Instrumental Variables and “Natural” Experiments

Female Labor Supply and Fertility

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Angrist and Evans (1)

We continue with the analysis of causal effects using "natural experiments" as instrumental variables and touch on a different area of research in labour economics.

The example comes from the paper by **Angrist and Evans** (1998) *American Economic Review*.

- The objective of this paper to explain why we have observed a **steep increase in labour force participation** of married (and cohabiting) women,
- while **fertility rates** have been steadily **decreasing over time** in many industrialised countries.

Angrist and Evans (2)

- One problem in attacking this research question is that both fertility and labour supply decisions are simultaneously chosen (one causes the other and vice versa, or they are **endogenous**)
- Therefore, the IV techniques may be useful
- Angrist and Evans (AE from now on) show that the **sex ratio** of the **first two children** affects subsequent fertility decisions [see AE Table 3]
- They find that the additional **third** child **reduces** female labour force participation [see AE Table 5, where there are Wald estimates].

Angrist and Evans (3)

Questions we will try to answer in this lecture are:

- Does the sex of the first two children (a **"natural" exogenous event**) turn out to be a valid instrument for the effect of children on mother's labour supply?
- Is it always a **good** instrument?
- Under what circumstances/**conditions** is this true? What are the **restrictions** that we need to defend it as a good instrument?

Angrist and Evans (4)

Three points before turning to the model:

- The (general) **assumption** that is needed for identification is that the **natural event** (i.e., the **same sex in the first two births**) does **not** affect **subsequent labour supply** of either parent, except through its effect on having an additional birth.
- But are there **other specific assumptions** about behaviour/technology that yield this restriction? What does the **Wald estimate** reveal about behaviour/technology?
- AE do **not** present a **behavioural model** within which to interpret their estimates. But we begin with a simple model which will help us interpret the relationship we are interested in estimating.

Angrist and Evans (5)

A Simple Model of Fertility and Labour Supply

Suppose, at any point in time, a women decides on **whether or not to have a child**, $n = \{0, 1\}$, and **whether or not to work**, $h = \{0, 1\}$, up to a period in which she can have no more children, but only works or does not.

A woman's **utility** in each period t depends on:

- c_t: woman's consumption
- $1 - h_t$: her leisure
- N_{t-1}: stock of children at beginning of the period
- $N_{t-2}, ..., N_1$: stock of children at beginning of all prior periods
- r the sex consumption of her children (i.e., fraction of female children)

Angrist and Evans (6)

Let us assume:

- If the woman **works**, she receives a wage w in each period she works
- She has an **exogenous income** (e.g., her husband's income) each period, which is denoted by Y_t.
- Let e be the **per-child rearing cost**, which depends on r and the spacing between births (difference in age between consecutive children) .

To make things easier we only consider the **last-period** labour supply decision.

Angrist and Evans (7)

We also assume:

- a **quadratic utility** function;
- a **bliss-point sex ratio** of 0.5 (parents prefer to have mixed-sex children); and
- child-rearing cost is **minimised when all children are at the same sex** , i.e. $r = 0$ or $r = 1$ (*economies of scale*).

A minimum of **four periods** is needed to capture the possibility of different sex ratios (remember we need three births, plus one extra period in which the mother does not have children anymore but only makes labour market decisions).

Angrist and Evans (8)

In period 4, the woman chooses h_4 to maximise the following utility function:

$$\begin{aligned} U_4 &= c_4 + \alpha_1 N_3 - \alpha_2 N_3^2 - \alpha_3 (r_3 - 0.5)^2 + \alpha_4 (1 - h_4) \\ &\quad + \alpha_5 c_4 N_3 + \alpha_6 c_4 (1 - h_4) + \alpha_7 N_3 (1 - h_4) \qquad (1) \\ &\quad + \alpha_{71} N_1 (1 - h_4) + \alpha_{72} N_2 (1 - h_4) + \alpha_8 (1 - h_4)(r_3 - 0.5)^2 \end{aligned}$$

subject to the following budget constraint (notice **no** saving, for simplicity):

$$c_4 = Y + wh_4 - e_1 N_3 - e_{11} N_1 - e_{12} N_2 - e_2 (r_3 - 0.5)^2. \qquad (2)$$

Angrist and Evans (9)

In period 4, the woman makes her decision by **comparing** the utility she gets **if she works** and the utility she gets **if she does not** .

Note:

- We are building up all the terms that will be needed to compute the **Wald estimator**, which in this context looks like:

  $$\frac{\Delta U}{\Delta N}$$

  (See also the notes earlier lecture)
- Before doing this we want to check whether we have a **valid instrument**

Angrist and Evans (10)

Suppose the woman has **two (non-twin) children** of the same sex by the end of the period 3.

The utility difference of working and not working, ΔU, is [after substituting (2) into (1)]:

$$
\begin{aligned}
& U_4[h_4=1, N_3=N_2=2, N_1=1, r3=\{0,1\}] \\
& \quad - U_4[h_4=0, N_3=N_2=2, N_1=1, r3=\{0,1\}] \\
& = w(1+2\alpha_5) - \alpha_4 - \alpha_6[Y - 2e_1 - 2e_{12} - e_{11} - 0.25e_2] \\
& \quad -2\alpha_{72} - \alpha_{71} - 0.25\alpha_8 \qquad (3)
\end{aligned}
$$

Angrist and Evans (11)

Notice: If some parameters in (3) are stochastic, we can use (3) to construct probability statements, so that the probability that a woman with a given wage and two children of the same sex work is the probability that (3) is positive.

Suppose now that $r_3 = 0.5$, i.e. by the beginning of period 4 the woman has **two children** of opposite sex. Then, the utility difference ΔU is given by:

$$
\begin{aligned}
& U_4[h_4 = 1, N_3 = N_2 = 2, N_1 = 1, r3 = 0.5] \\
& \quad - U_4[h_4 = 0, N_3 = N_2 = 2, N_1 = 1, r3 = 0.5] \\
& = w(1 + 2\alpha_5) - \alpha_4 - \alpha_6[Y - 2e_1 - 2e_{12} - e_{11}] \\
& \quad -2\alpha_7 - \alpha_{71} - 2\alpha_{72} \qquad (4)
\end{aligned}
$$

Angrist and Evans (12)

The difference of the expressions in (4) and (3) will give us the extent to which the change in utility from working is affected by having two children of the same sex as opposed to two children of different sexes (holding parity constant, and equal to 2).

Let ΔU_4 be the difference between $U_4(h_4 = 1, \cdot; r = 0.5) -$ $U_4(h_4 = 0, \cdot; r = 0.5)$ (as given in (4)) <u>and</u> $U_4(h_4 = 1, \cdot; r3 = \{0, 1\}) -$ $U_4(h_4 = 0, \cdot; r3 = \{0, 1\})$ (as given in (3)), and let

$$\Delta r_3^* = \Delta\big(\mid r_3 - 0.5 \mid \big)$$

denote the absolute deviation from period-3 sex ratio from 0.5.

Angrist and Evans (13)

Then, after subtracting (3) from (4) and noting that r_3^* is a constant, we get:

$$\frac{\Delta U_4}{\Delta r_3^*} |_{N_3=N_2=2,N_1=1} = -0.25\alpha_6 e_2 - 2\alpha_7 + 0.25\alpha_8 \tag{5}$$

Instrument validity requires (5) to be zero.

Therefore, deviation from sex-sameness affects the mother's labour supply decision as long as:

- (i) deviation from sex-sameness affects the **marginal utility of leisure** ($\alpha_8 \neq 0$); or
- (ii) changes in sex-sameness affect the **cost of child rearing** ($e_2 \neq 0$) and consumption and leisure are **not separable** ($\alpha_6 \neq 0$)
- (iii) variation in sex-sameness is associated with differences in the way the **marginal utility of leisure** varies with the **number of children** ($\alpha_7 \neq 0$)

Angrist and Evans (14)

Therefore, AE need to assume that:

1. **child sex composition** and **leisure** are **strongly separable** ($\alpha_8 = 0$); and
2. *either* **sex-sameness does not affect child costs** ($e_2 = 0$) *or* **consumption and leisure are separable** ($\alpha_6 = 0$); and
3. **leisure** and **family size** are **not separable** ($\alpha_7 = 0$).

in order to justify their (implicit) restriction that sex-sameness of children does *not* affect labour supply decision of the mother directly.

Angrist and Evans (15)

We can now assess the impact of having an additional child (keeping sex-sameness constant) on mother's labour supply by computing the Wald estimator.

Let:

$$U_4[h_4 = 1, N_3 = 3, N_2 = 2, N_1 = 1, r3 = \{0,1\}]$$
$$- U_4[h_4 = 0, N_3 = 3, N_2 = 2, N_1 = 1, r3 = \{0,1\}] \equiv \Delta_1$$

and

$$U_4[h_4 = 1, N_3 = N_2 = 2, N_1 = 1, r3 = \{0,1\}]$$
$$- U_4[h_4 = 0, N_3 = N_2 = 2, N_1 = 1, r3 = \{0,1\}] \equiv \Delta_2$$

Angrist and Evans (16)

Define $\Delta\widetilde{U_4} = \Delta_1 - \Delta_2$, which is the numerator of the Wald estimator, while the denominator is equal to 1 (as we move from 2 to 3 children). It turns out that (check this result as an exercise):

$$\frac{\Delta\widetilde{U_4}}{\Delta N_3} |_{N_2=2, N_1=1, r_3=\{0,1\}} = wa_5 + \alpha_6 e_1 - \alpha_7 \tag{6}$$

Expression (6) therefore tells us that **fertility directly affects utility** (and thus **labour supply**) in this model for a given sex composition and birth spacing as long as:

(i) **consumption** and **family size** are **non-separable** ($\alpha_5 \neq 0$); or

(ii) **consumption** and **leisure** are **non-separable** ($\alpha_6 \neq 0$); or

(iii) **family size** and **leisure** are **non-separable** ($\alpha_7 \neq 0$).

Angrist and Evans (17)

The Wald estimator of the labour supply response to an increase in the number of children based on changes in r is given by:

$$\frac{\Delta h_4/\Delta r_2^*}{\Delta N_3/\Delta r_2^*}, \tag{7}$$

where Δr_2^* is the deviation of the sex ratio at the beginning of the penultimate period from 0.5 (the bliss point).

Now, expression (7) is equal to:

$$\frac{\Delta \widetilde{h_4}}{\Delta N_3} \,|_{N_2,N_1,r_2} + \frac{\Delta \widetilde{h_4}}{\Delta r_3^*} \,|_{N_3,N_2,N_1} \times \frac{\Delta r_3^*}{\Delta N_3}, \tag{8}$$

Angrist and Evans (18)

where:

- the <u>first term</u> of (8) captures the direct effect of a change in family size on mother's labour supply (the effect of interest)
- the <u>second term</u> of (8) arises because having a third birth will also change the subsequent sex ratio and this may directly affect the marginal utility of leisure ($\alpha_8 \neq 0$), child costs ($e_2 \neq 0$) or how the marginal utility of leisure changes with family size ($\alpha_7 \neq 0$)

Beside the issue of <u>instrument validity</u>, another problem of this approach is:

- **Lack of generalisability** : moving from 2 to 3 children may not be the same as moving from 0 to 1 (or from 1 to 2). So results found in AE may not be true for other parts of the distribution.
- this is the issue of localness of this IV approach: it leads to **local average treatment effects** (**LATE**)

Angrist and Evans (19)

Food for thought:

- Can *you* think of other cases in which you can analyse the effect of fertility (number of children) on mothers' labour supply?
- Make sure you do not identify the opposite effect (i.e., the effect of work decisions on the decision of having children)
- e.g., "exogenous" changes in the incentive of having a child, such as changes in the length and generosity of parental leave, changes in the availability of effective contraception, etc.