

The only child

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Motivation - The only child

- Worldwide there are more **only children** than ever before.
 - 22 percent of all US families are one-child families (Pew Research Center 2015).
 - 70 percent of all urban families in China are one-child families (NBS China 2007).
 - 21 percent of Danish families are one-child families (Statistics Denmark 2020).
- We call attention to these children, and want to know (more on) how they fare in school/life.

Motivation - The only child

- Would only children do better or worse in school if they have siblings?
- On theoretical grounds, all answers are possible.
 - Becker's **QQ model** predicts that only children do better because they do not have to share the family resources (Becker and Lewis 1973; Becker and Tomes 1976).
 - Zajonc's **confluence model** also allows that only children do worse because they have no younger siblings to teach to/socialize with (Zajonc and Markus 1975; Zajonc 1976).
- On empirical grounds, most answers are uninformative.
 - Most existing studies compare the non-cognitive, cognitive and educational outcomes of (first born) children with and without siblings.
 - Such comparisons provide mixed results. But more importantly, they are not enough to make causal claims (Falbo 2012).
- What we need is a **natural experiment** that generates as-good-as-random variation in the likelihood that children have siblings or not.

Motivation - The only child

- We will apply an IV strategy based on IVF treatments among all one-child families that undergo IVF treatment for a second child in Denmark (**IVF-IV strategy**).
 - IVF (In Virto Fertilization) is the leading treatment to help infertile couples to get pregnant.
- Its **intuition** is rather straightforward:
 - If IVF-induced second births occur more or less randomly, some children have siblings whereas otherwise similar children have not and remain only children.
 - If we subsequently compare their school outcomes (including non-cognitive and cognitive test scores), we believe we have identified the causal impact of being the only child.
- Lundborg, Plug, and Rasmussen (2017) introduced this IVF-IV approach to estimate the motherhood penalty exploiting IVF treatments among childless couples.
 - We further refine our IVF-IV strategy to alleviate concerns about the exclusion restriction.

Related sibling literature - The only child

- **Sibling size literature** estimates sibling size effects on child quality (test scores, educational attainment, earnings) using twin births and sibling sex composition as natural experiments: mostly zero effects (Black, Devereux and Salvanes 2005; Åslund and Grönqvist 2010; Angrist, Lavy and Schlosser 2010; De Haan 2010).

Our contribution: we estimate the effect of having siblings (moving from zero to one sibling) as opposed to the estimated effect of having one more sibling (moving from two to three, or three to four siblings) in the twin and same-sex sibling studies.

- **Sibling order literature** estimates birth order effects on child quality using sibling-fixed effects specifications: first borns do mostly better than later borns (Black, Devereux and Salvanes 2005 2011; Conley and Glauber 2006; Gary-Bobo, Picard and Pietro 2006; Kantarevic and Mechoulam 2006; Kristensen and Bjerkedal 2007; Booth and Kee 2009; De Haan 2010).

Our contribution: sibling-fixed-effects studies are not informative about only children; we contrast the outcomes of first borns w/o siblings (for exogenous reasons).

Related sibling literature - The only child

- **Sibling spacing literature** estimate sibling spacing effects using miscarriage and parental benefit reforms as natural experiments (Pettersson-Lidbom and Skogman-Thoursy 2009; Buckles and Munnich 2012): child cognition benefits from having siblings later (and being the only child for a longer time).

Our contribution: sibling spacing effect is a possible confounder in our IV-IVF strategy; and reversely, the only child effect is a possible confounder in these sibling spacing effect studies; if most couples continue after first failed treatment, we could in principle identify sibling spacing effects.

- **Siblinglessness literature** estimates the only child effect on various school outcomes exploiting (variation in) China's one-child policy: mixed results, ranging from positive (Li, Zhang, and Zhu 2008; Rosenzweig and Zhang 2009; Li and Zhang 2017), weak (Liu 2014; Xiao 2021), and sometimes negative (Qian 2009).

Our contribution: we estimate the only child effect in a developed context where families do not rely (or rely much less) on their children for their pensions, social security, and health care.

IVF treatments (in Denmark) - The only child

- IVF treatments are given to couples with fertility problems. These are couples who are unable to get pregnant despite having frequent, unprotected sex (for at least a year).
- Each year, about 2,500 couples start treatment. Average success rate is 25-35 percent. Most women undergo 3 to 4 IVF treatments, with an overall success rate of 70-75 percent.
- The vast majority of treatments is given to childless couples. With a practitioner's referral, childless couples are entitled to have 3 free IVF treatments.
- Couples with children, however, have to pay. A 3 IVF treatment package goes for about 60.000 DKK (€8,000). IVF treatments are also costly in physical and mental terms.

IVF register - The only child

- IVF register holds records of the census of Danish women who received IVF treatment from 1994 onwards (up to 2005 reporting is mandatory).
- The main variables (for us) include the outcomes of treatment (birth, abortion, stillbirth, or not pregnant), date of treatment, and date of birth.
- IVF register is matched to other administrative registers to get parental information on standard demographic and labor market variables (including education, age, marital status, number of children, labor market attachment, and annual earnings).
- IVF register is matched to education registers to get cognitive outcomes (taken from test scores on nationwide tests taken in grades 2 to 8). These tests were introduced in 2010.
- IVF register is also matched to nationwide primary and secondary school surveys with information on social and personality outcomes. These surveys were introduced in 2014. These surveys are taken in grades 4 to 9.

Our cognitive and noncognitive outcomes

- **Cognitive outcomes:**

- Children take multiple nationwide tests (4 tests in reading, 2 tests in math).
- We standardize each test score by cohort. We take averages over all standardized test scores in reading and math.

- **Noncognitive outcomes:**

- Children respond to survey questions that measure personality traits (6 annual scores in agreeableness, conscientiousness, emotional stability).
 - These personality traits have been identified as strong predictors for important economic outcomes (Plug and Mueller 2006; Almund et al 2011).
- We complement these traits with a measure of overall school wellbeing.
- We standardize each annual outcome by cohort. We take averages over all standardized scores in agreeableness, conscientiousness, emotional stability, and school wellbeing.

Our noncognitive outcomes

- **Agreeableness** is based on 2 questions: Do you try to understand your friends' feelings when they are sad or upset? Are you good at collaborating with others?
- **Conscientiousness** is based on 3 questions: How often can you complete what you set out to do? Can you concentrate during class? If you are interrupted during lessons, can you quickly concentrate again?
- **Emotional stability** is based on 3 questions: Do you feel lonely? Do other students accept you as you are? How often do you feel safe at school?
 - These trait measures have been validated in a register-matched personality survey (Anderson et al 2020).
- **Overall school wellbeing** is based on 1 question: Are you happy with your school?
- **Answers** to these questions are measured on a 5 point scale (almost always, often, now and then, rarely, and never).

Our sample - The only child

- We cut our primary IVF sample as follows:
 - we select all mothers with one child (*focal child*) that receive IVF treatment for a second child;
 - the *focal child* must be old enough to have test scores (from 2010 onwards) and survey responses (from 2014 onwards);
- This leaves us with almost **12,000** and **8,500** focal children with cognitive and non-cognitive outcomes, respectively.
- We similarly cut our representative sample:
 - we select all mothers with first-born children born around the same time as the focal children in the IVF sample.
- This leaves us with about **375,000** and **250,000** representative children with cognitive and non-cognitive outcomes, respectively.

IVF instrument - The only child

- In constructing the **IVF instrument**, we let the following considerations guide us.
 - most mothers undergo multiple treatments, which is selective; we focus on **single treatments**.
 - we are interested in the transition out of siblingness; we follow mothers (and one child) from **first treatments** for a second child onwards.
- Within the sample of mothers with one child, we choose **success at the first IVF treatment for a second child** as our instrument.
- If treatment success is to a large extent exogenously determined, some children will end up having siblings for random reasons.

Table 1 - Some sample statistics

	1st IVF failure	1st IVF success	difference
<i>Pre-treatment characteristics:</i>			
mother age at first treatment	32.765	32.121	-0.644
	4.309	3.971	0.185***
mother years of schooling	13.534	13.531	-0.004
	2.237	2.236	0.098
mother labor earnings (in 100,000 DKK)	2.538	2.555	0.017
	1.429	1.376	0.062
mother positive labor earnings (0/1)	0.921	0.924	0.003
	0.269	0.265	0.012
partner age at first treatment	35.060	34.381	-0.679
	5.095	4.298	0.221***
partner years of schooling	13.078	13.171	0.093
	2.437	2.441	0.107
partner labor earnings (in 100,000 DKK)	3.410	3.404	-0.006
	2.155	2.375	0.097
partner positive labor earnings (0/1)	0.878	0.884	0.006
	0.327	0.320	0.014

IVF treatment success - The only child

- Is treatment success exogenously determined?
- **Arguments in favor:**
- Mothers are comparable in their decision to enter the IVF treatment for a second child, regardless treatment success.
- Mothers (and fathers) are comparable in their educational attainment and pre-treatment earnings, which are both strong predictors of child test scores.
- **Arguments against:**
- But mothers (and fathers) differ in age.
- There is a medical literature arguing that age is the single most important variable influencing outcomes in assisted reproduction (Rosenwaks et al. 1995). These age effects are typically interpreted as evidence that egg quantity and quality fall with maternal age.
- **Our approach:**
- We will control for age effects in all our regressions and continue as if **treatment success is conditionally as good as random.**

Table 2 (on instrument independence)
Linking treatment success to pre-treatment characteristics

	all children	all children
mother years of education	0.003 <i>0.004</i>	−0.000 <i>0.004</i>
mother earnings (in 100,000 DKK)	0.007 <i>0.007</i>	0.007 <i>0.007</i>
mother positive earnings (0/1)	−0.009 <i>0.036</i>	−0.009 <i>0.036</i>
father years of education		0.007 <i>0.004*</i>
father earnings (in 100,000 DKK)		−0.002 <i>0.005</i>
father positive earnings (0/1)		0.004 <i>0.032</i>
R-squared	0.009	0.011
p-value (for joint significance)	0.520	0.438

Additional controls include child gender, child birth year, and parents' birth year.

OLS strategy - The only child

- The **naive regression** is:

$$Y_i = \rho X_i + \lambda S_i + \omega_{it}.$$

- Y_i include standardized cognitive and noncognitive outcomes of focal children;
- S_i is the endogenous sibling indicator (having any siblings);
- X_i include exogenous variables (child age and gender, parents' age and education);
- We run this regression model on two samples: (i) the representative sample of first born children; and (ii) the sample of first born children whose parents undergo IVF treatment for a second child.
- The association λ_{OLS} reflects a blend of causal and selection effects.

Table 3
The OLS relationship between having siblings and cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
<i>Representative sample:</i>						
having siblings	0.170 0.004***	0.087 0.004***	0.075 0.005***	0.120 0.005***	0.109 0.005***	0.135 0.005***
observations	306,958	376,178	251,252	251,361	251,312	251,497
<i>IVF sample:</i>						
having siblings	0.097 0.021***	0.054 0.019***	0.036 0.020***	0.066 0.021***	0.055 0.021***	0.082 0.021***
observations	9,778	11,637	8,366	8,370	8,370	8,374

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

IVF-IV strategy - The only child

- The **first-stage regression** is:

$$S_i = \alpha X_i + \beta Z_i + u_i,$$

- The **reduced-form regression** is:

$$Y_i = \gamma X_i + \delta Z_i + v_i,$$

- The **second-stage regression** is:

$$Y_i = \rho X_i + \lambda \hat{S}_i + \omega_{it}.$$

- Y_i include standardized cognitive and noncognitive outcomes of focal children;
- S_i is the endogenous sibling indicator (having any siblings);
- X_i include exogenous variables (child age and gender, parents' age and education);
- Z_i is the instrument (success at first IVF treatment).

Local Average Treatment Effect - First stage impact

- We follow the standard LATE framework (and ignore X for now).
- Each first-born child i has two potential sibling outcomes: S_{1i} (if Z_i is 1) and S_{0i} (if Z_i is 0).
- In our IVF setting, there are only *always takers* ($S_{1i}=1, S_{0i}=1$) and *compliers* ($S_{1i}=1, S_{0i}=0$).
- With *instrument independence*, the **first-stage estimate** of Z_i on S_i reads as:

$$\begin{aligned}\beta_{LS} &= E[S_i|Z_i=1] - E[S_i|Z_i=0] = E[S_{1i}|Z_i=1] - E[S_{0i}|Z_i=0] \\ &= E[S_{1i} - S_{0i}] = P[S_{1i}=1, S_{0i}=1] \underbrace{E[S_{1i} - S_{0i}|S_{1i}=1, S_{0i}=1]}_0 \\ &\quad + P[S_{1i}=1, S_{0i}=0] \underbrace{E[S_{1i} - S_{0i}|S_{1i}=1, S_{0i}=0]}_1 = \beta_C\end{aligned}$$

- The first-stage impact β_C represents the complier share of first-born children.

Table 4 (first stage)
The effect of having siblings on cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
first stage	0.339 <i>0.006***</i>	0.341 <i>0.006***</i>	0.332 <i>0.005***</i>	0.332 <i>0.005***</i>	0.332 <i>0.006***</i>	0.332 <i>0.007***</i>
reduced form	-0.027 <i>0.019</i>	-0.024 <i>0.017</i>	-0.013 <i>0.017</i>	0.006 <i>0.019</i>	-0.024 <i>0.017</i>	-0.017 <i>0.020</i>
second stage	-0.079 <i>0.057</i>	-0.072 <i>0.050</i>	-0.041 <i>0.052</i>	-0.018 <i>0.059</i>	-0.072 <i>0.052</i>	-0.051 <i>0.061</i>
observations	9,778	11,637	8,366	8,370	8,370	8,374

Estimation sample contains all focal children whose parents enter treatment for second child.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

Local Average Treatment Effect - Reduced form impact

- Child i also has potential test score outcomes: $Y_{1i}(S_{1i})$ (if Z_i is 1) and $Y_{0i}(S_{0i})$ (if Z_i is 0).
- With *instrument independence*, the **reduced-form estimate** of Z_i on Y_i reads as:

$$\begin{aligned}
 \delta_{LS} &= E[Y_i|Z_i=1] - E[Y_i|Z_i=0] \\
 &= E[Y_{1i}(S_{1i})|Z_i=1] - E[Y_{0i}(S_{0i})|Z_i=0] = E[Y_{1i}(S_{1i}) - Y_{0i}(S_{0i})] \\
 &= \underbrace{P[S_{1i}=1, S_{0i}=0]}_{\beta_C} E[Y_{1i}(1) - Y_{0i}(0)|S_{1i}=1, S_{0i}=0] + \\
 &\quad \underbrace{P[S_{1i}=1, S_{0i}=1]}_{1-\beta_C} E[Y_{1i}(1) - Y_{0i}(1)|S_{1i}=1, S_{0i}=1]
 \end{aligned}$$

- With only compliers and always takers, we distinguish two effects:
 - $E[Y_{1i}(1) - Y_{0i}(0)|S_{1i}=1, S_{0i}=0]$ - impact of having siblings (for children without siblings);
 - $E[Y_{1i}(1) - Y_{0i}(1)|S_{1i}=1, S_{0i}=1]$ - impact of having siblings early/late (for children with siblings).

Table 4 (reduced form)
The effect of having siblings on cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
first stage	0.339 <i>0.006***</i>	0.341 <i>0.006***</i>	0.332 <i>0.005***</i>	0.332 <i>0.005***</i>	0.332 <i>0.006***</i>	0.332 <i>0.007***</i>
reduced form	-0.027 <i>0.019</i>	-0.024 <i>0.017</i>	-0.013 <i>0.017</i>	0.006 <i>0.019</i>	-0.024 <i>0.017</i>	-0.017 <i>0.020</i>
second stage	-0.079 <i>0.057</i>	-0.072 <i>0.050</i>	-0.041 <i>0.052</i>	-0.018 <i>0.059</i>	-0.072 <i>0.052</i>	-0.051 <i>0.061</i>
observations	9,778	11,637	8,366	8,370	8,370	8,374

Estimation sample contains all focal children whose parents enter treatment for second child.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

Local Average Treatment Effect - Second-stage impact

- With *instrument independence*, the **second-stage estimate** of S_i on Y_i reads as:

$$\begin{aligned}\lambda_{2SLS} = & E[Y_{1i}(1) - Y_{0i}(0)|S_{1i}=1, S_{0i}=0] \\ & + \frac{1 - \beta_C}{\beta_C} E[Y_{1i}(1) - Y_{0i}(1)|S_{1i}=1, S_{0i}=1]\end{aligned}$$

- The *exclusion* condition says that:

$$E[Y_{1i}(1) - Y_{0i}(1)|S_{1i}=1, S_{0i}=1] = 0$$

- If the *exclusion* condition holds, we identify **only child effect** (or the reverse thereof):

$$\lambda_{2SLS} = E[Y_{1i}(1) - Y_{0i}(0)|S_{1i}=1, S_{0i}=0]$$

Table 4 (second stage)
The effect of having siblings on cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
first stage	0.339 <i>0.006***</i>	0.341 <i>0.006***</i>	0.332 <i>0.005***</i>	0.332 <i>0.005***</i>	0.332 <i>0.006***</i>	0.332 <i>0.007***</i>
reduced form	-0.027 <i>0.019</i>	-0.024 <i>0.017</i>	-0.013 <i>0.017</i>	0.006 <i>0.019</i>	-0.024 <i>0.017</i>	-0.017 <i>0.020</i>
second stage	-0.079 <i>0.057</i>	-0.072 <i>0.050</i>	-0.041 <i>0.052</i>	-0.018 <i>0.059</i>	-0.072 <i>0.052</i>	-0.051 <i>0.061</i>
observations	9,778	11,637	8,366	8,370	8,370	8,374

Estimation sample contains all focal children whose parents enter treatment for second child.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

IVF-IV strategy - The only child

- There is clearly one issue here: the **exclusion condition**.
- Our effect estimates do not allow for a causal interpretation if the *exclusion condition fails*.
- We provide **an alternative way** to explore the empirical relevance of *exclusion* violations.
- We do this by exploiting randomness in later treatments among *children without siblings (never successfully treated compliers)*.

The exclusion condition - The impact of having first-cycle siblings

- The exclusion restriction is (possibly) violated by those children who get siblings at later treatments.
- Our new target of estimation is **the impact of having first-cycle siblings** in a sample without children with later-cycle siblings (which is then free from exclusion violations).
- **Step 1:** We distinguish the following k types of IVF couples:

$$\left\{ \begin{array}{ll} C_i=1 & \text{couples that always undergo 1 IVF cycle} \\ C_i=2 & \text{couples that always undergo 2 IVF cycles after 1 failed cycle} \\ C_i=3 & \text{couples that always undergo 3 IVF cycles after 2 failed cycles} \\ C_i=k & \text{couples that reach the last IVF cycle after } k-1 \text{ failed cycles} \end{array} \right.$$

- **Step 2:** We can identify these fractions of the k types from couples that only experience failed cycles (under assumed random treatment success in each cycle):

$$\left\{ \begin{array}{ll} P[C_i=1] = \theta_1 & \text{fraction always undergo 1 cycle} \\ P[C_i=2] = (1 - \theta_1)\theta_2 & \text{fraction always undergo 2 cycles after 1 failed cycle} \\ P[C_i=3] = (1 - \theta_1)(1 - \theta_2)\theta_3 & \text{fraction always undergo 3 cycles after 2 failed cycles} \\ P[C_i=k] = (1 - \theta_1) \cdots (1 - \theta_{k-1}) & \text{fraction final cycle after } k-1 \text{ failed cycles} \end{array} \right.$$

The exclusion condition - The impact of having first-cycle siblings

- **Step 3:** The *observed* average school outcome for first-born children with first-cycle siblings represents a weighted average of *observed shares* and *unobserved* conditional means:

$$E[Y_{1i}(1)] = \theta_1 E[Y_{1i}(1)|C_i=1] + (1 - \theta_1)\theta_2 E[Y_{1i}(1)|C_i=2] \\ + \dots + (1 - \theta_1)(1 - \theta_2) \dots (1 - \theta_{k-1}) E[Y_{1i}(1)|C_i=k]$$

- **Step 4:** The *unobserved* average school outcome for the counterfactual first-born children in never successfully treated families also represents a weighted average of *observed shares* and *observed* conditional means:

$$E[Y_{0i}(0)] = \theta_1 E[Y_{0i}(0)|C=1] + (1 - \theta_1)\theta_2 E[Y_{0i}(0)|C=2] \\ + \dots + (1 - \theta_1)(1 - \theta_2) \dots (1 - \theta_{k-1}) E[Y_{0i}(0)|C=k].$$

- With the observed $E[Y_{1i}(1)]$ and calculated $E[Y_{0i}(0)]$, we have identified **the impact of having first-cycle siblings** (which is free from exclusion bias):

$$E[Y_{1i}(1)] - E[Y_{0i}(0)].$$

- Here we rely on three (additional) assumptions: (a) failed treatments do not impact the outcomes of only children; (b) treatment success is as good as random in each IVF cycle; and (c) never successfully treated couples do not get children through other means.

Table 5
The effect of having first-cycle siblings on cognitive and non-cognitive skills

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
first stage	0.566 0.009***	0.570 0.009***	0.559 0.009***	0.559 0.009***	0.559 0.010***	0.559 0.010***
reduced form	-0.017 0.023	-0.020 0.013	0.006 0.021	0.009 0.028	-0.002 0.021	-0.003 0.023
second stage	-0.030 0.040	-0.036 0.040	0.012 0.038	-0.016 0.049	-0.005 0.039	-0.006 0.042
observations	6,870	8,178	5,802	5,804	5,805	5,807

Estimation sample restricted to focal children without later-cycle IVF siblings.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

The exclusion condition - The impact of having siblings

- Identification of the only effect relies, among others, on the assumption that **never successfully treated couples do not get children through other means**.
- In our sample, however, about 45 percent of couples that seek treatment for a second child get a second child through other means.
- The exclusion condition remains violated!
- What to do with IVF treated parents who get second children through other means?
 - First, we can run an **IV-IVF strategy** on the restricted sample and reweigh the new reduced-form estimate by the share of IVF treated couples that get children through other means. With a stronger first stage, exclusion violations turn empirically less relevant.
 - Second, we can impose a less implausible condition that **fertility among these parents is conditionally random**. If having non-IVF siblings is effectively random, we can simply remove these observations and calculate/interpret the impact of having first-cycle siblings with exclusion/sibling spacing bias.

Table 5
The effect of having siblings on cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
first stage	0.566 <i>0.009***</i>	0.570 <i>0.009***</i>	0.559 <i>0.009***</i>	0.559 <i>0.009***</i>	0.559 <i>0.010***</i>	0.559 <i>0.010***</i>
reduced form	-0.017 <i>0.023</i>	-0.020 <i>0.013</i>	0.006 <i>0.021</i>	0.009 <i>0.028</i>	-0.002 <i>0.021</i>	-0.003 <i>0.023</i>
second stage	-0.030 <i>0.040</i>	-0.036 <i>0.040</i>	0.012 <i>0.038</i>	-0.016 <i>0.049</i>	-0.005 <i>0.039</i>	-0.006 <i>0.042</i>
observations	6,870	8,178	5,802	5,804	5,805	5,807

Estimation sample restricted to focal children without later-cycle IVF siblings.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

The exclusion condition - The impact of having siblings

- Identification of the only effect relies, among others, on the assumption that **never successfully treated couples do not get children through other means**.
- In our sample, however, about 45 percent of couples that seek treatment for a second child get children through other means.
- The exclusion condition remains violated!
- What to do with IVF treated parents who get second children through other means?
 - First, we can run our **IV-IVF strategy** on the restricted sample and reweigh the new reduced-form estimate by the share of IVF treated couples that get children through other means. With a stronger first stage, exclusion violations turn empirically less relevant.
 - Second, we can impose a less implausible condition that **fertility among these parents is conditionally random**. If having non-IVF siblings is effectively random, we can simply remove these observations and calculate/interpret the impact of having first-cycle siblings with exclusion/sibling spacing bias.

Table 6
The effect of having first-cycle siblings on cognitive and non-cognitive outcomes

	math test scores	reading test scores	agreeable	conscientious	emotional stability	overall school wellbeing
having siblings	−0.019 <i>0.029</i>	−0.023 <i>0.028</i>	0.029 <i>0.028</i>	0.029 <i>0.036</i>	0.005 <i>0.029</i>	0.035 <i>0.033</i>
observations	5,238	6,320	4,449	4,450	4,451	4,452

Estimation sample restricted to focal children without later-cycle IVF and non-IVF siblings.

Additional controls include child birth year and gender, and parents' birth year and education. All outcomes are standardized.

What's been done and still to do - The only child

- **Summary (thus far):**

- Regarding cognitive and non-cognitive outcomes (measured in primary and lower secondary education), almost all our effect estimates are small and statistically insignificant. There seems to be little value of having siblings.
- When we test for possible only child effect heterogeneity, we find that our estimates are remarkably stable. The only child effect does not vary by family income, fertility-related health disparities, age of the mothers, and age and gender of the child.

- **Still to do:**

- Regarding **external validity**, we want to test for *generalizability* by comparing how IVF and non-IVF children respond to having twins.

**Thank you,
for listening,
and asking questions!**

Table A
Predicting child test scores with parental education and earnings

	(1)	(2)	(3)
years of education mother	0.076 0.004***		0.070 0.003***
years of education father	0.064 0.003***		0.061 0.003***
earnings mother (in 10,000 DKK)		0.009 0.001***	0.005 0.001***
earnings father (in 10,000 DKK)		0.003 0.0004***	0.002 0.0003***

Taken from Lundborg, Plug and Rasmussen (2023).