638	2.353	3.182	4.541	5.841
	4	1.533	2.132	2.776	3.747	4.604
	5	1.476	2.015	2.571	3.365	4.032
	6	1.440	1.943	2.447	3.143	3.707
	7	1.415	1.895	2.365	2.998	3.499
	8	1.397	1.860	2.306	2.896	3.355
	9	1.383	1.833	2.262	2.821	3.250
	10	1.372	1.812	2.228	2.764	3.169
	11	1.363	1.796	2.201	2.718	3.106
	12	1.356	1.782	2.179	2.681	3.055
	13	1.350	1.771	2.160	2.650	3.012
	14	1.345	1.761	2.145	2.624	2.977
	15	1.341	1.753	2.131	2.602	2.947
	16	1.337	1.746	2.120	2.583	2.921
	17	1.333	1.740	2.110	2.567	2.898
	18	1.330	1.734	2.101	2.552	2.878
	19	1.328	1.729	2.093	2.539	2.861
	20	1.325	1.725	2.086	2.528	2.845
	21	1.323	1.721	2.080	2.518	2.831
	22	1.321	1.717	2.074	2.508	2.819
	23	1.319	1.714	2.069	2.500	2.807
	24	1.318	1.711	2.064	2.492	2.797
	25	1.316	1.708	2.060	2.485	2.787
	26	1.315	1.706	2.056	2.479	2.779
	27	1.314	1.703	2.052	2.473	2.771
	28	1.313	1.701	2.048	2.467	2.763
	29	1.311	1.699	2.045	2.462	2.756
	30	1.310	1.697	2.042	2.457	2.750
	40	1.303	1.684	2.021	2.423	2.704
	60	1.296	1.671	2.000	2.390	2.660
	90	1.291	1.662	1.987	2.368	2.632
	120	1.289	1.658	1.980	2.358	2.617
	∞	1.282	1.645	1.960	2.326	2.576

Examples: The 1% critical value for a one-tailed test with 25 *df* is 2.485. The 5% critical value for a two-tailed test with large (> 120) *df* is 1.96.

Source: This table was generated using the Stata® function invttail.

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TABLE G.3a 10% Critical Values of the *F* Distribution

		Numerator Degrees of Freedom									
		1	2	3	4	5	6	7	8	9	10
Denominator Degrees of Freedom	10	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32
	11	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25
	12	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19
	13	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14
	14	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10
	15	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06
	16	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	2.06	2.03
	17	3.03	2.64	2.44	2.31	2.22	2.15	2.10	2.06	2.03	2.00
	18	3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04	2.00	1.98
	19	2.99	2.61	2.40	2.27	2.18	2.11	2.06	2.02	1.98	1.96
	20	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94
	21	2.96	2.57	2.36	2.23	2.14	2.08	2.02	1.98	1.95	1.92
	22	2.95	2.56	2.35	2.22	2.13	2.06	2.01	1.97	1.93	1.90
	23	2.94	2.55	2.34	2.21	2.11	2.05	1.99	1.95	1.92	1.89
	24	2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94	1.91	1.88
	25	2.92	2.53	2.32	2.18	2.09	2.02	1.97	1.93	1.89	1.87
	26	2.91	2.52	2.31	2.17	2.08	2.01	1.96	1.92	1.88	1.86
	27	2.90	2.51	2.30	2.17	2.07	2.00	1.95	1.91	1.87	1.85
	28	2.89	2.50	2.29	2.16	2.06	2.00	1.94	1.90	1.87	1.84
	29	2.89	2.50	2.28	2.15	2.06	1.99	1.93	1.89	1.86	1.83
	30	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.88	1.85	1.82
	40	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.79	1.76
	60	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74	1.71
	90	2.76	2.36	2.15	2.01	1.91	1.84	1.78	1.74	1.70	1.67
	120	2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.68	1.65
	∞	2.71	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.63	1.60

Example: The 10% critical value for numerator $df = 2$ and denominator $df = 40$ is 2.44.
Source: This table was generated using the Stata® function invFtail.

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TABLE G.3b 5% Critical Values of the *F* Distribution

		Numerator Degrees of Freedom									
		1	2	3	4	5	6	7	8	9	10
Denominator Degrees of Freedom	10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98
	11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85
	12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75
	13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67
	14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60
	15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54
	16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
	17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45
	18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
	19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38
	20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35
	21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32
	22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30
	23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27
	24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25
	25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24
	26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
	27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20
	28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
	29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
	30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16
	40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
	60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99
	90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94
	120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91
	∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83

Example: The 5% critical value for numerator $df = 4$ and large denominator $df(\infty)$ is 2.37.

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TABLE G.3c 1% Critical Values of the *F* Distribution

Denominator Degrees of Freedom	Numerator Degrees of Freedom: 1	2	3	4	5	6	7	8	9	10
10	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85
11	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54
12	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30
13	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10
14	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68	3.59
18	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60	3.51
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52	3.43
20	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37
21	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40	3.31
22	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17
25	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22	3.13
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18	3.09
27	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15	3.06
28	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12	3.03
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09	3.00
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63
90	6.93	4.85	4.01	3.54	3.23	3.01	2.84	2.72	2.61	2.52
120	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56	2.47
∞	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32

Example: The 1% critical value for numerator $df = 3$ and denominator $df = 60$ is 4.13.

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