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Examination paper for SØK3001 – Econometrics I

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1 Exercise 1 (40 points)

Standard economic theory predicts that the demand for children is influenced by the cost of raising children. Holding other things constant, a decrease in the cost of raising children should lead to an increase in the demand for children. Whittington, Alm, and Peters (1990) provide evidence for this relationship, exploiting the fact that between 1913 and 1984 the value of child tax benefits in the U.S. increased substantially relative to estimates of the cost of raising children. Whittington, Alm, and Peters (1990) claim a large positive effect of child tax benefits on fertility using time series methods. Their key conclusion is based on the following equation, estimated for the period 1913 to 1984:

$$\begin{aligned}\text{Fertility Rate}_t = &\beta_0 + \beta_1 \text{Personal Exemption}_t + \beta_2 \text{Male and Asset Income}_t + \\ &+ \beta_3 \text{Unemployment}_t + \beta_4 \text{Infant Mortality}_t + \beta_5 \text{Immigration}_t + \\ &+ \beta_6 \text{Female Wage}_t + \beta_6 \text{Pill}_t + \beta_8 \text{WW2}_t + \beta_9 \text{Time Trend}_t + u_t.\end{aligned} \tag{1}$$

Here Fertility Rate$_t$ measures the number of children born per 1,000 women; Personal Exemption$_t$ is the dollar value of the personal tax exemption, that is, the dollar amount that a resident taxpayer is entitled to claim as a tax deduction in the presence of dependent children; Male and Asset Income$_t$ is the dollar value of personal income per family, net of female earnings; Unemployment$_t$ measures the share of people who are unemployed; Infant Mortality$_t$ measures the number of children who die per 1,000 live births; Immigration$_t$ measures the share of people who are foreign born; Female Wage$_t$ is the dollar value of after-tax female wage; Pill$_t$ is a dummy variable that equals one in years 1963-1984, when birth control became widely available; WW2$_t$ is a dummy variable that equals one in years during which the US was in World War II and Time Trend$_t$ is a time trend equal to one in 1913 and increasing by one unit each year.

In this exercise you are asked to revisit this question, discussing and interpreting the findings in Whittington, Alm, and Peters (1990) and the critique provided in Goda and Mumford (2010). All relevant results are reported in Table 1, on page 3.

(a) Interpret the regression results reported in column (1).

(b) Column (1) reports results of a simplified version of column (2). Assuming that the error is homoskedastic, explain the restrictions that are imposed in column (1) compared to column (2). Explain the consequences on the model in column (1) if these restrictions are violated. Finally, explain how you could test these restrictions.

(c) Compare and contrast the estimators used in column (1) and column (2). You can still assume homoskedasticity in the error term.

(d) Whittington et al. (1990) also estimate a model in which they include a new variable, which they call *Triangular Personal Exemption*, constructed in the following way:

$$\text{Triangular Personal Exemption}_t = \frac{1}{3}\Big(\text{Personal Exemption}_t + \text{Personal Exemption}_{t-1} + \\ + \text{Personal Exemption}_{t-2}\Big)$$

Does this variable capture the long run impact of personal exemptions on fertility? Why could it be of interest to include Triangular Personal Exemption$_t$ in the model?

(e) Zhang et al. (1994) mention that there is a concern that some series in the Whittington et al. (1990)'s study may be non-stationary. However, Zhang et al. dismiss this criticism claiming that because "the time trend is insignificant" in their estimation, there is no concern that the results are being driven by a regression of "time against time". Using results in column (3), show that the time trend is insignificant and then discuss whether you agree or disagree with this statement. Discuss this issue also comparing results with those presented in column (4).

(f) Goda and Mumford (2010) examine additional features of the tax code that provide tax subsidies to families with children. Rather than focusing only on the personal tax exemption, they construct a new variable, *total child tax subsidy*, that is the sum of personal exemption and additional child tax benefits, namely child tax benefits from the earned income tax credit, the child and dependent care tax credit, and the child tax credit Their results are reported in column (5) of Table 1. Discuss why results might differ between column (4) and (5).

(g) Conclude this exercise by summarizing the results in Table 1 and drawing conclusions on the relationship between tax incentives and fertility. In writing your conclusions, pay particular attention to discussing the statistical and economic significance of the relationship between child benefits and tax benefits across models. What is your preferred model among those presented? Could one further improve on your preferred model?

Table 1: Child Tax Benefits and Fertility

	OLS	FGLS	FGLS	First Difference	First Difference
	(1)	(2)	(3)	(4)	(5)
Personal Exemption	0.178	0.121	-	-0.084	-
	(0.0977)	(0.0446)	-	(0.042)	-
Triangular P. Exepmtion	-	-	0.191	-	-
	-	-	(0.0477)	-	-
Total Child Tax Subsidy	-	-	-	-	-0.007
	-	-	-	-	(0.006)
Male and Asset Income	0.0035	-0.0004	-0.0004	-0.003	-0.001
	(0.0031)	(0.0027)	(0.0027)	(0.002)	(0.000)
Unemployment	-68.12	-73.43	-36.800	-20.985	-8.957
	(25.818)	(34.20)	(39.60)	(31.280)	(27.301)
Infant Mortality	0.393	0.083	0.303	-0.042	-0.054
	(0.321)	(0.255)	(0.3817)	(0.315)	(0.274)
Immigration	964.13	774.24	1529.2	68.878	194.315
	(329.44)	(311.31)	(480.44)	(119.073)	(138.742)
Female Wage	15.427	5.647	-2.157	7.472	1.924
	(5.286)	(15.686)	(14.098)	(5.792)	(1.196)
Pill	-25.383	-10.856	-8.958	-1.91	-0.44
	(11.961)	(6.126)	(5.522)	(1.020)	(0.841)
WW II	-29.419	-17.223	-5.353	5.138	3.468
	(8.057)	(4.989)	(3.947)	(3.377)	(2.572)
Time Trend	-0.843	-0.539	-0.377		
	(0.543)	(0.538)	(4.71)		
Intercept	55.944	102.979	81.628	-0.618	-1.174
	(25.831)	(24.666)	(32.251)	(0.954)	(0.943)
R^2	0.829	0.916	0.941	0.203	0.103
N	72	71	68	71	71

In all columns, the dependent variable is the fertility rate at time t, which measures the number of children born per 1,000 women. *Personal Exemption* is the dollar value of the personal tax exemption, that is the dollar amount that a resident taxpayer is entitled to claim as a tax deduction if one has dependent children; *Triangular P. Exemption* is the triangular personal exemption, as defined in the text; *Male and Asset Income* is the dollar value of personal income per family net of female earnings; *Unemployment* measures the share of people who are unemployed; *Infant Mortality* measures the number of children who die per 1,000 live births; *Immigration* measures the share of people who are foreign born; *Female Wage* is the dollar value of after tax female wage; *Pill* is a dummy variable that equals one in years 1963-1984; *WW2* is a dummy variable that equals one in years during which the US was in World War II and *Time Trend* is a time trend equal to one in 1913 and increasing by one unit each year.

2 Exercise 2 (40 points)

Classical criminology assumes that criminals are rational beings who weigh the costs and benefits of their actions. Gary Becker (1968) produced the first fully fledged theory of crime based on rational behavior. His research led to an upsurge of interest in the economics of criminal behavior. One of the central predictions of Becker's theory is that crime will decrease when police presence increases. A basic problem with this prediction is that it largely failed to find empirical support during the 1970s and 1980s. In a survey of the literature, Samuel Cameron (1988) reports that in 18 out of 22 papers surveyed researchers found either a positive effect of police presence on crime or no relationship between these variables.

Most of these studies estimated models in which the number of violent crimes in city c at time t were regressed on the number of policemen per capita in city c at time t.

In this exercise you are asked to revisit this question, discussing and interpreting the findings in Levitt (1997). The sample includes 122 cities observed between 1975 and 1995. Levitt revisits previous evidence and estimates several versions of the following model:

$$\begin{aligned}\log(\text{Violent Crime})_{ct} =& \beta_0 + \beta_1 \log(\text{Police per Capita})_{ct} + \\ &+ \beta_2 \log(\text{State prisoners per capita})_{ct} + \beta_3 \text{Unemployment rate}_{ct} + \\ &+ \beta_4 \text{State income per capita}_{ct} + \\ &+ \beta_5 \text{Effective abortion rate}_{ct} + \beta_6 \log(\text{City population})_{ct} + \\ &+ \beta_7 \text{Percentage black}_{ct} + u_{ct}.\end{aligned} \tag{2}$$

Here $\log(\text{Violent Crime})_{ct}$ is the log of per capita violent crime in city c at time t, $\log(\text{Police per Capita})_{ct}$ and $\log(\text{State prisoners per capita})_{ct}$ are the log of police per capita and of the number of prisoners in the State in city c at time t, respectively; $\text{Unemployment rate}_{ct}$ measures the shares of unemployed in the population in city c at time t; $\text{State income per capita}_{ct}$ measures State income per capita in 10,000 dollars; the effective abortion rate (in 100) is the weighted average of the abortion rate of crime-aged individuals; $\log(\text{City population})_{ct}$ is the log of the population in city c at time t and $\text{Percentage black}_{ct}$ is the percentage of African American individuas in city c at time t. All relevant results are reported in Table 2, on page 5.

(a) Consider first the model in column (1) of Table 2. Discuss under which conditions this model pins down the causal impact of police on crime and discuss whether these conditions are likely to hold in this context.

(b) Test whether permanent differences in crime rates across cities are important in explaining violent crimes. Explain whether a model that includes such differences is sufficient to identify the causal effect of police on crime.

(c) Define the problem of weak instruments and discuss whether you think that the model exhibits a weak instrument problem.

Table 2: The Impact of Police on Crime

	OLS	OLS	OLS	IV
	log(V. Crime)	log(V. Crime)	log(Police p.c.)	log(V. Crime)
	(1)	(2)	(4)	(3)
log(Firefighters per capita)	-	-	0.206	-
	-	-	(0.050)	-
log(Police per capita)	0.562	-0.076	-	-0.435
	(0.056)	(0.061)	-	(0.231)
log(State prisoners per capita)	0.25	-0.131	-0.077	-0.171
	(0.039)	(0.036)	(0.022)	(0.044)
Unemployment rate	3.573	-0.741	0.265	-0.48
	(0.473)	(0.365)	(0.314)	(0.404)
State income per capita	0.05	-0.003	0.211	0.003
(x10,000)	(0.005)	(0.006)	(0.005)	(0.007)
Effective abortion rate	-0.214	-0.15	0.045	-0.141
(x100)	(0.045)	(0.023)	(0.026)	(0.025)
log(City population)	0.072	0.203	-0.014	0.178
	(0.012)	(0.063)	(0.047)	(0.067)
Percentage black	0.627	0.233	0.493	0.398
	(0.074)	(0.334)	(0.264)	(0.345)
City dummies and year dummies?	Only year	yes	yes	yes
R^2	0.601	0.93	0.962	-
N	2005	2005	2005	2005

The dependent variables are reported in the first row on top of each column, with *log(V. Crime)* being the log of per capita violent crime in city c at time t and *log(Police p.c.)* being the log of police per capita in city c at time t. *log(Firefighters per capita)* is the log of the number of firefighters per capita; *log(State prisoners per capita)* is the number of prisoners in the State in city c at time t, respectively; *Unemployment rate* measures the shares of unemployed in the population in city c at time t; *State income per capita* measures State income per capita in 10,000 dollars; the effective abortion rate (in 100) is the weighted average of the abortion rate of crime-aged individuals; *log(City population per capita)* is the log of the population in city c at time t and *Percentage Blacks* is the percentage of African American individuas in city c at time t.

3 Exercise 3 (20 points)

Throughout the course we have analyzed linear models of the form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + u.$$

Albeit linear relationships are very powerful, not all economic models are linear.

Hence, consider now a non-linear specification in which y is a generic, known, non-linear function $f(\cdot)$ of characteristics and parameters:

$$y = f(x_1, \ldots, x_k; \beta_0, \beta_1, \ldots, \beta_k) + u.$$

Data are assumed to be i.i.d, $E(u|x_1, \ldots, x_k) = 0$ and $V(u|x_1, \ldots, x_k) = \sigma^2$.

(a) Define a method that you could use to estimate the vector of parameters $\beta_1, \ldots, \beta_k$. Note: you do not have do derive these parameters, only to describe a method for doing it.

(b) Let $\hat{\beta}_0, \ldots, \hat{\beta}_k$ indicate the estimator resulting from part (a). Describe which statistical properties you would like this estimator to exhibit. Note that, as before, you are not required to make derivations.

(c) Explain how you would check *empirically* that the estimator you have proposed at point (a) satisfies the properties that you have discussed at point (b).