Socioeconomic Determinants for Fertility

Mette Gerster

PhD Defense, September 15th 2009
How to measure fertility?

Fertility - actual births

Fertility is a process that evolves over several years (in principle, from menarche to menopause)

Several aspects are potentially of interest - several ways to measure it:

1. Number of children at a given age → static or
2. the parity progressions → dynamic (magnifying glass)
How to measure fertility?

- Fertility - actual births
- Fertility is a process that evolves over several years (in principle, from menarche to menopause)
- Several aspects are potentially of interest - several ways to measure it:
  1. Number of children at a given age → static or
  2. the *parity progressions* → dynamic (magnifying glass)
How to measure fertility?

- Fertility - actual births
- Fertility is a process that evolves over several years (in principle, from menarche to menopause)
- Several aspects are potentially of interest - several ways to measure it:
  1. Number of children at a given age → static or
  2. the parity progressions → dynamic (magnifying glass)
How to measure fertility?

- Fertility - actual births
- Fertility is a process that evolves over several years (in principle, from menarche to menopause)
- Several aspects are potentially of interest - several ways to measure it:
  1. Number of children at a given age → static or
  2. the parity progressions → dynamic (magnifying glass)
How to measure fertility?

- Fertility - actual births
- Fertility is a process that evolves over several years (in principle, from menarche to menopause)
- Several aspects are potentially of interest - several ways to measure it:
  1. Number of children at a given age → static or
  2. the *parity progressions* → dynamic (magnifying glass)
Determinants for fertility

- Biological factors, health, fecundity
- Factors which potentially influence the (woman’s) choice (when) to have children
- I will give two examples of the latter: the socioeconomic factors
  1. education and
  2. labour market attachment
Determinants for fertility

- Biological factors, health, fecundity
- Factors which potentially influence the (woman’s) choice (when) to have children
- I will give two examples of the latter: the socioeconomic factors
  1. education and
  2. labour market attachment
Determinants for fertility

- Biological factors, health, fecundity
- Factors which potentially influence the (woman’s) choice (when) to have children
- I will give two examples of the latter: the socioeconomic factors
  1. education and
  2. labour market attachment
\[ t \quad \Delta t \quad X(t-) \quad T \quad X(T) \leftrightarrow N(T) \quad t \quad t + \Delta t \]
Education and labour market attachment
Effect on fertility?

- Subject of numerous studies in the demographic literature for many years
- Economic and sociological theory provide a theoretical framework for the underlying mechanisms
Education and labour market attachment
Effect on fertility?

- Subject of numerous studies in the demographic literature for many years
- **Economic and sociological theory** provide a theoretical framework for the underlying mechanisms
Education and labour market attachment
Effect on fertility?

- Subject of numerous studies in the demographic literature for many years
- Economic and sociological theory provide a theoretical framework for the underlying mechanisms
Two examples

Parity transitions
- Labour market attachment
- Norway
- Simultaneous Equations Models
- Administrative register data: Statistisk Sentralbyrå

Ultimate fertility
- Educational attainment
- Denmark
- Marginal Structural Models
- Administrative register data: Danmarks Statistik
Two examples

Parity transitions
- Labour market attachment
- Norway
- Simultaneous Equations Models
- Administrative register data: Statistisk Sentralbyrå

Ultimate fertility
- Educational attainment
- Denmark
- Marginal Structural Models
- Administrative register data: Danmarks Statistik
Two examples

Parity transitions
- Labour market attachment
- Norway
- Simultaneous Equations Models
- Administrative register data: Statistisk Sentralbyrå

Ultimate fertility
- Educational attainment
- Denmark
- Marginal Structural Models
- Administrative register data: Danmarks Statistik
Two examples

Parity transitions
- Labour market attachment
- Norway
- Simultaneous Equations Models
- Administrative register data: Statistisk Sentralbyrå

Ultimate fertility
- Educational attainment
- Denmark
- Marginal Structural Models
- Administrative register data: Danmarks Statistik
Two examples

<table>
<thead>
<tr>
<th>Parity transitions</th>
<th>Ultimate fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Labour market attachment</td>
<td>▶ Educational attainment</td>
</tr>
<tr>
<td>▶ Norway</td>
<td>▶ Denmark</td>
</tr>
<tr>
<td>▶ Simultaneous Equations Models</td>
<td>▶ Marginal Structural Models</td>
</tr>
</tbody>
</table>
| ▶ Administrative register data: 
  *Statistisk Sentralbyrå* | ▶ Administrative register data: 
  *Danmarks Statistik* |
Overview

Parity transitions in Norway

Ultimate fertility in Denmark
Background

- Transition from being a one-child mother to a two-child mother and from two-child to three-child mother
- How does it depend on her current labour market attachment (employed vs non-employed)?
- Is this relationship possibly different across the parities?
- Do unobserved characteristics of the women play a role?
Background

- Transition from being a one-child mother to a two-child mother and from two-child to three-child mother
- How does it depend on her *current* labour market attachment (employed vs non-employed)?
- Is this relationship possibly different across the parities?
- Do unobserved characteristics of the women play a role?
Background

- Transition from being a one-child mother to a two-child mother and from two-child to three-child mother
- How does it depend on her current labour market attachment (employed vs non-employed)?
- Is this relationship possibly different across the parities?
- Do unobserved characteristics of the women play a role?
Background

- Transition from being a one-child mother to a two-child mother and from two-child to three-child mother
- How does it depend on her *current* labour market attachment (employed vs non-employed)?
- Is this relationship possibly different across the parities?
- Do unobserved characteristics of the women play a role?
Study population

- All women of NO-origin
- whose first child reaches age 15 mths April 1994-Oct 2002
- 19-40 years old at first birth
- registered with a partner at first birth
- no students
- → 126608 women
Study population

- All women of NO-origin
- whose first child reaches age 15 mths April 1994-Oct 2002
- 19-40 years old at first birth
- registered with a partner at first birth
- no students

→ 126608 women
Study population

- All women of NO-origin
- whose first child reaches age 15 mths April 1994-Oct 2002
- 19-40 years old at first birth
- registered with a partner at first birth
- no students

→ 126608 women
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
  - Periods away from the labour market are potentially more costly for women who are currently in a job
    1. loss of skills (human capital)
    2. forgone income
  - the right to paid maternity leave
  - Can better afford to have a child?
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
- Periods away from the labour market are potentially more costly for women who are currently in a job:
  1. loss of skills (human capital)
  2. forgone income
- the right to paid maternity leave
- Can better afford to have a child?
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
  - Periods away from the labour market are potentially more costly for women who are currently in a job
    1. loss of skills (human capital)
    2. forgone income
  - The right to paid maternity leave
  - Can better afford to have a child?
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
  - Periods away from the labour market are potentially more costly for women who are currently in a job
    1. loss of skills (human capital)
    2. forgone income
  - the right to paid maternity leave
  - Can better afford to have a child?
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
  - Periods away from the labour market are potentially more costly for women who are currently in a job
    1. loss of skills (human capital)
    2. forgone income
  - the right to paid maternity leave

- Can better afford to have a child?
Why effect of employment?

- Employment status might influence the decision to have the next child via several channels:
  - Periods away from the labour market are potentially more costly for women who are currently in a job
    1. loss of skills (human capital)
    2. forgone income
  - the right to paid maternity leave
  - Can better afford to have a child?
Unobserved heterogeneity

Intuition

Why...

▶ Possibly influencing the birth intensities (e.g. more family-orientation)
▶ Possibly influencing the employment process (e.g. career-orientation)
▶ Might give rise to a spurious relationship
▶ Potentially correlated
▶ The employment status is endogenous (as opposed to exogenous)

How...

▶ Set up model equations for the births with random effect
▶ Set up model equations for the employment process with random effect(s)
▶ Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

▶ Possibly influencing the birth intensities (*e.g.* more *family-orientation*)
▶ Possibly influencing the employment process (*e.g.* *career-orientation*)
▶ Might give rise to a spurious relationship
▶ Potentially correlated
▶ The employment status is endogenous (as opposed to exogenous)

How...

▶ Set up model equations for the births with random effect
▶ Set up model equations for the employment process with random effect(s)
▶ Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (e.g. more family-orientation)
- Possibly influencing the employment process (e.g. career-orientation)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (e.g. *more family-orientation*)
- Possibly influencing the employment process (e.g. *career-orientation*)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (e.g. more family-orientation)
- Possibly influencing the employment process (e.g. career-orientation)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (e.g. *more family-orientation*)
- Possibly influencing the employment process (e.g. *career-orientation*)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is *endogenous* (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- Allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (*e.g. more family-orientation*)
- Possibly influencing the employment process (*e.g. career-orientation*)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

▶ Possibly influencing the birth intensities (*e.g.* more *family-orientation*)
▶ Possibly influencing the employment process (*e.g.* *career-orientation*)
▶ Might give rise to a spurious relationship
▶ Potentially correlated
▶ The employment status is endogenous (as opposed to exogenous)

How...

▶ Set up model equations for the births with random effect
▶ Set up model equations for the employment process with random effect(s)
▶ allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

**Why...**
- Possibly influencing the birth intensities (*e.g. more family-orientation*)
- Possibly influencing the employment process (*e.g. career-orientation*)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

**How...**
- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- allow these random effects to be correlated by estimating these equations simultaneously
Unobserved heterogeneity

Intuition

Why...

- Possibly influencing the birth intensities (e.g. more family-orientation)
- Possibly influencing the employment process (e.g. career-orientation)
- Might give rise to a spurious relationship
- Potentially correlated
- The employment status is endogenous (as opposed to exogenous)

How...

- Set up model equations for the births with random effect
- Set up model equations for the employment process with random effect(s)
- allow these random effects to be correlated by estimating these equations simultaneously
Model

**Birth intensities**

\[
\log \lambda_2(t) = \log \lambda_0^{(2)}(t) + \beta'_2 \cdot X^{(2)}(t-)
\]

\[
\log \lambda_3(t) = \log \lambda_0^{(3)}(t) + \beta'_3 \cdot X^{(3)}(t-)
\]

where \( t \) denotes age of previous child (-15 months)

**Employment and non-employment intensities**

\[
\log \lambda_e(s) = \log \lambda_0^{(e)}(s) + \beta'_e \cdot X^{(e)}(s)
\]

\[
\log \lambda_{ne}(s) = \log \lambda_0^{(ne)}(s) + \beta'_{ne} \cdot X^{(ne)}(s)
\]

where \( s \) denotes time since beginning of each spell

→ **Simultaneous Equations Model (SEM)**
Birth intensities

\[
\log \lambda_2(t) = \log \lambda_0^{(2)}(t) + \beta_2' \cdot X^{(2)}(t-)
\]
\[
\log \lambda_3(t) = \log \lambda_0^{(3)}(t) + \beta_3' \cdot X^{(3)}(t-)
\]

where \( t \) denotes age of previous child (-15 months)

Employment and non-employment intensities

\[
\log \lambda_e(s) = \log \lambda_0^{(e)}(s) + \beta_e' \cdot X^{(e)}(s)
\]
\[
\log \lambda_{ne}(s) = \log \lambda_0^{(ne)}(s) + \beta_{ne}' \cdot X^{(ne)}(s)
\]

where \( s \) denotes time since beginning of each spell

→ Simple Model (SM)
Model

Birth intensities

\[ \log \lambda_2(t) = \log \lambda_0^{(2)}(t) + \beta_2' \cdot X^{(2)}(t-) + \varepsilon_b \]
\[ \log \lambda_3(t) = \log \lambda_0^{(3)}(t) + \beta_3' \cdot X^{(3)}(t-) + \varepsilon_b \]

where \( t \) denotes age of previous child (-15 months)

Employment and non-employment intensities

\[ \log \lambda_e(s) = \log \lambda_0^{(e)}(s) + \beta_e' \cdot X^{(e)}(s) + \varepsilon_e \]
\[ \log \lambda_{ne}(s) = \log \lambda_0^{(ne)}(s) + \beta_{ne}' \cdot X^{(ne)}(s) + \varepsilon_{ne} \]

where \( s \) denotes time since beginning of each spell

→ Simultaneous Equations Model (SEM)
Not quite done...

Assume that

\[ (\varepsilon_b \quad \varepsilon_e \quad \varepsilon_{ne})^T \sim \mathcal{N}_3(0, \Omega_{\varepsilon_b,\varepsilon_e,\varepsilon_{ne}}) \]

conditional on \((\varepsilon_b \quad \varepsilon_e \quad \varepsilon_{ne})^T\), the separate birth spells for each woman are independent

and so are the employment and non-employment spells
Not quite done...

Assume that

$$\begin{pmatrix} \varepsilon_b & \varepsilon_e & \varepsilon_{ne} \end{pmatrix}^T \sim \mathcal{N}_3(0, \Omega_{\varepsilon_b, \varepsilon_e, \varepsilon_{ne}})$$

conditional on $$\begin{pmatrix} \varepsilon_b & \varepsilon_e & \varepsilon_{ne} \end{pmatrix}^T$$, the separate birth spells for each woman are independent

and so are the employment and non-employment spells
Not quite done...

Assume that

\[ (\varepsilon_b \quad \varepsilon_e \quad \varepsilon_{ne})^T \sim \mathcal{N}_3(\mathbf{0}, \Omega_{\varepsilon_b,\varepsilon_e,\varepsilon_{ne}}) \]

conditional on \((\varepsilon_b \quad \varepsilon_e \quad \varepsilon_{ne})^T\), the separate birth spells for each woman are independent

and so are the employment and non-employment spells
Not quite done…

Assume that

\[ (\varepsilon_b \ \varepsilon_e \ \varepsilon_{ne})^T \sim \mathcal{N}_3(0, \Omega_{\varepsilon_b,\varepsilon_e,\varepsilon_{ne}}) \]

conditional on \((\varepsilon_b \ \varepsilon_e \ \varepsilon_{ne})^T\), the separate birth spells for each woman are independent

and so are the employment and non-employment spells
Results

<table>
<thead>
<tr>
<th></th>
<th>Model SEM</th>
<th></th>
<th>Model SM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$RR$</td>
<td>$p$</td>
<td>$RR$</td>
</tr>
<tr>
<td>Employed (ref)</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Non-employed</td>
<td>0.929</td>
<td>&lt; 0.01</td>
<td>0.956</td>
</tr>
</tbody>
</table>

Controlled for...

*mother’s age, calendar year, and education.*
## Results

### 3rd child:

<table>
<thead>
<tr>
<th></th>
<th>Model SEM</th>
<th></th>
<th>Model SM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RR</td>
<td>p</td>
<td>RR</td>
<td>p</td>
</tr>
<tr>
<td>Employed (ref)</td>
<td>1</td>
<td>&lt; 0.01</td>
<td>1</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Non-employed</td>
<td>1.097</td>
<td>&lt; 0.01</td>
<td>1.132</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Controlled for...

*mother’s age, calendar year, and education*
Results

Unobserved heterogeneity

| \( \text{sd} (\varepsilon_b) \) | 0.379 | \( \text{corr} (\varepsilon_b, \varepsilon_e) \) | -0.245 |
| \( \text{sd} (\varepsilon_e) \) | 1.436 | \( \text{corr} (\varepsilon_b, \varepsilon_{ne}) \) | -0.318 |
| \( \text{sd} (\varepsilon_{ne}) \) | 0.782 | \( \text{corr} (\varepsilon_e, \varepsilon_{ne}) \) | 0.551 |
Conclusion

Parity transitions in Norway

- The second birth intensity is smaller for non-employed women ($RR = 0.93$)
- The third birth intensity is larger for non-employed women ($RR = 1.097$)
- Child 2: when??
- Child 3: if??
Conclusion
Parity transitions in Norway

- The second birth intensity is smaller for non-employed women ($RR = 0.93$)
- The third birth intensity is larger for non-employed women ($RR = 1.097$)
- Child 2: when??
- Child 3: if??
Conclusion

Parity transitions in Norway

- The second birth intensity is smaller for non-employed women ($RR = 0.93$)
- The third birth intensity is larger for non-employed women ($RR = 1.097$)
- Child 2: when??
- Child 3: if??
Conclusion

Parity transitions in Norway

- The second birth intensity is smaller for non-employed women \((RR = 0.93)\)
- The third birth intensity is larger for non-employed women \((RR = 1.097)\)
- Child 2: when??
- Child 3: if??
Overview

Parity transitions in Norway

Ultimate fertility in Denmark
Illustration

\[ X(t-) \leftrightarrow N(T) \]
Ultimate fertility

- Number of children at age 41
- How does it depend on educational attainment?
- Is this relationship static?
- Feedback...
Ultimate fertility

- Number of children at age 41
- How does it depend on educational attainment?
- Is this relationship static?
- Feedback...
Ultimate fertility

- Number of children at age 41
- How does it depend on educational attainment?
- Is this relationship static?
- Feedback...
Ultimate fertility

- Number of children at age 41
- How does it depend on educational attainment?
- Is this relationship static?
- Feedback...
Why an effect of education on fertility?

- Women with a higher education might have higher opportunity costs - more likely to pursue a career
- Their labour market situation might be more flexible - easier to combine
- Other factors? More resources?
Why an effect of education on fertility?

- Women with a higher education might have higher opportunity costs - more likely to pursue a career
- Their labour market situation might be more flexible - easier to combine
- Other factors? More resources?
Why an effect of education on fertility?

- Women with a higher education might have higher *opportunity costs* - more likely to pursue a career
- Their labour market situation might be more flexible - easier to *combine*
- Other factors? More resources?
The study population

All women who...

- born in 1963
- living in Denmark Jan 1st 1981 (and each year 1982-2005)
- of Danish origin
- who have completed a *preparatory upper secondary education* (*PUSE, da: Studentereksamen*) no later than October 1983
# Descriptives

## Education and fertility (2005)

<table>
<thead>
<tr>
<th>Education</th>
<th>% chless</th>
<th>Avg. children</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSE</td>
<td>17.8</td>
<td>1.71</td>
<td>1169</td>
<td>14.6</td>
</tr>
<tr>
<td>Vocational</td>
<td>13.2</td>
<td>1.84</td>
<td>1317</td>
<td>16.4</td>
</tr>
<tr>
<td>Short tertiary</td>
<td>14.7</td>
<td>1.80</td>
<td>672</td>
<td>8.4</td>
</tr>
<tr>
<td>Medium tertiary</td>
<td>11.4</td>
<td>1.97</td>
<td>3544</td>
<td>44.1</td>
</tr>
<tr>
<td>Long tertiary</td>
<td>16.7</td>
<td>1.81</td>
<td>1330</td>
<td>16.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13.8</strong></td>
<td><strong>1.87</strong></td>
<td><strong>8032</strong></td>
<td><strong>100.1</strong></td>
</tr>
</tbody>
</table>
## Descriptives

**Education and fertility (2005)**

<table>
<thead>
<tr>
<th>Education</th>
<th>% chless</th>
<th>Avg. children</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSE</td>
<td>17.8</td>
<td>1.71</td>
<td>1169</td>
<td>14.6</td>
</tr>
<tr>
<td>Vocational</td>
<td>13.2</td>
<td>1.84</td>
<td>1317</td>
<td>16.4</td>
</tr>
<tr>
<td>Short tertiary</td>
<td>14.7</td>
<td>1.80</td>
<td>672</td>
<td>8.4</td>
</tr>
<tr>
<td><strong>Medium tertiary</strong></td>
<td>11.4</td>
<td>1.97</td>
<td>3544</td>
<td>44.1</td>
</tr>
<tr>
<td>Long tertiary</td>
<td>16.7</td>
<td>1.81</td>
<td>1330</td>
<td>16.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13.8</td>
<td>1.87</td>
<td>8032</td>
<td>100.1</td>
</tr>
</tbody>
</table>
## Descriptives

**Education and fertility (2005)**

<table>
<thead>
<tr>
<th>Education</th>
<th>% chless</th>
<th>Avg. children</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSE</td>
<td>17.8</td>
<td>1.71</td>
<td>1169</td>
<td>14.6</td>
</tr>
<tr>
<td>Vocational</td>
<td>13.2</td>
<td>1.84</td>
<td>1317</td>
<td>16.4</td>
</tr>
<tr>
<td>Short tertiary</td>
<td>14.7</td>
<td>1.80</td>
<td>672</td>
<td>8.4</td>
</tr>
<tr>
<td>Medium tertiary</td>
<td><strong>11.4</strong></td>
<td><strong>1.97</strong></td>
<td>3544</td>
<td><strong>44.1</strong></td>
</tr>
<tr>
<td>Long tertiary</td>
<td>16.7</td>
<td>1.81</td>
<td>1330</td>
<td>16.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13.8</strong></td>
<td><strong>1.87</strong></td>
<td><strong>8032</strong></td>
<td><strong>100.1</strong></td>
</tr>
</tbody>
</table>
### Descriptives

**Education and fertility (2005)**

<table>
<thead>
<tr>
<th>Education</th>
<th>% chless</th>
<th>Avg. children</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSE</td>
<td>17.8</td>
<td>1.71</td>
<td>1169</td>
<td>14.6</td>
</tr>
<tr>
<td>Vocational</td>
<td>13.2</td>
<td>1.84</td>
<td>1317</td>
<td>16.4</td>
</tr>
<tr>
<td>Short tertiary</td>
<td>14.7</td>
<td>1.80</td>
<td>672</td>
<td>8.4</td>
</tr>
<tr>
<td>Medium tertiary</td>
<td>11.4</td>
<td>1.97</td>
<td>3544</td>
<td>44.1</td>
</tr>
<tr>
<td>Long tertiary</td>
<td>16.7</td>
<td>1.81</td>
<td>1330</td>
<td>16.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13.8</strong></td>
<td><strong>1.87</strong></td>
<td><strong>8032</strong></td>
<td><strong>100.1</strong></td>
</tr>
</tbody>
</table>
### Descriptives

**Education and fertility (2005)**

<table>
<thead>
<tr>
<th>Education</th>
<th>% chless</th>
<th>Avg. children</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSE</td>
<td>17.8</td>
<td>1.71</td>
<td>1169</td>
<td>14.6</td>
</tr>
<tr>
<td>Vocational</td>
<td>13.2</td>
<td>1.84</td>
<td>1317</td>
<td>16.4</td>
</tr>
<tr>
<td>Short tertiary</td>
<td>14.7</td>
<td>1.80</td>
<td>672</td>
<td>8.4</td>
</tr>
<tr>
<td>Medium tertiary</td>
<td>11.4</td>
<td>1.97</td>
<td>3544</td>
<td>44.1</td>
</tr>
<tr>
<td>Long tertiary</td>
<td>16.7</td>
<td>1.81</td>
<td>1330</td>
<td>16.6</td>
</tr>
</tbody>
</table>

**Total**          | 13.8     | 1.87          | 8032      | 100.1    |
Feedback

Intuition

- We wish to assess to which extent educational differences in ultimate fertility are attributable to feedback patterns

- **Example:**
  - Assume women who become mothers while enrolled in university are more inclined to interrupt/change to a shorter one (deviate from their original strategy as a result of their fertility)
  - → fewer children among highly educated women

- The birth process itself acts as a *time-dependent confounder* for the effect of education on fertility
Feedback

Intuition

- We wish to assess to which extent educational differences in ultimate fertility are attributable to feedback patterns
- **Example:**
  - Assume women who become mothers while enrolled in university are more inclined to interrupt/change to a shorter one (deviate from their original strategy as a result of their fertility)
  - → fewer children among highly educated women
- The birth process itself acts as a time-dependent confounder for the effect of education on fertility
Feedback

Intuition

- We wish to assess to which extent educational differences in ultimate fertility are attributable to feedback patterns.

- **Example:**
  - Assume women who become mothers while enrolled in university are more inclined to interrupt/change to a shorter one (deviate from their original strategy as a result of their fertility).
  - Fewer children among highly educated women.

- The birth process itself acts as a *time-dependent confounder* for the effect of education on fertility.
Feedback

Intuition

- We wish to assess to which extent educational differences in ultimate fertility are attributable to feedback patterns
- **Example:**
  - Assume women who become mothers while enrolled in university are more inclined to interrupt/change to a shorter one (deviate from their original strategy as a result of their fertility)
  - \(\rightarrow\) fewer children among highly educated women
- The birth process itself acts as a *time-dependent confounder* for the effect of education on fertility
Feedback

Intuition

- We wish to assess to which extent educational differences in ultimate fertility are attributable to feedback patterns
- Example:
  - Assume women who become mothers while enrolled in university are more inclined to interrupt/change to a shorter one (deviate from their original strategy as a result of their fertility)
    - → fewer children among highly educated women
- The birth process itself acts as a *time-dependent confounder* for the effect of education on fertility
Feedback
Is it in the data? Can we remove it?

1. Is feedback present in the study population at hand?
2. If so, to which extent are the educational differences in ultimate fertility attributable to the feedback?
3. Educational differences in ultimate fertility if there were no feedback?
4. One particular aspect of ultimate fertility: What is the probability of having 3 children at age 41 for different educational attainments?
Feedback (Endogeneity)
Definition [Hernán et al., 2001]

- Assume study population followed throughout the time-period \( \{0, 1, \ldots, T\} \)
- Let \( B(t) \) be the fertility process and \( E(t) \) the education process
- Feedback: If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition

\[
E(t) \prod_{\substack{t=2} \overset{t-1}{\cdots}} B(t) \mid (E(t-1), Z)
\]

is not met.

- Endogeneity (vs. exogeneity)
Feedback (Endogeneity)
Definition [Hernán et al., 2001]

- Assume study population followed throughout the time-period \(\{0, 1, \ldots, T\}\)
- Let \(B(t)\) be the fertility process and \(E(t)\) the education process
- Feedback: If there exists \(t \in \{0, 1, \ldots, T\}\) s.t. the condition

\[ E(t) \big| B(t), E(t-1), Z \]

is not met.
- Endogeneity (vs. exogeneity)
Feedback (Endogeneity)
Definition [Hernán et al., 2001]

- Assume study population followed throughout the time-period \( \{0, 1, \ldots, T\} \)
- Let \( B(t) \) be the fertility process and \( E(t) \) the education process
- Feedback: If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition
  \[
  E(t) \prod_{t=1}^{T} B(t) \mid (\bar{E}(t-1), Z)
  \]
  is not met.
- Endogeneity (vs. exogeneity)
Feedback (Endogeneity)

Definition [Hernán et al., 2001]

- Assume study population followed throughout the time-period \( \{0, 1, \ldots, T\} \)
- Let \( B(t) \) be the fertility process and \( E(t) \) the education process
- Feedback: If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition

\[
E(t) \prod \bar{B}(t) \mid (\bar{E}(t-1), Z)
\]

is not met.

- **Endogeneity** (vs. exogeneity)
Is feedback present in the study population?

**Young mothers and drop-outs**

- Mother before 1986 - education in 2005?  
  Table
- Leaving education after birth - education in 2005?  
  Table

**Model probability of dropping out of education**

- $Y_{it}$: indicator for woman $i$ interrupting educational enrolment in year $t$ (cond. on being enrolled)
- $\text{logit } [\Pr(Y_{it} \mid X_{it}, Z_i, \text{enrolled})] = \alpha + \beta' \cdot X_{it} + \gamma' \cdot Z_i$
- Interaction between giving birth and education in which she is enrolled  
  Illustration
Is feedback present in the study population?

**Young mothers and drop-outs**

- Mother before 1986 - education in 2005?  
  ![Table]
- Leaving education after birth - education in 2005?  
  ![Table]

**Model probability of dropping out of education**

- $Y_{it}$: indicator for woman $i$ interrupting educational enrolment in year $t$ (cond. on being enrolled)
- $\text{logit} \left[ \Pr \left( Y_{it} \mid X_{it}, Z_i, \text{enrolled} \right) \right] = \alpha + \beta' \cdot X_{it} + \gamma' \cdot Z_i$
- Interaction between giving birth and education in which she is enrolled  
  ![Illustration]
Educational differences if there were no feedback?
Marginal Structural Models (MSM) [Hernán et al., 2001]

Potential Outcomes:

$Y_e$: the indicator of being a mother of 3 children (as opposed to less than 3) by age 41 if educational strategy $e$ were followed

Marginal Structural Model (MSM):

$$\text{logit} \left[ \Pr(Y_e = 1 \mid Z_i) \right] = \delta_1 + \epsilon_1 \cdot Z_i + \phi_1 \cdot f(e)$$

How to assess information on potential outcomes?
Use observed data - along with a suitable set of assumptions
Educational differences if there were no feedback?
Marginal Structural Models (MSM) [Hernán et al., 2001]

Potential Outcomes:

$Y^{e}$: the indicator of being a mother of 3 children (as opposed to less than 3) by age 41 if educational strategy $\bar{e}$ were followed

Marginal Structural Model (MSM):

$$\text{logit} \left[ \Pr(Y^{e} = 1 \mid Z_i) \right] = \delta_1 + \epsilon_1 \cdot Z_i + \phi_1 \cdot f(\bar{e})$$

How to assess information on potential outcomes?
Use observed data - along with a suitable set of assumptions
Educational differences if there were no feedback?
Marginal Structural Models (MSM) [Hernán et al., 2001]

Potential Outcomes:

$Y^\bar{e}$: the indicator of being a mother of 3 children (as opposed to less than 3) by age 41 if educational strategy $\bar{e}$ were followed

Marginal Structural Model (MSM):

$$\text{logit} \left[ \frac{\text{Pr}(Y^\bar{e} = 1 | Z_i)}{\text{Pr}(Y^\bar{e} = 0 | Z_i)} \right] = \delta_1 + \epsilon_1 \cdot Z_i + \phi_1 \cdot f(\bar{e})$$

How to assess information on potential outcomes?
Use observed data - along with a suitable set of assumptions
Marginal Structural Models (contd)

Inverse Probability of Treatment Weights

- **Idea:** re-weight the original population to construct a hypothetical (pseudo-) population which is free of feedback

\[ \hat{SW}_i(T + 1) = \prod_{s \leq T} \frac{\hat{Pr}(E_i(s) = e_{is} | \overline{E}_i(s - 1), Z_i)}{\hat{Pr}(E_i(s) = e_{is} | \overline{E}_i(s - 1), \overline{B}(s), Z_i)} \]

- Recall the definition of *feedback*:
  If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition

\[ E(t) \prod \overline{B}(t) | (\overline{E}(t - 1), Z) \]

is not met

- The weights need to be estimated - need models
Marginal Structural Models (contd)
Inverse Probability of Treatment Weights

- Idea: re-weight the original population to construct a hypothetical (pseudo-) population which is free of feedback

\[ SW_i(T + 1) = \prod_{s \leq T} \frac{\Pr(E_i(s) = e_{is} \mid \bar{E}_i(s - 1), Z_i)}{\Pr(E_i(s) = e_{is} \mid \bar{E}_i(s - 1), \bar{B}(s), Z_i)} \]

- Recall the definition of feedback:
  If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition
  \[ E(t) \prod \bar{B}(t) \mid (\bar{E}(t - 1), Z) \]
  is not met

- The weights need to be estimated - need models
Marginal Structural Models (contd)

Inverse Probability of Treatment Weights

- Idea: re-weight the original population to construct a hypothetical (pseudo-) population which is free of feedback

\[
SW_i(T + 1) = \prod_{s \leq T} \frac{Pr(E_i(s) = e_{is} | \overline{E}_i(s - 1), Z_i)}{Pr(E_i(s) = e_{is} | \overline{E}_i(s - 1), B(s), Z_i)}
\]

- Recall the definition of feedback:
  If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition

\[
E(t) \prod \overline{B}(t) | (\overline{E}(t - 1), Z)
\]

is not met

- The weights need to be estimated - need models
Marginal Structural Models (contd)

Inverse Probability of Treatment Weights

- Idea: re-weight the original population to construct a hypothetical (pseudo-) population which is free of feedback

\[ \hat{SW}_i(T + 1) = \prod_{s \leq T} \frac{\hat{Pr}(E_i(s) = e_{is} \mid \bar{E}_i(s - 1), Z_i)}{\hat{Pr}(E_i(s) = e_{is} \mid \bar{E}_i(s - 1), B(s), Z_i)} \]

- Recall the definition of feedback:
  If there exists \( t \in \{0, 1, \ldots, T\} \) s.t. the condition
  \[ E(t) \prod \bar{B}(t) \mid (\bar{E}(t - 1), Z) \]
  is not met

- The weights need to be estimated - need models
By employing the weighting technique we get a hypothetical population in which some women are "weighted up" and some are "weighted down" - and by construction the educational attainment in 2005 is not affected by previous fertility.

Hence, by using this population we can answer the question: What would be the educational differences in the odds of being a mother of 3 - if there were no feedback in the data?
The hypothetical population
The pseudo-population

By employing the weighting technique we get a hypothetical population in which some women are "weighted up" and some are "weighted down" - and by construction the educational attainment in 2005 is not affected by previous fertility.

Hence, by using this population we can answer the question: What would be the educational differences in the odds of being a mother of 3 - if there were no feedback in the data?
Example

Imagine a woman who...

- Takes her *Studentereksamen* in 1983, enrols in university
- Becomes a mother 1984
- Leaves university, start nursing school 1985
- Graduates 1991, 2 more children at ages 30 and 32

Weights:

- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid E_i(1984), Z_i) = \frac{1}{20}$
- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid E_i(1984), B(1984), Z_i) = \frac{1}{10}$
- $\hat{SW}_i(2005) = 1 \cdot 1 \cdot (10)/20 \cdot 1 \cdots 1 = 0.5$
Example

Imagine a woman who...

- Takes her *Studentereksamen* in 1983, enrols in university
- Becomes a mother 1984
- Leaves university, start nursing school 1985
- Graduates 1991, 2 more children at ages 30 and 32

Weights:

- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid \overline{E}_i(1984), Z_i) = \frac{1}{20}$
- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid \overline{E}_i(1984), B(1984), Z_i) = \frac{1}{10}$
- $\hat{SW}_i(2005) = 1 \cdot 1 \cdot (10)/20 \cdot 1 \cdots 1 = 0.5$
Example

Imagine a woman who...

- Takes her *Studentereksamen* in 1983, enrolls in university
- Becomes a mother 1984
- Leaves university, starts nursing school 1985
- Graduates 1991, 2 more children at ages 30 and 32

Weights:

- \[ \hat{\Pr}(E_i(1985) = \text{nurse} \mid \bar{E}_i(1984), Z_i) = \frac{1}{20} \]
- \[ \hat{\Pr}(E_i(1985) = \text{nurse} \mid \bar{E}_i(1984), \bar{B}(1984), Z_i) = \frac{1}{10} \]
- \[ \hat{SW}_i(2005) = 1 \cdot 1 \cdot (10)/20 \cdot 1 \cdots 1 = 0.5 \]
Imagine a woman who...

- Takes her *Studentereksamen* in 1983, enrols in university
- Becomes a mother 1984
- Leaves university, start nursing school 1985
- Graduates 1991, 2 more children at ages 30 and 32

Weights:

- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid \overline{E}_i(1984), Z_i) = \frac{1}{20}$
- $\hat{\Pr}(E_i(1985) = \text{nurse} \mid \overline{E}_i(1984), \overline{B}(1984), Z_i) = \frac{1}{10}$
- $\hat{SW}_i(2005) = 1 \cdot 1 \cdot (10)/20 \cdot 1 \cdots 1 = 0.5$
Results
Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual:</th>
<th></th>
<th>Hypothetical:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>p-value</td>
<td>OR</td>
<td>p-value</td>
</tr>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
# Results

## Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
## Results

### Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*(controlled for baseline variables)*
### Results

**Actual vs. hypothetical population**

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>Enrolled: T(m)</strong></td>
<td><strong>1.47</strong></td>
<td><strong>0.07</strong></td>
<td><strong>1.22</strong></td>
<td><strong>0.24</strong></td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*(controlled for baseline variables)*
Results

Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td><strong>Tert(m)</strong></td>
<td><strong>1.32</strong></td>
<td><strong>0.001</strong></td>
<td><strong>0.65</strong></td>
<td><strong>&lt; .0001</strong></td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
## Results

### Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
### Results

**Actual vs. hypothetical population**

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td>0.65</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*(controlled for baseline variables)*
## Results

**Actual vs. hypothetical population**

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual: OR</th>
<th>p-value</th>
<th>Hypothetical: OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
<td>0.36</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
<td>0.46</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
<td>0.51</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
<td><strong>0.65</strong></td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
<td>1.13</td>
<td>0.80</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
<td>1.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
<td>1.52</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
## Results

### Actual vs. hypothetical population

<table>
<thead>
<tr>
<th>Education (2005)</th>
<th>Actual:</th>
<th>Hypothetical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>p-value</td>
</tr>
<tr>
<td>Never enrolled</td>
<td>0.84</td>
<td>0.15</td>
</tr>
<tr>
<td>Prev enrolled</td>
<td>0.81</td>
<td>0.12</td>
</tr>
<tr>
<td>Tert(s)/voc</td>
<td>0.92</td>
<td>0.40</td>
</tr>
<tr>
<td>Tert(m)</td>
<td>1.32</td>
<td>0.001</td>
</tr>
<tr>
<td>Tert(l) (REF)</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Enrolled: T(s)/voc</td>
<td>2.54</td>
<td>0.02</td>
</tr>
<tr>
<td>Enrolled: T(m)</td>
<td>1.47</td>
<td>0.07</td>
</tr>
<tr>
<td>Enrolled: T(l)</td>
<td>0.97</td>
<td>0.91</td>
</tr>
</tbody>
</table>

(controlled for baseline variables)
Assumptions
are they possibly violated?

4 main assumptions:
1. Exchangeability (no unmeasured confounders) \( Y_e \perp\!
\perp E \mid Z \)
2. No mis-specification of the models for the weights
3. Consistency
4. Positivity

All of these are important → all subject to possible violations
Not testable...
Assumptions
are they possibly violated?

4 main assumptions:

1. Exchangeability (no unmeasured confounders) $Y_e \perp \perp E \mid Z$

2. No mis-specification of the models for the weights

3. Consistency

4. Positivity

All of these are important → all subject to possible violations

Not testable...
Assumptions
are they possibly violated?

4 main assumptions:

1. Exchangeability (no unmeasured confounders) $Y_e \perp E \mid Z$

2. No mis-specification of the models for the weights

3. Consistency

4. Positivity

All of these are important $\rightarrow$ all subject to possible violations

Not testable...
Assumptions
are they possibly violated?

▶ 4 main assumptions:
1. Exchangeability (no unmeasured confounders) $Y_e \perp\!
\!
\!\perp E \mid Z$
   
   baseline cov

2. No mis-specification of the models for the weights

3. Consistency

4. Positivity

▶ All of these are important $\rightarrow$ all subject to possible violations

▶ Not testable...
Assumptions
are they possibly violated?

► 4 main assumptions:

1. Exchangeability (no unmeasured confounders) \( Y_e \perp E \mid Z \)  
   - baseline cov

2. No mis-specification of the models for the weights

3. Consistency

4. Positivity

► All of these are important → all subject to possible violations

► Not testable...
Assumptions
are they possibly violated?

▶ 4 main assumptions:
1. Exchangeability (no unmeasured confounders) $Y_e \perp\!
\perp E \mid Z$
2. No mis-specification of the models for the weights
3. Consistency
4. Positivity

▶ All of these are important $\rightarrow$ all subject to possible violations

▶ Not testable...
Assumptions
are they possibly violated?

4 main assumptions:
1. Exchangeability (no unmeasured confounders) \( Y_e \perp \parallel E \mid Z \)
2. No mis-specification of the models for the weights
3. Consistency
4. Positivity

All of these are important \( \rightarrow \) all subject to possible violations

Not testable...
Conclusion

Ultimate fertility in Denmark

- There are educational differences in ultimate fertility
- There is some tendency that women who become mothers while enrolled in education are more likely to drop out and women who become mothers early are less likely to have a university degree, more likely to have no further degree or a T(m)
- This might play a role in the relationship between ultimate fertility and educational attainment
Conclusion

Ultimate fertility in Denmark

- There are educational differences in ultimate fertility
- There is some tendency that women who become mothers while enrolled in education are more likely to drop out and women who become mothers early are less likely to have a university degree, more likely to have no further degree or a T(m)
- This might play a role in the relationship between ultimate fertility and educational attainment
Conclusion

Ultimate fertility in Denmark

- There are educational differences in ultimate fertility
- There is some tendency that women who become mothers while enrolled in education are more likely to drop out and women who become mothers early are less likely to have a university degree, more likely to have no further degree or a T(m)
- This might play a role in the relationship between ultimate fertility and educational attainment
Thank you very much!
References


Assumptions for MSMs

Exchangeability

Need to include enough baseline covariates, $Z$, s.t. within each subgroup defined by these, the women are exchangeable:

In this study, $Z$ includes:

1. mark attained at the PUSE
2. number of mother-siblings
3. grandmother’s age at first birth
4. grandmother’s and grandfather’s educational attainment

What’s missing? Health, men, others?
Assumptions for MSMs
Exchangeability

Need to include enough baseline covariates, $Z$, s.t. within each subgroup defined by these, the women are exchangeable:

In this study, $Z$ includes:

1. mark attained at the PUSE
2. number of mother-siblings
3. grandmother’s age at first birth
4. grandmother’s and grandfather’s educational attainment

What’s missing? Health, men, others?
Assumptions for MSMs

Exchangeability

Need to include enough baseline covariates, $Z$, s.t. within each subgroup defined by these, the women are exchangeable:

In this study, $Z$ includes:

1. mark attained at the PUSE
2. number of mother-siblings
3. grandmother’s age at first birth
4. grandmother’s and grandfather’s educational attainment

What’s missing? Health, men, others?
Model for the weights

Models

\[
\log \left[ \frac{\pi_{ikt}}{\pi_{i1t}} \right] = \alpha_k + \beta_k \cdot A_{it} + \gamma_k \cdot Z_i, \quad k = 2, \ldots, 8
\]

\[
\log \left[ \frac{\pi_{ikt}}{\pi_{i1t}} \right] = \alpha_k + \beta_k \cdot A_{it} + \gamma_k \cdot Z_i + \delta_{k1} \cdot B_{i,t-1} + \delta_{k2} \cdot B_{i,t-2}
\]

where \( \pi_{ikt} = \Pr(E_i(t) = k) \)

Categories (\( k \)):

1. **not enrolled**, several subcategories
2. **enrolled**, several subcategories
## Final educational attainments

### Ever enrolled in university

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone</td>
<td>14.6%</td>
<td>24.8%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>

### Ever enrolled in university → child (yes/no)

<table>
<thead>
<tr>
<th></th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td>24.8%</td>
<td>5.7%</td>
<td>51.4%</td>
<td>18.1%</td>
<td>105</td>
</tr>
<tr>
<td>No child</td>
<td>16.7%</td>
<td>10.6%</td>
<td>43.2%</td>
<td>29.4%</td>
<td>902</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>
## Final educational attainments

### Ever enrolled in university

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone</td>
<td>14.6%</td>
<td>24.8%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>

### Ever enrolled in university → child(yes/no)

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td>24.8%</td>
<td>5.7%</td>
<td>51.4%</td>
<td>18.1%</td>
<td>105</td>
</tr>
<tr>
<td>No child</td>
<td>16.7%</td>
<td>10.6%</td>
<td>43.2%</td>
<td>29.4%</td>
<td>902</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>
## Final educational attainments

### Ever enrolled in university

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone</td>
<td>14.6%</td>
<td>24.8%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>

### Ever enrolled in university → child(yes/no)

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td>24.8%</td>
<td>5.7%</td>
<td>51.4%</td>
<td>18.1%</td>
<td>105</td>
</tr>
<tr>
<td>No child</td>
<td>16.7%</td>
<td>10.6%</td>
<td>43.2%</td>
<td>29.4%</td>
<td>902</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>
## Final educational attainments

### Ever enrolled in university

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone</td>
<td>14.6%</td>
<td>24.8%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>

### Ever enrolled in university → child(yes/no)

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td>24.8%</td>
<td>5.7%</td>
<td>51.4%</td>
<td>18.1%</td>
<td>105</td>
</tr>
<tr>
<td>No child</td>
<td>16.7%</td>
<td>10.6%</td>
<td>43.2%</td>
<td>29.4%</td>
<td>902</td>
</tr>
<tr>
<td>Int/Change</td>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
</tr>
</tbody>
</table>
## Final educational attainments

### Ever enrolled in university

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Everyone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.6%</td>
<td>24.8%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
<td></td>
</tr>
<tr>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
<td></td>
</tr>
</tbody>
</table>

### Ever enrolled in university → child(yes/no)

<table>
<thead>
<tr>
<th>Edu(2005)</th>
<th>PUSE</th>
<th>Voc/T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.8%</td>
<td>5.7%</td>
<td>51.4%</td>
<td>18.1%</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>16.7%</td>
<td>10.6%</td>
<td>43.2%</td>
<td>29.4%</td>
<td>902</td>
<td></td>
</tr>
<tr>
<td><strong>No child</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.6%</td>
<td>10.1%</td>
<td>44.1%</td>
<td>28.2%</td>
<td>1007</td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td>PUSE</td>
<td>Voc</td>
<td>T(s)</td>
<td>T(m)</td>
<td>T(l)</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>No</td>
<td>14.4%</td>
<td>16.2%</td>
<td>8.5%</td>
<td>44.0%</td>
<td>17.0%</td>
</tr>
<tr>
<td>Yes</td>
<td>18.0%</td>
<td>21.4%</td>
<td>6.5%</td>
<td>47.6%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Total</td>
<td>14.6%</td>
<td>16.4%</td>
<td>8.4%</td>
<td>44.1%</td>
<td>16.6%</td>
</tr>
<tr>
<td>Mother</td>
<td>PUSE</td>
<td>Voc</td>
<td>T(s)</td>
<td>T(m)</td>
<td>T(l)</td>
</tr>
<tr>
<td>--------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>No</td>
<td>14.4%</td>
<td>16.2%</td>
<td>8.5%</td>
<td>44.0%</td>
<td>17.0%</td>
</tr>
<tr>
<td>Yes</td>
<td>18.0%</td>
<td>21.4%</td>
<td>6.5%</td>
<td>47.6%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Total</td>
<td>14.6%</td>
<td>16.4%</td>
<td>8.4%</td>
<td>44.1%</td>
<td>16.6%</td>
</tr>
</tbody>
</table>
### Mothers by Jan 1st 1986 by education (2005)

<table>
<thead>
<tr>
<th>Mother</th>
<th>PUSE</th>
<th>Voc</th>
<th>T(s)</th>
<th>T(m)</th>
<th>T(l)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>14.4%</td>
<td>16.2%</td>
<td>8.5%</td>
<td>44.0%</td>
<td>17.0%</td>
<td>7677</td>
</tr>
<tr>
<td>Yes</td>
<td>18.0%</td>
<td>21.4%</td>
<td>6.5%</td>
<td>47.6%</td>
<td>6.5%</td>
<td>355</td>
</tr>
<tr>
<td>Total</td>
<td>14.6%</td>
<td>16.4%</td>
<td>8.4%</td>
<td>44.1%</td>
<td>16.6%</td>
<td>8032</td>
</tr>
</tbody>
</table>
Is feedback present in the study population?

Birth this year

$\hat{\beta}_1 = 1.27$

$\hat{\beta}_2 = 0.34$

$\hat{\beta}_3 = 0.39$

$\hat{\beta}_4 = 0.3$