Sibling Gender Composition and Participation in STEM Education

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Motivation

- Women attain more education than men in most OECD countries

  54 pct. of new entrants in tertiary edu are female (OECD 2016)
- Large differences in sex composition across fields of study
  - 28 pct. of new entrants within Science, Technology, Engineering, and Mathematics (STEM) are female
  - 75 pct. within Education, Health, and Welfare
- Returns to education vary greatly by field of study

  (Altonji et al. 2012; Kirkebøen et al. 2016)

Motivation

Why are women underrepresented in STEM?

- Differences in talent cannot explain these gender gaps (Kahn and Ginther 2017)
- Different aspects of the social environment affect gender differences in math test scores
  E.g. teacher gender bias, gender peer composition, teacher gender, parents' gendered stereotype beliefs and expectations, cultural stereotypes (see references in Kahn and Ginther 2017)
- Few studies trace effects into actual choice of studying and working within STEM

Research Question and Contributions

How does sibling gender composition affect participation in STEM fields?

1. Educational STEM choice from first place of enrollment after grade 9 through age 30
2. Causal estimation of sibling gender
3. Large quantitative analysis of child-parent interactions (mechanisms)

Imagine Two Girls

Barbara has a younger Brother

Sarah has a younger Sister

- Siblings as peers might interact differently
- Exposure to gender-stereotypical behavior $\Rightarrow$ acquisition of traditional gender norms
  (Booth et al. 2014; Schneeweis and Zweimüller 2012)

Imagine Two Girls and Their Parents

- Parental gender-specific investments: time, type of activities, etc.

Preview of Findings

1. Having an opposite sex sib: ↑ gender-typed enrollment
   - Women: ↓ enroll in and complete STEM education
     Effects persist into occupation and labor earnings
   - Men: ↑ enroll in STEM, not completion
   - No effect on educational achievement or attainment
   - Not due to family size
2. Likely mechanism: gender-specific parenting
   - Parents of mixed sex children invest more time in their first-born same sex child
   - Strongest effects among individuals with a more "gender-stereotypical" same sex parent

   ⇒ Stronger transmission of traditional gender norms in families with mixed sex children

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Empirical Strategy

- Natural Experiment: second child's gender is random, conditional on first child's gender and having a second child.

- Estimate separately for men and women:

$$Y_i^{First-Born} = \alpha_0 + \alpha_1 Opposite\ Sex_s^{Second-Born} + X_i'\delta + \epsilon_i$$

X_i: Fixed effects for birth municipality; year-month of birth; immigrant; spacing in months to younger sib; parents' age at birth and level-field of education/occupation

Data

- Danish administrative data from 1980–2015:
  - Link individual to parents and siblings
  - Annual data on:
    - Educational enrollment (level, type, field)
    - Highest completed educational degree
    - Labor earnings and occupation

- Sample restriction
  - Firstborn children (mother's *and* father's first child)
  - Born 1962–1986
  - Spacing to sib $<$ 4 years, same parents
  - No twins, child not first generation immigrant

Descriptive Statistics

Educational System in Denmark

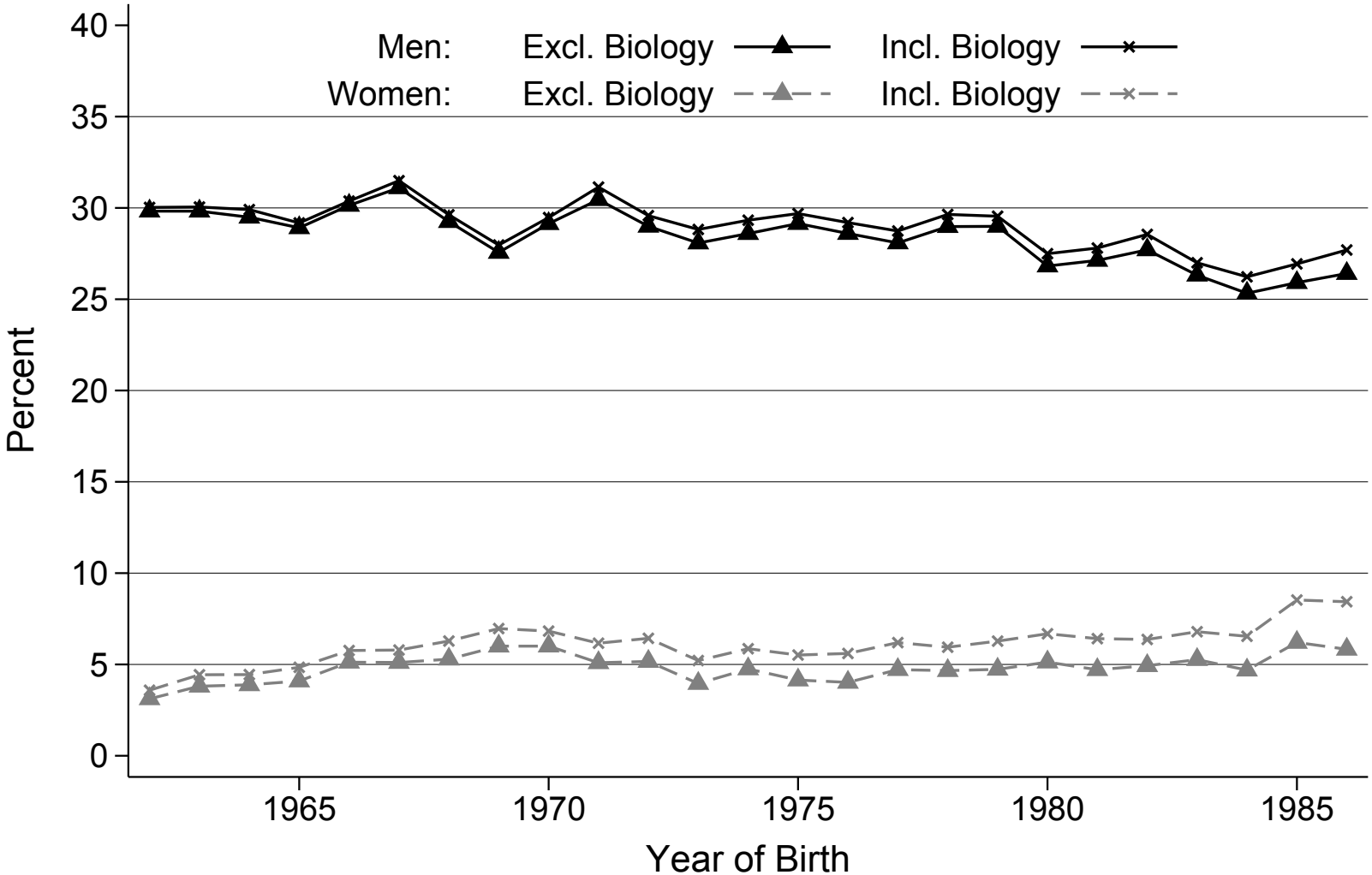
- Primary school 9 years (compulsory)
- Secondary school:
  - General academic (four tracks)
  - Vocational (various fields)
- Tertiary education:
  - Vocational (two-year college)
  - Professional (four-year college)
  - Academic (university)

Vocational

College

Male Share

Field-Specific STEM Degree at Age 30 by Gender



Field-Specific STEM Enrollment and Completion

Sample of First-Born	Women		Men	
	Enroll-ment (1)	Comple-tion (2)	Enroll-ment (3)	Comple-tion (4)
Second-Born Opposite Sex	-0.48***	-0.53***	0.80***	0.32
	(0.14)	(0.10)	(0.23)	(0.22)
Same Sex Baseline	8.7	5.0	40.9	28.5
Percent Effect	-5.5	-10.5	2.0	1.1
Observations	164,733		173,340	

Note: All estimates are multiplied by 100. STEM excluding Biology.

Graphs Women: detailed Men: detailed Labor Market

Summary of STEM Results

$\Rightarrow$ Opposite sex sib makes choice more gender-stereotypical

Only limited effect for men —But potent effect for women

- **Women**
  - Persistent effects from first enrollment after Grade 9 through occupational choice in mid-career
  - Lower earnings
- **Men**
  - Effect on STEM enrollment
  - No consistent effect on STEM completion or STEM occupation
- Educational Performance and Attainment
  - No effect $\Rightarrow$ effect through interest not ability

Performance Attainment

Possible Mechanisms: Changes in Identity

Overarching argument: individuals with an opposite sex sib more exposed to gender-stereotypical behavior and therefore more inclined to acquire traditional gender norms

- Child-parent interactions: Gender-specialized parenting
  - Parents more productive in creating own-sex human capital (Becker 1973; McHale et al. 2003; Stoneman et al. 1986)
  - Parents might derive more utility from spending time with same sex child
  - Parents spend more time and feel closer to same sex children (Bonke and Esping-Andersen 2009; Leaper et al. 1998; Maccoby 1990; Noller and Callan 1990)
- Child-sibling interactions: greater awareness of "appropriate" behavior for own gender

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- Child-sibling interactions: greater awareness of "appropriate" behavior for own gender

Parental Time Investment at Age 7 and 11

	Mother		Father	
	Age 7 (1)	Age 11 (2)	Age 7 (3)	Age 11 (4)
Sample of First-Born Girls				
Second-Born	0.14*	0.16*	-0.15*	-0.21**
Brother	(0.08)	(0.09)	(0.09)	(0.09)
Average	0.04	-0.00	-0.08	-0.08
Observations	657	616	470	453
Sample of First-Born Boys				
Second-Born	-0.15**	-0.18**	-0.08	-0.05
	(0.08)	(0.08)	(0.09)	(0.10)
Average	-0.04	0.00	0.07	0.08
Observations	694	645	514	460

Note: Parental quality time index (mean 0, SD 1)
Danish Longitudinal Survey of Children, born 1995

Parental Investment in Children

Parents of mixed sex children:

- gender-specialize time investment more
  especially in families with first-born daughter
- expose boys less to female-typed housework Housework
- worse relationship between fathers and daughters Relations

Parental gender-specialization also found in main sample

Non-traditional family: Opposite sex sib ↑ first-born child lives with same sex parent and second-born child with opposite sex parent

Family Structure

Heterogeneity

- Parental Field Field
  - Effects are concentrated among individuals with a more "gender-stereotypical" same sex parent
    Mother in Administration or Health —Father in STEM
- Parental Division of Labor Traditional
  - Women: No heterogeneity
  - Men: Effect is strongest among traditional families
    Father works $\geq$ 75 pct. of parental labor supply
- Spacing Spacing
  - Only effect for women $\leq$ 4 years
  - Only effect for men $\leq$ 2 years

Robustness to Family Size

- First-born children with second-born same sex sib have 0.07 more siblings Fertility
- Family size has no effect on educational attainment (Angrist et al. 2010; Black et al. 2005)
  - I replicate this finding for main sample, using twins as IV
  - ... and show no effect on STEM enrollment
  - Women: negative effect of family size on STEM completion

  $\Rightarrow$ Estimates of sib gender might be conservative for women

Family Size and STEM

Other Robustness Checks

Main results are robust to:

- Restricting sample to families with 2/3+ children
- Controlling for family size
- Definition of STEM and Care fields Narrow Field
- Same sign of correlation between second-born child's STEM choice and first-born's gender Second-Born
- Effect of co-twin's gender First parity Any parity

Conclusion

1. Having an opposite sex sib: ↑ gender-typed enrollment
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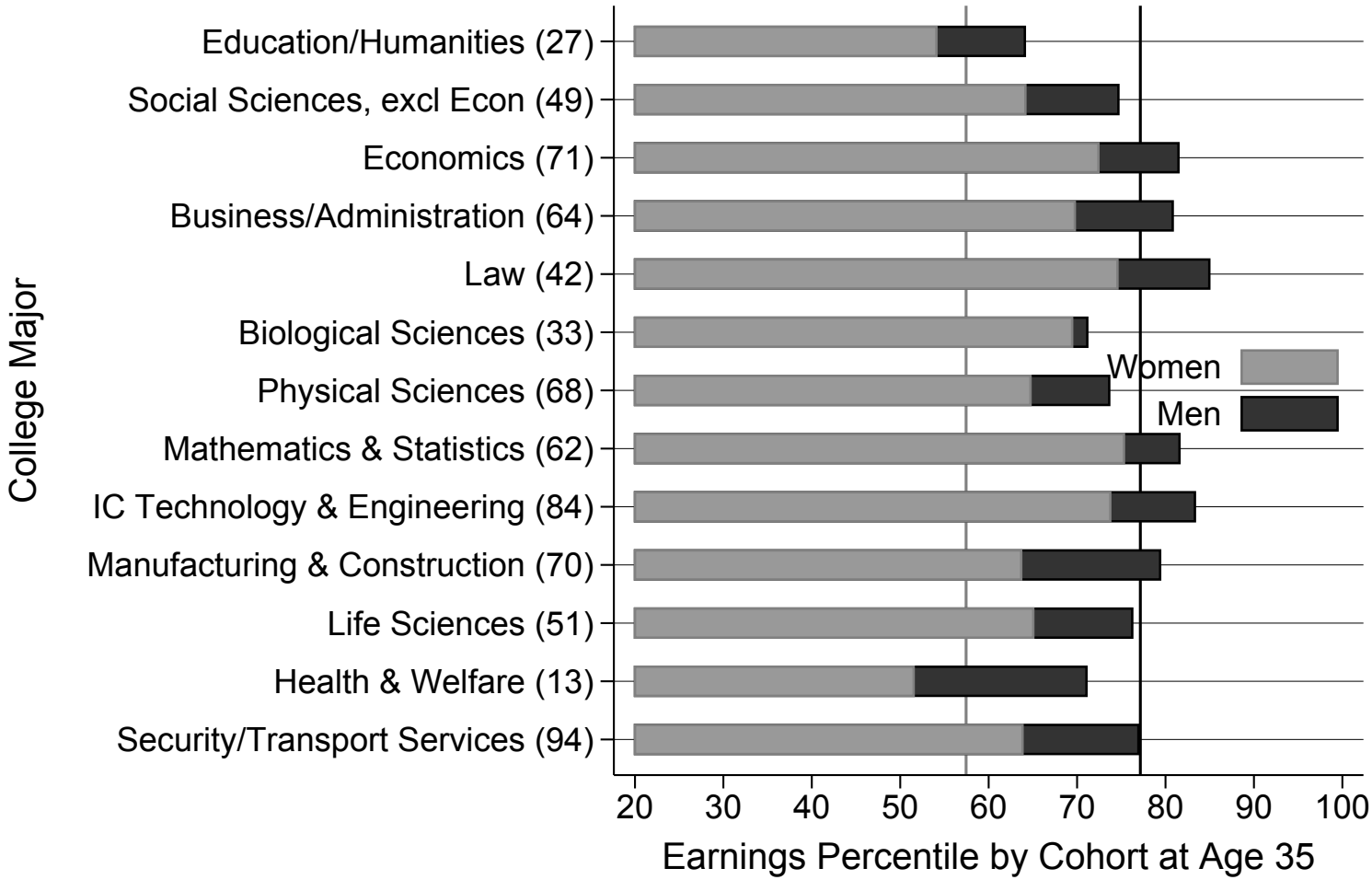
Implications

The family environment plays an important role for shaping STEM interests

1. Early interventions needed if we want to increase children's (girls') interests in math and science
2. More people in STEM, need to focus on early exposure to gender-stereotypes in the social environment
3. To give boys and girls same labor market opportunities, policy makers would need to focus on how to counteract the transmission of gender norms across generations

Thank you!

Ave Earnings Percentile at age 35 by College Field



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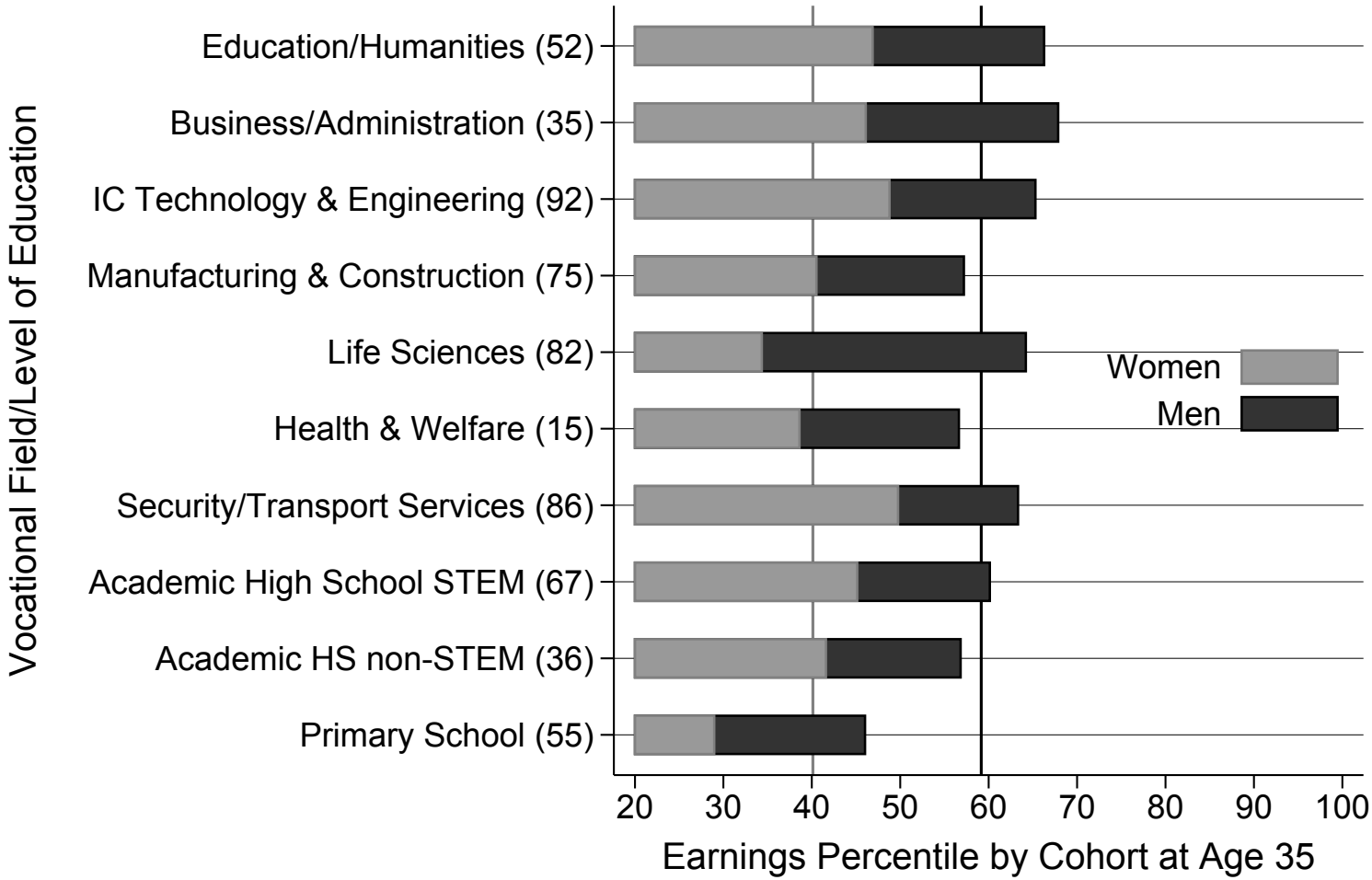
Ave Earnings Pctile at age 35 by Field and Type of Edu



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Descriptive Statistics

	First-Born Women		*First-Born Men*	
Panel A: Average by Gender of the Second-Born Sibling				
Second-Born	Sister (1)	Brother (2)	Sister (3)	Brother (4)
Spacing (months)	30.4	30.5	30.5	30.4
2^{nd} Gen. Immigrant (pct.)	1.2	1.2	1.2	1.1
Mother's age (years)	23.3	23.3	23.3	23.3
Father's age (years)	26.1	26.0	26.1	26.0
Mother's education (years)	11.2	11.2	11.2	11.2
Father's education (years)	12.0	12.0	12.0	12.0
Observations	80,593	84,140	84,360	88,980
Panel B: Balancing Test				
Joint F-statistic	0.90		0.95	
Prob $>$ F	0.98		0.83	

Note: Balancing Test of whether family background can predict having younger gender-discordant sibling.

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Women's Field-Spec STEM Edu: Brother-Sister

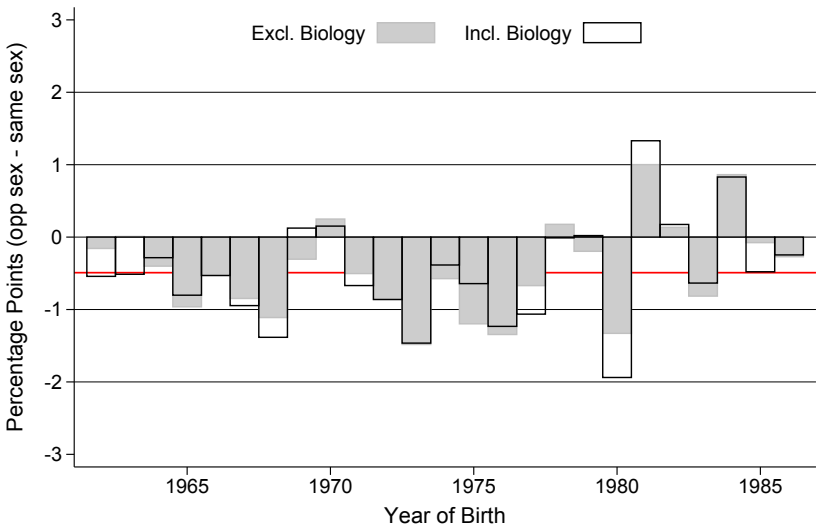

Figure: Enrollment

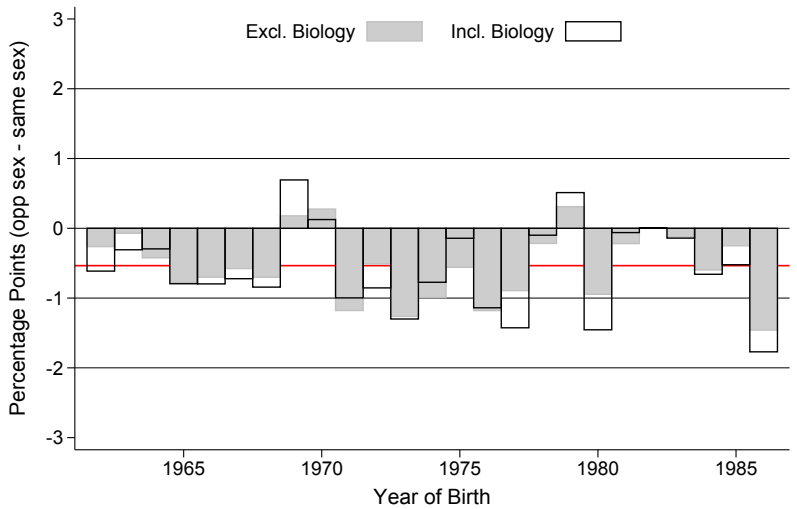

Figure: Completion

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Men's Field-Specific STEM Edu: Sister-Brother

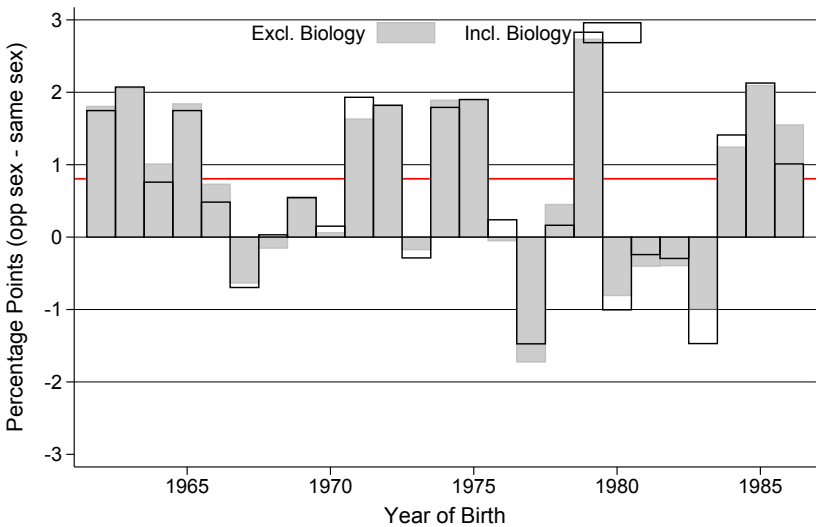

Figure: Enrollment

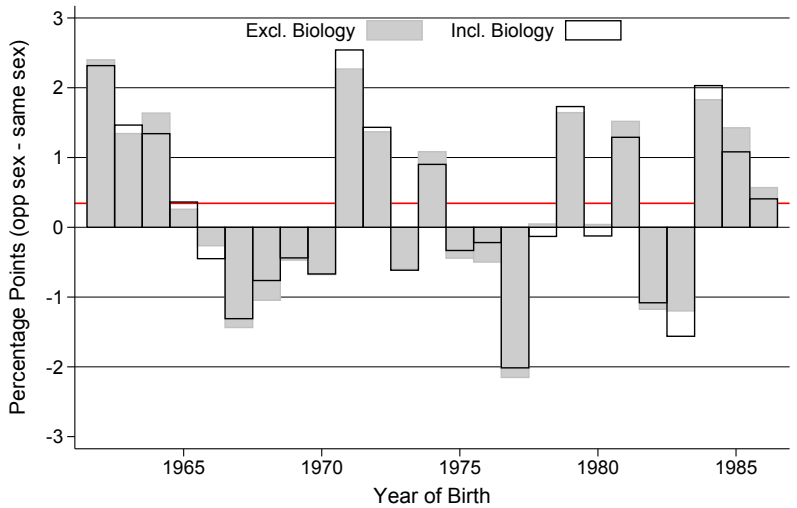

Figure: Completion

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Women: STEM Educational Process

	STEM in First	Academic HS STEM Track		Vocational STEM		College STEM Major	
	Enrollment	Enrollment	Completion	Enrollment	Completion	Enrollment	Completion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Second-Born Brother	-0.89***	-0.91***	-0.87***	-0.18*	-0.18***	-0.37***	-0.36***
	(0.21)	(0.22)	(0.19)	(0.11)	(0.07)	(0.10)	(0.08)
SS Baseline	25.7	26.7	20.8	4.2	2.0	4.9	3.1
Percent Effect	-3.5	-3.4	-4.2	-4.3	-9.0	-7.6	-11.5

Note: All estimates are multiplied by 100.

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Men: STEM Educational Process

	STEM in First	Academic HS STEM Track		Vocational STEM		College STEM Major	
	Enrollment (1)	Enrollment (2)	Completion (3)	Enrollment (4)	Completion (5)	Enrollment (6)	Completion (7)
Second-Born Sister	0.40*	0.22	0.12	0.53**	0.26	0.33**	0.09
	(0.24)	(0.23)	(0.19)	(0.22)	(0.20)	(0.15)	(0.13)
SS Baseline	51.5	36.0	25.2	30.4	21.0	12.5	8.3
Percent Effect	0.8	0.6	0.5	1.7	1.2	2.6	1.1

Note: All estimates are multiplied by 100.

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STEM Occupation and Labor Earnings

	Sample of First-Born Women				*Sample of First-Born Men*			
Age	21–25	26–30	31–35	36–40	21–25	26–30	31–35	36–40
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Share of Years in STEM Occupation				
Second-Born	-0.05	-0.14**	-0.34***	-0.45***	0.00	0.04	0.13	0.30*
Brother	(0.04)	(0.06)	(0.10)	(0.10)	(0.05)	(0.09)	(0.17)	(0.18)
Same Sex Baseline	1.1	2.4	4.5	4.6	2.1	5.8	11.9	12.3
Percent Effect	-4.7	-5.9	-7.5	-9.7	0.0	0.7	1.1	2.4
Observations	120,615	120,621	119,967	119,034	126,981	126,983	126,354	124,933
				Log(Labor Earnings)				
Second-Born	-0.07	-0.14	-1.27**	-1.50***	-0.40	-0.23	-1.58***	-1.47**
Sister	(0.51)	(0.61)	(0.52)	(0.50)	(0.49)	(0.49)	(0.54)	(0.57)
Observations	118,766	117,269	115,522	113,346	125,814	124,973	123,027	120,031

Note: All estimates are multiplied by 100.

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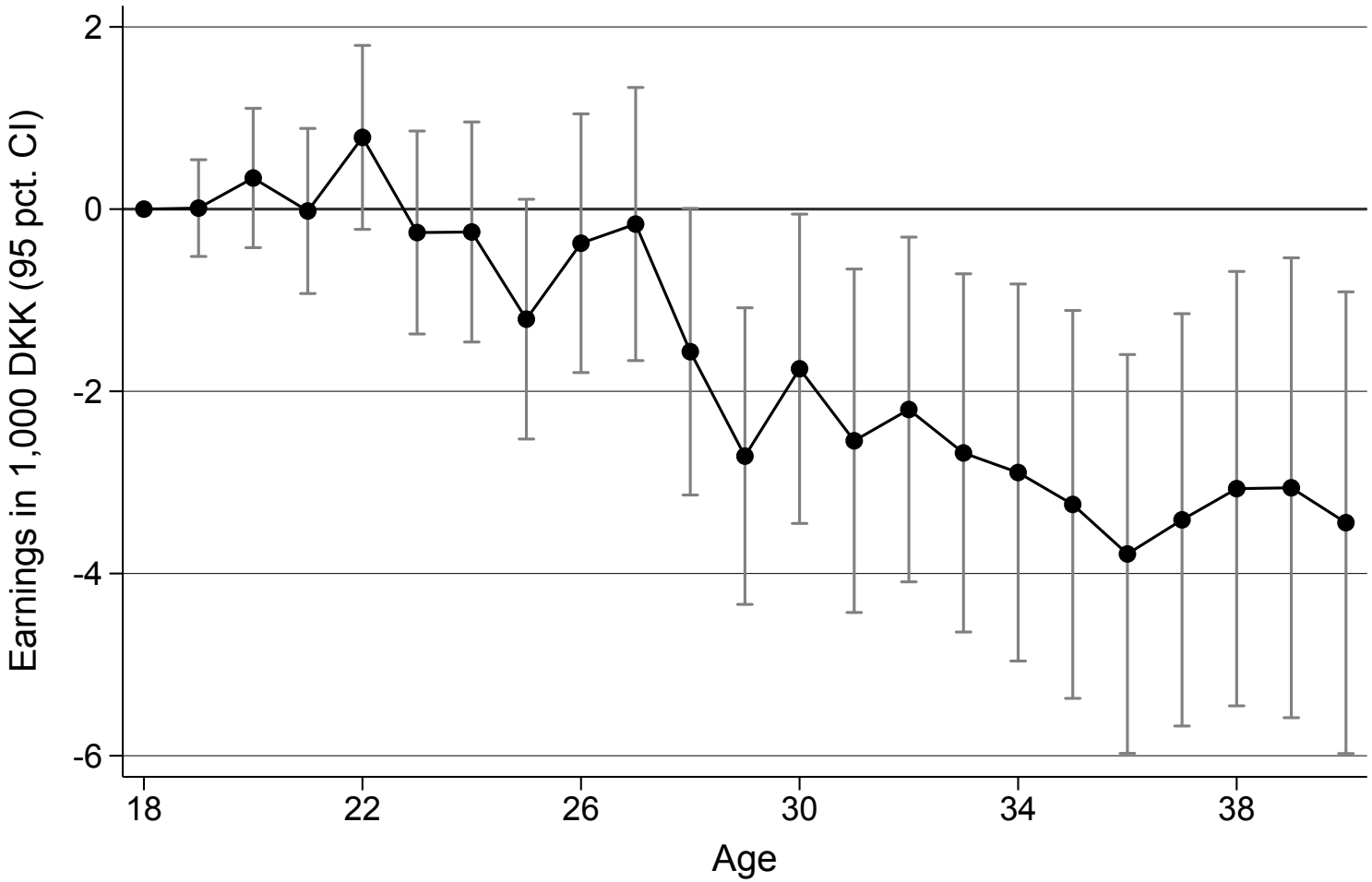
Women: Labor Earnings (1,000 DKK)



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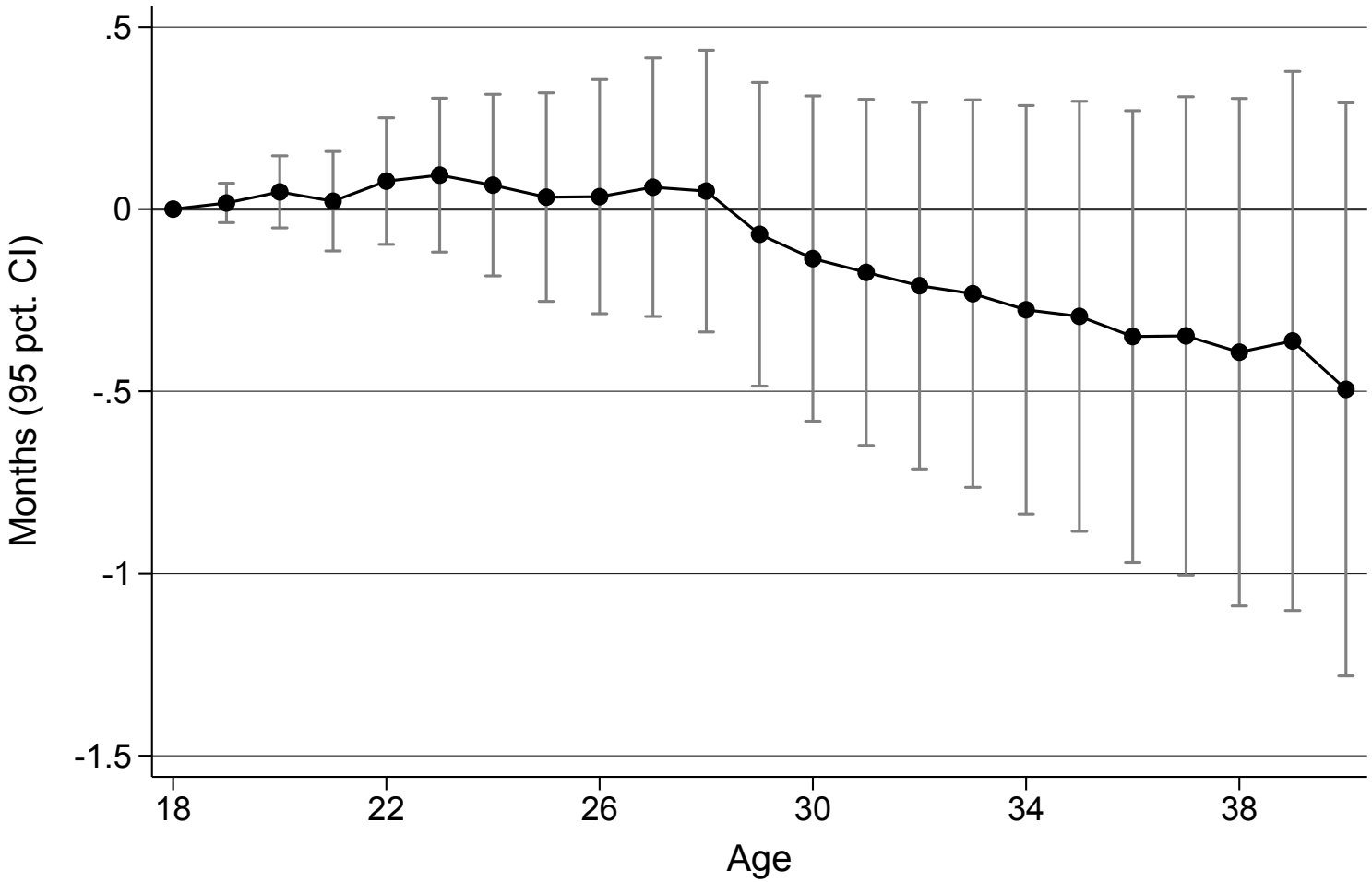
Women: Cumulated Work Experience (Months)



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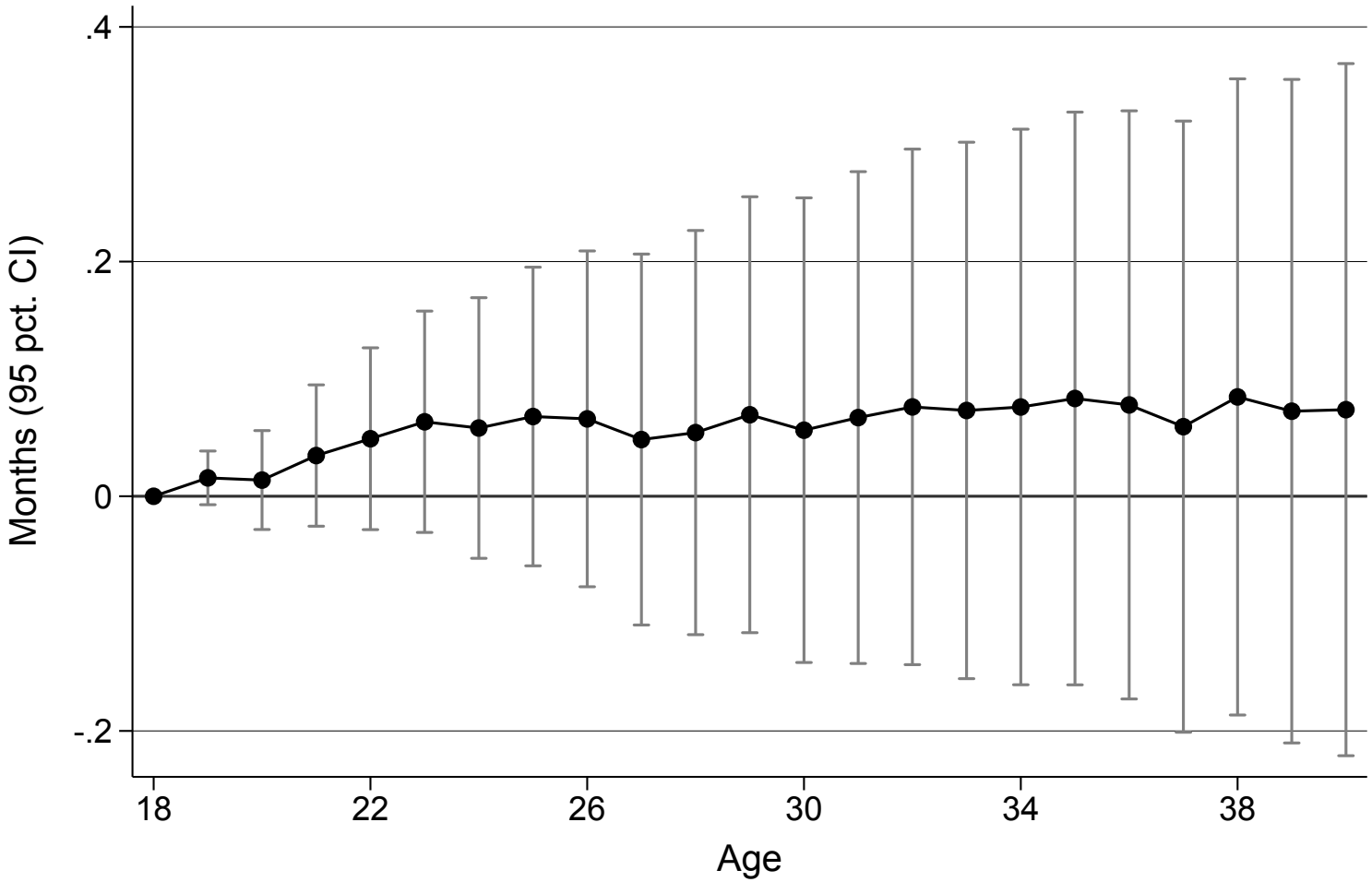
Women: Cumulated Unemployment (Months)



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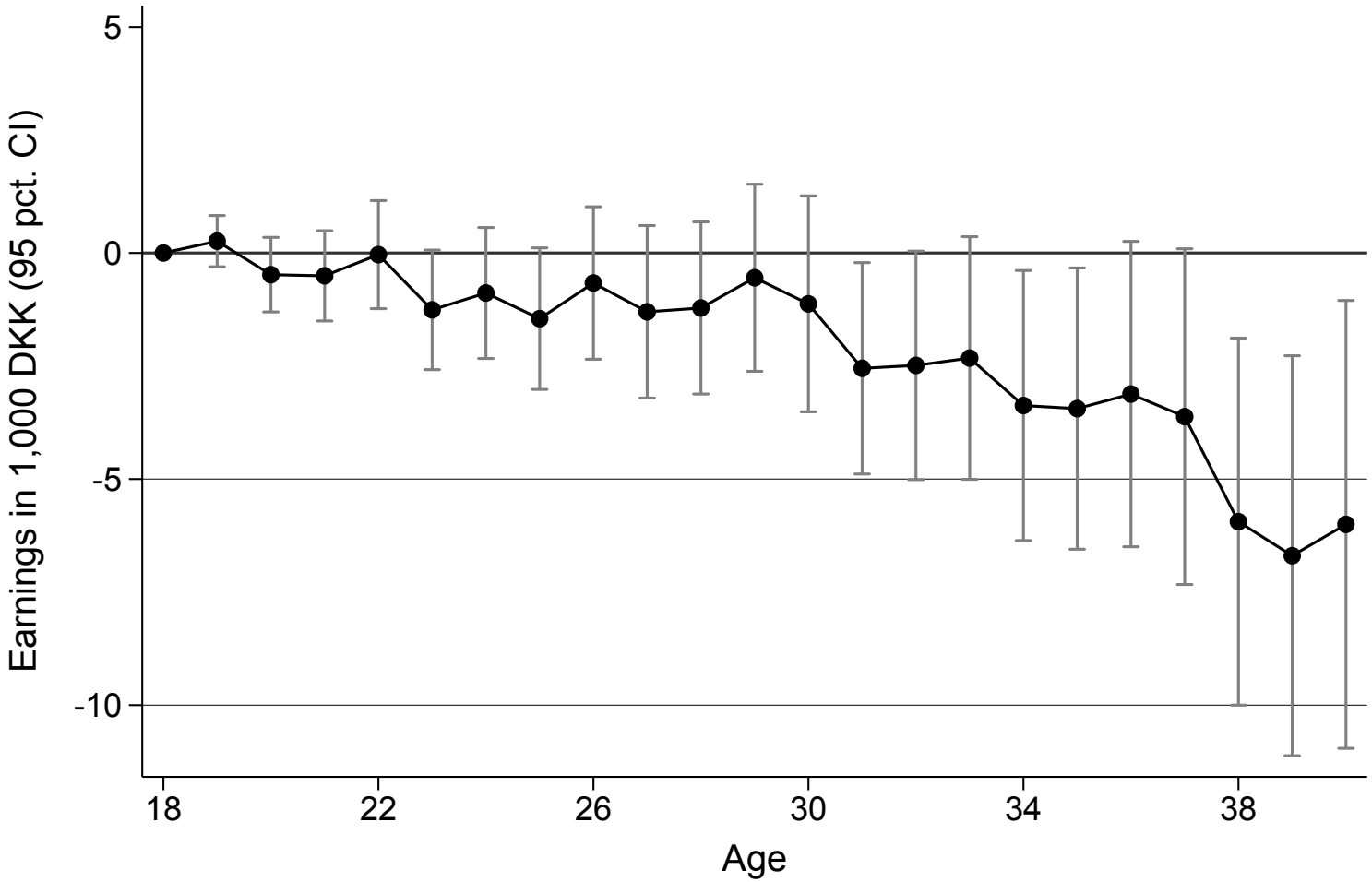
Men: Labor Earnings (1,000 DKK)



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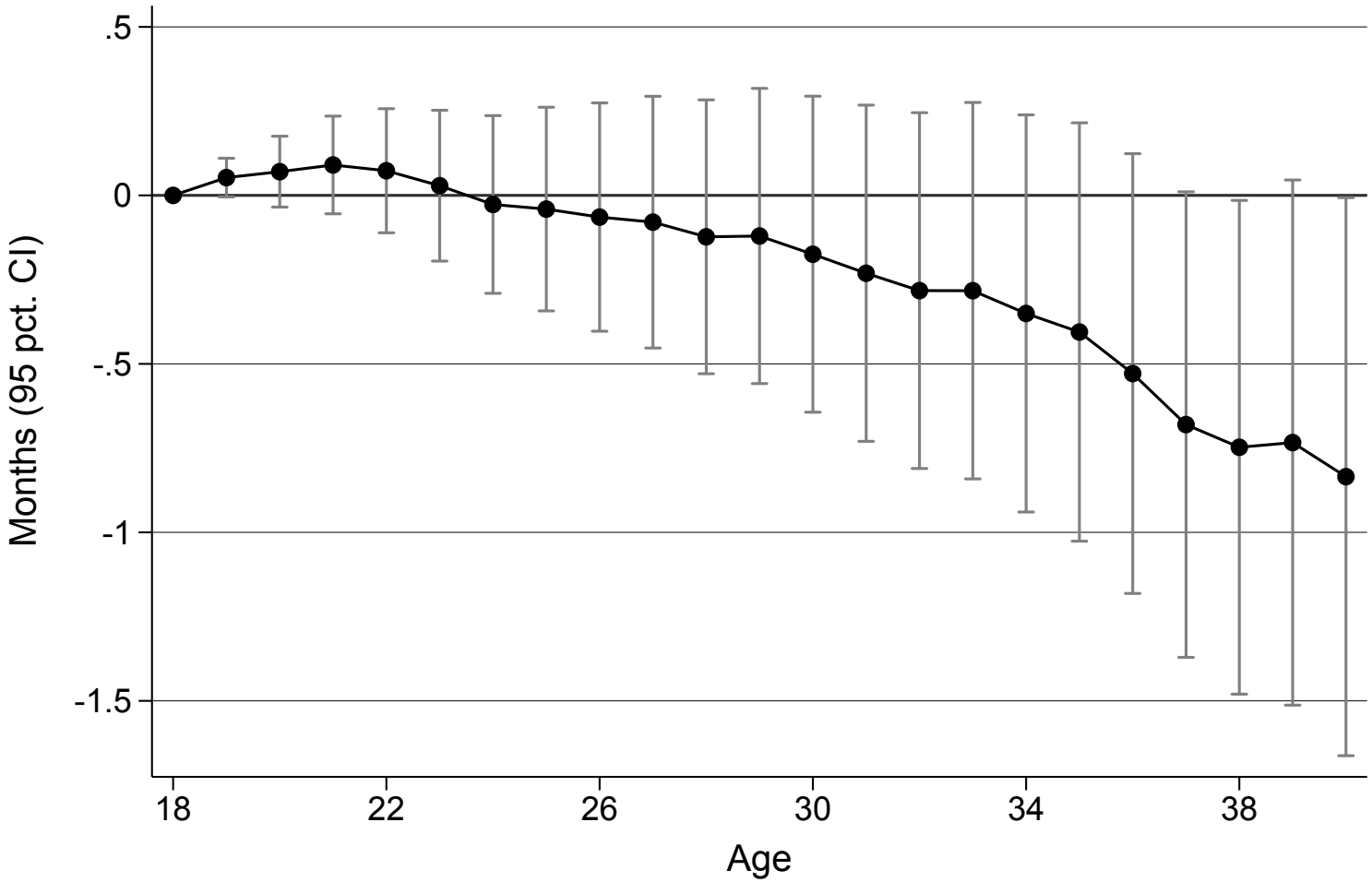
Men: Cumulated Work Experience (Months)



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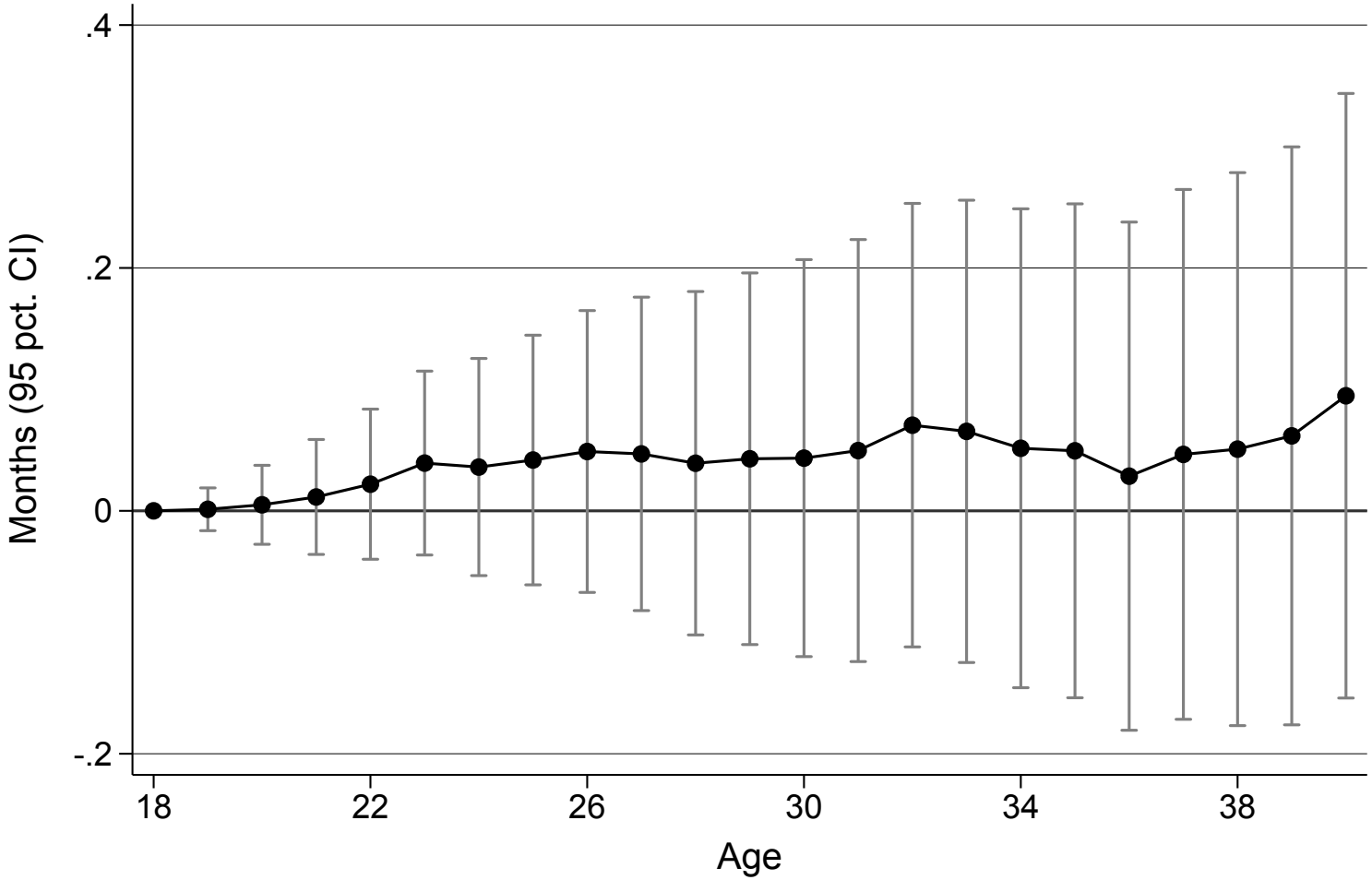
Men: Cumulated Unemployment (Months)



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Educational Performance

Sample of	*First-Born Girls*			*First-Born Boys*		
	Grade 9 written exam		Academic	Grade 9 written exam		Academic
	Danish	Math	HS	Danish	Math	HS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Standardized GPA (Population Mean 0, SD 1)						
Second-Born	-0.009	-0.009	-0.009	0.002	0.004	0.009
Opposite Sex	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)
Average	0.411	0.191	0.042	-0.031	0.288	0.064
Observations	87,070	86,383	85,524	88,631	88,465	58,608

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Educational Attainment

	Post-Compulsory		Vocational		College	
	Enroll-ment (1)	Comple-tion (2)	Enroll-ment (3)	Comple-tion (4)	Enroll-ment (5)	Comple-tion (6)
Sample of First-Born Women						
Second-Born	0.00	-0.09	-0.06	0.04	-0.04	-0.20
Brother	(0.12)	(0.17)	(0.24)	(0.23)	(0.21)	(0.22)
Same Sex Baseline	95.2	85.7	54.3	40.5	45.7	38.5
Percent Effect	0.0	-0.1	-0.1	0.1	-0.1	-0.5
Sample of First-Born Men						
Second-Born	-0.06	-0.20	0.13	-0.06	-0.06	-0.28
Sister	(0.10)	(0.19)	(0.21)	(0.24)	(0.20)	(0.20)
Same Sex Baseline	94.7	82.4	66.2	50.9	34.0	26.8
Percent Effect	-0.1	-0.2	0.2	-0.1	-0.2	-1.0

Note: All estimates are multiplied by 100.

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Housework at Age 7 and 11

Sample of First-Born	Girls		Boys	
Age	7	11	7	11
	(1)	(2)	(3)	(4)
Second-Born	0.01	-0.04	-0.17**	0.02
Opposite Sex	(0.09)	(0.10)	(0.09)	(0.09)
Same Sex Baseline	0.05	0.11	-0.05	-0.11
Observations	485	448	533	452

Note: Index of how much the parents involve the child in housework activities. Danish Longitudinal Survey of Children, born 1995

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Quality of Child-Parent and Child-Sib Relations

	Mother's	Fathers'	Child's relationship to		
	Relationship to Child		Mother	Father	Siblings
Child Age	11/15	7	15	15	15
	(1)	(2)	(3)	(4)	(5)
Sample of First-Born Girls					
Second-Born	-0.08	-0.23***	-0.01	-0.20**	-0.37***
Brother	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)
Average	0.01	0.02	0.08	-0.06	0.09
Observations	494	485	558	547	537
Sample of First-Born Boys					
Second-Born	0.08	0.05	-0.09	0.01	-0.17**
Sister	(0.09)	(0.09)	(0.08)	(0.07)	(0.09)
Average	-0.01	-0.01	-0.08	0.06	-0.08
Observations	513	529	596	587	565

Note: Indexes with mean 0 and SD 1 (higher value, better relation).
Danish Longitudinal Survey of Children, born 1995

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Family Structure at Age 17

	First-Born Women			*First-Born Men*		
Sample	All	Non-Traditional		All	Non-Traditional	
First-Born lives w	Both parents	SSP	SSP, sib w OSP	Both parents	SSP	SSP, sib w OSP
	(1)	(2)	(3)	(4)	(5)	(6)
Second-Born Opposite Sex	-0.04	0.91**	5.23***	-0.07	0.47	3.55***
	(0.18)	(0.39)	(0.27)	(0.20)	(0.47)	(0.38)
Same Sex Baseline	78.6	78.2	4.4	79.1	29.2	13.8
Percent Effect	-0.1	1.2	119.6	-0.1	1.6	25.7
Observations	162,564	34,922	34,745	171,416	35,913	35,736

Note: All estimates are multiplied by 100.

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Field-Specific STEM Education: Parental Field

Sample of	*First-Born Women*		*First-Born Men*	
	Enroll-ment (1)	Comple-tion (2)	Enroll-ment (3)	Comple-tion (4)
Second-Born	-0.08	-0.21	0.62	0.08
Opposite Sex (SBOS)	(0.20)	(0.15)	(0.38)	(0.34)
SBOS × Mom Admin	-1.41***	-0.71*	-1.00	-0.69
	(0.49)	(0.38)	(0.75)	(0.68)
SBOS × Mom Health	-0.66**	-0.63***	-0.04	-0.13
	(0.29)	(0.22)	(0.53)	(0.48)
SBOS × Dad STEM	-0.05	-0.08	0.76*	0.88**
	(0.28)	(0.22)	(0.45)	(0.42)

Note: All estimates are multiplied by 100.

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Field-Specific STEM Edu: Parental Labor Division

Sample of	*First-Born Women*		*First-Born Men*	
	Enroll-ment (1)	Comple-tion (2)	Enroll-ment (3)	Comple-tion (4)
Second-Born	-0.43**	-0.40***	0.57**	0.26
Opposite Sex (SBOS)	(0.17)	(0.13)	(0.26)	(0.17)
SBOS×Traditional	-0.25	0.08	1.26**	0.31
Division	(0.33)	(0.24)	(0.56)	(0.36)

Note: All estimates are multiplied by 100.

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Field-Specific STEM Education by Spacing

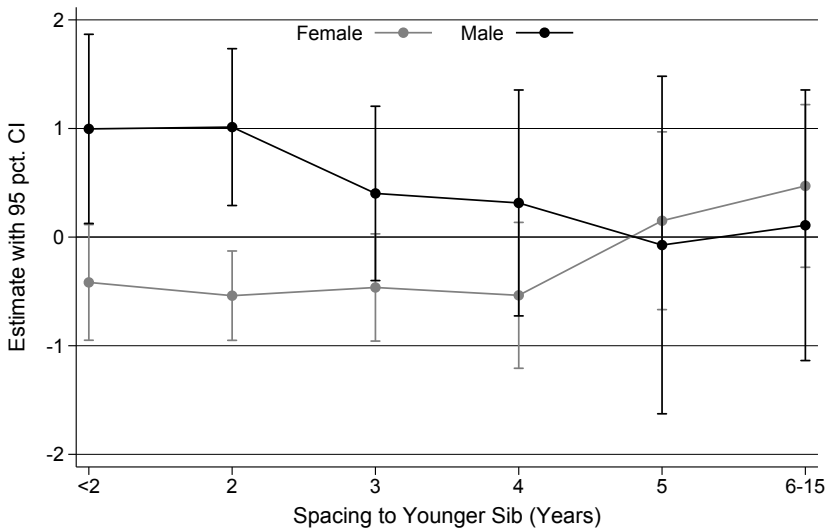

Figure: Enrollment

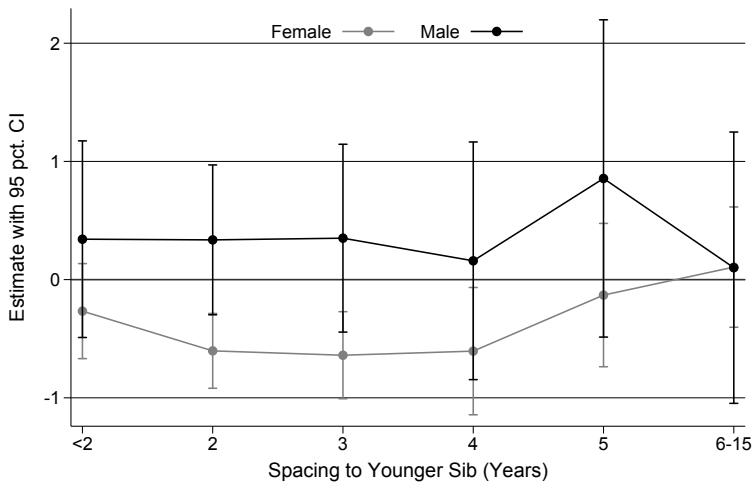

Figure: Completion

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Sibling Gender Composition and Number of Siblings

Sample of	*First-Born Women*			*First-Born Men*		
	# of Siblings (1)	≥ 2 Siblings (2)	≥ 3 Siblings (3)	# of Siblings (4)	≥ 2 Siblings (5)	≥ 3 Siblings (6)
Second-Born	-0.07***	-4.96***	-1.43***	-0.08***	-6.89***	-1.33***
Opposite Sex	(0.00)	(0.22)	(0.13)	(0.00)	(0.23)	(0.13)
Same Sex Baseline	1.7	38.1	8.5	1.7	40.1	8.4
Percent Effect	-4.2	-13.0	-16.9	-4.7	-17.2	-15.8

Note: All estimates are multiplied by 100.

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Family Size and STEM Education using Twins as IV

	First Stage	Second Stage				
	# of Siblings	Years of education	Field-spec STEM		College STEM	
			Enrollment	Completion	Enrollment	Completion
	(1)	(2)	(3)	(4)	(5)	(6)
Sample of First-Born Women ($N = 166,213$)						
Twins at 2^{nd} parity	0.74***					
	(0.018)					
# of Siblings		0.03	-0.87	-1.13*	-0.15	-0.93*
		(0.07)	(0.92)	(0.63)	(0.76)	(0.52)
Average	1.6	13.5	8.5	4.8	4.7	2.9
Effect×0.07		0.00	-0.06	-0.08	-0.01	-0.07
Sample of First-Born Men ($N = 175,032$)						
Twins at 2^{nd} parity	0.72***					
	(0.016)					
# of Siblings		-0.11	-0.67	0.81	0.25	-0.01
		(0.08)	(1.58)	(1.56)	(1.01)	(0.88)
Average	1.7	13.3	41.2	28.7	12.7	8.3
Effect×0.08		-0.01	-0.05	0.06	0.02	0.00

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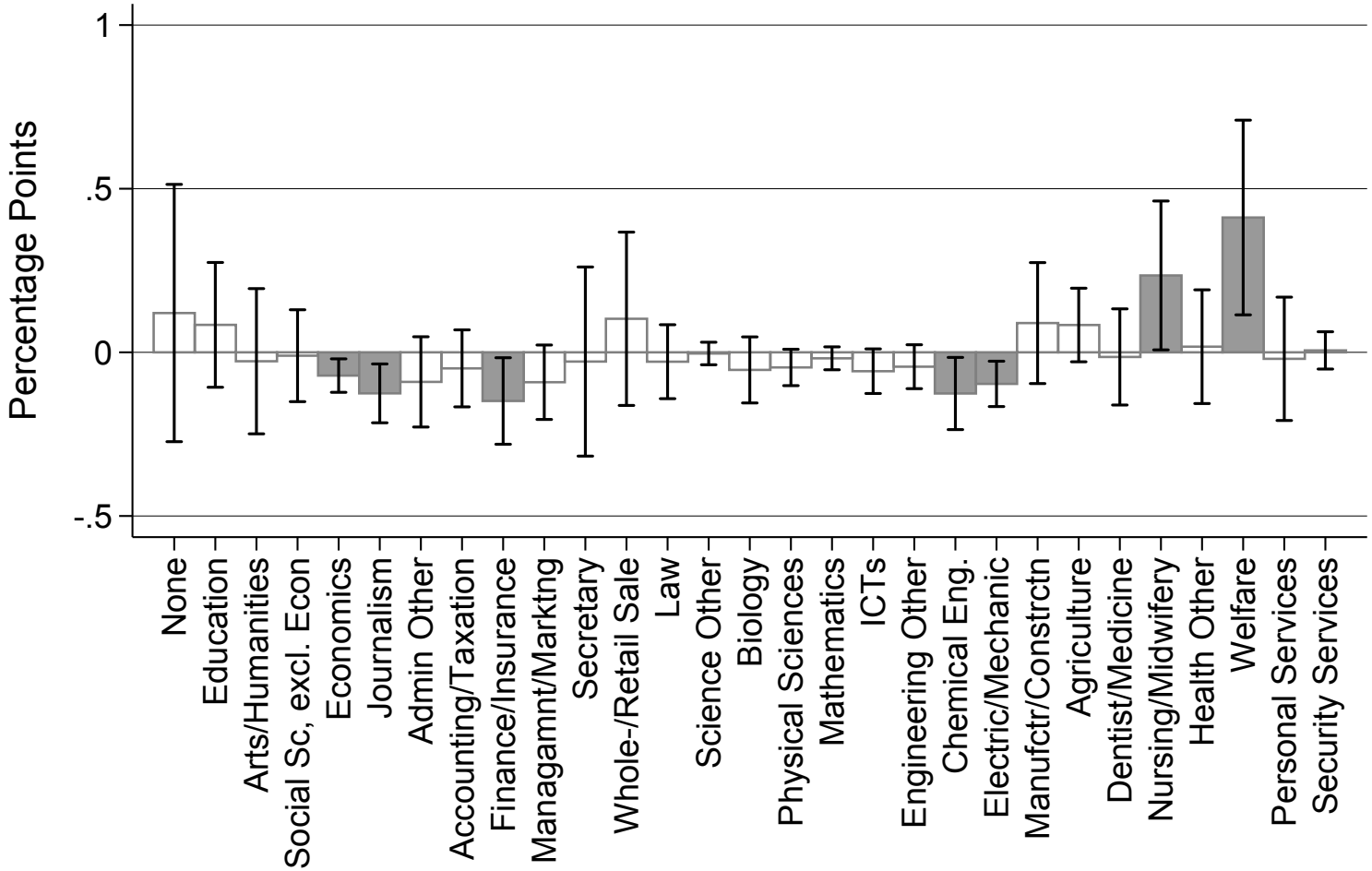
Women: Narrow Field (highest compl)



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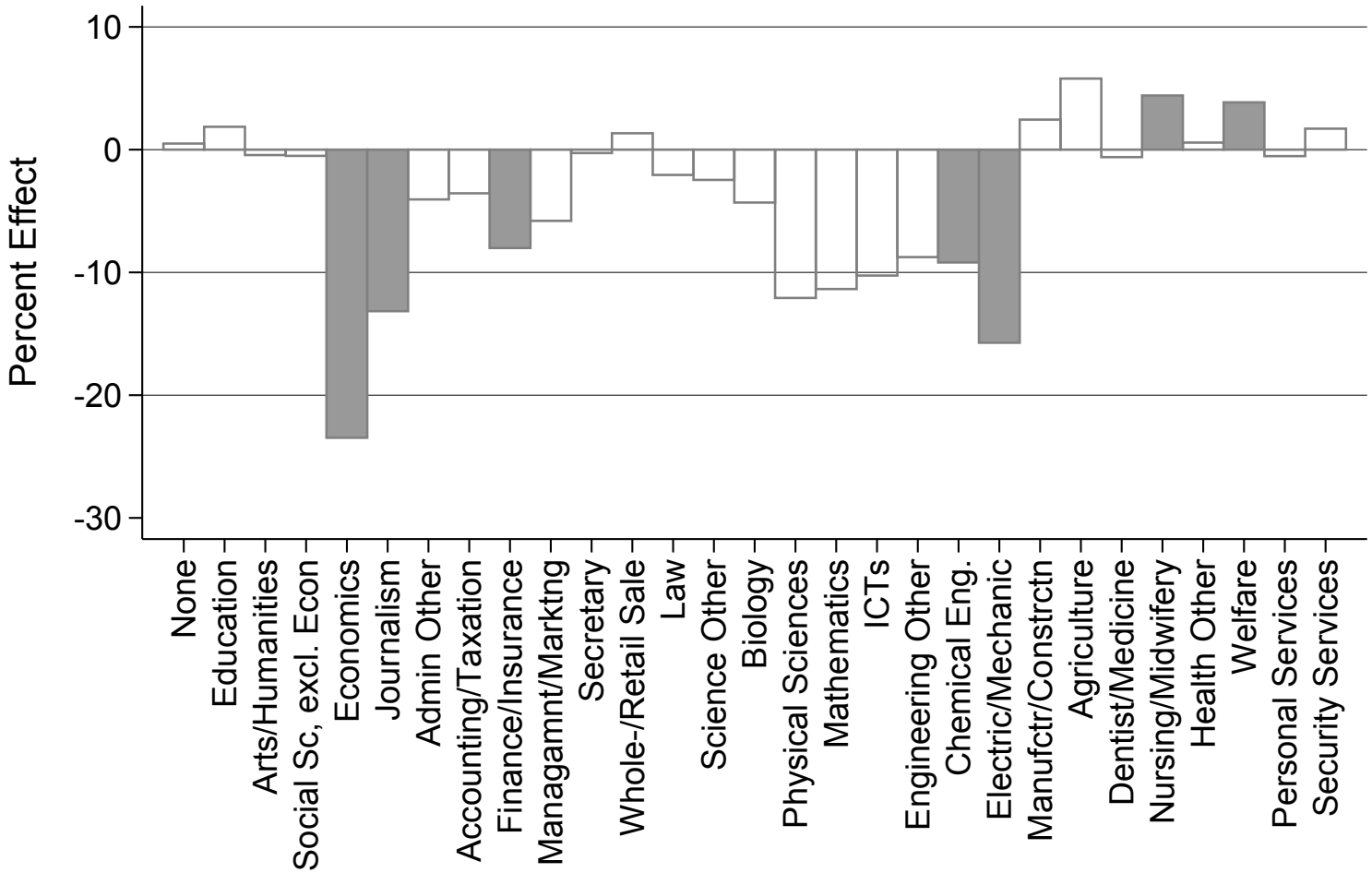
Women: Narrow Field (highest compl, pct.)



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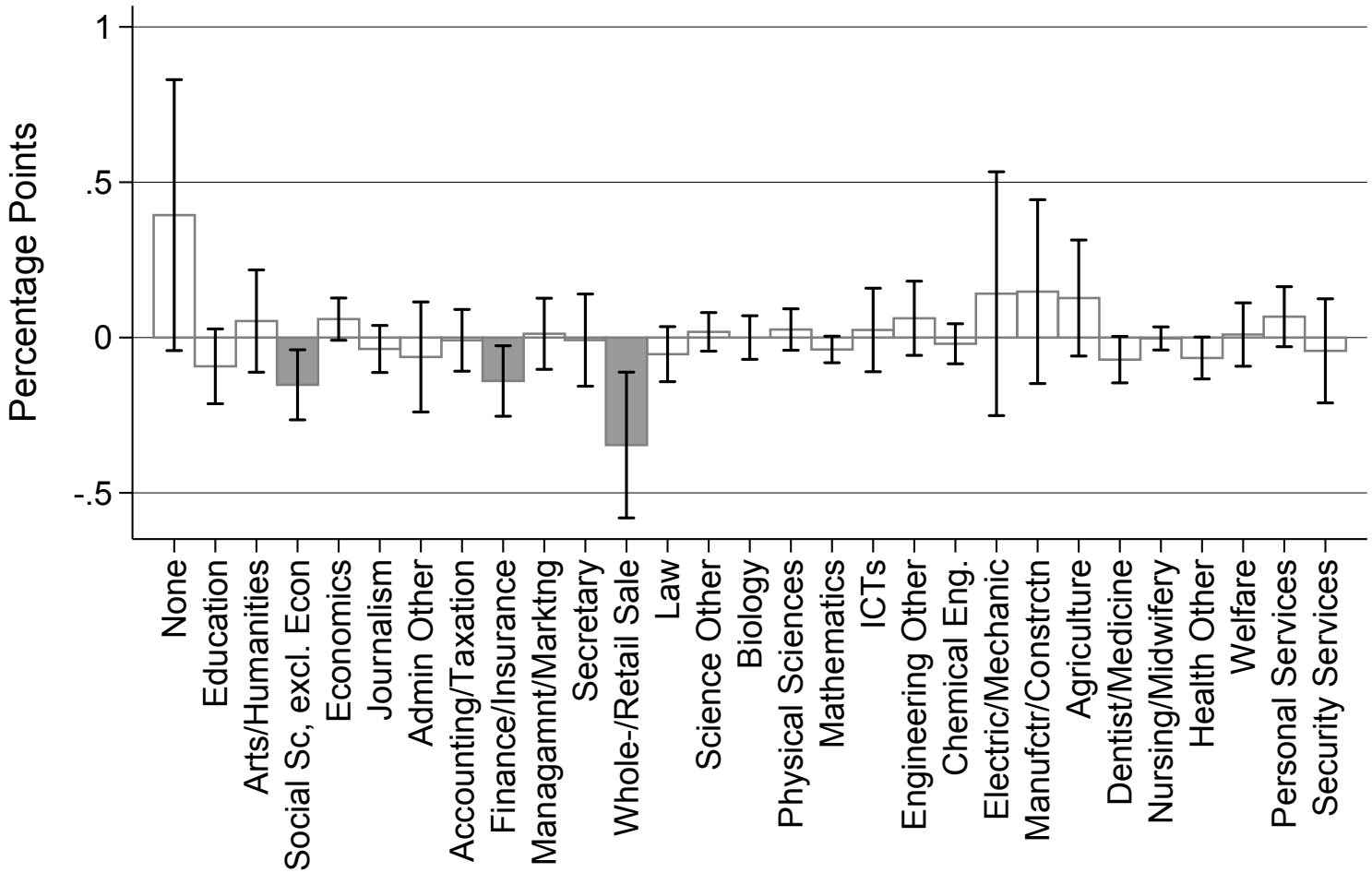
Men: Narrow Field (highest compl)



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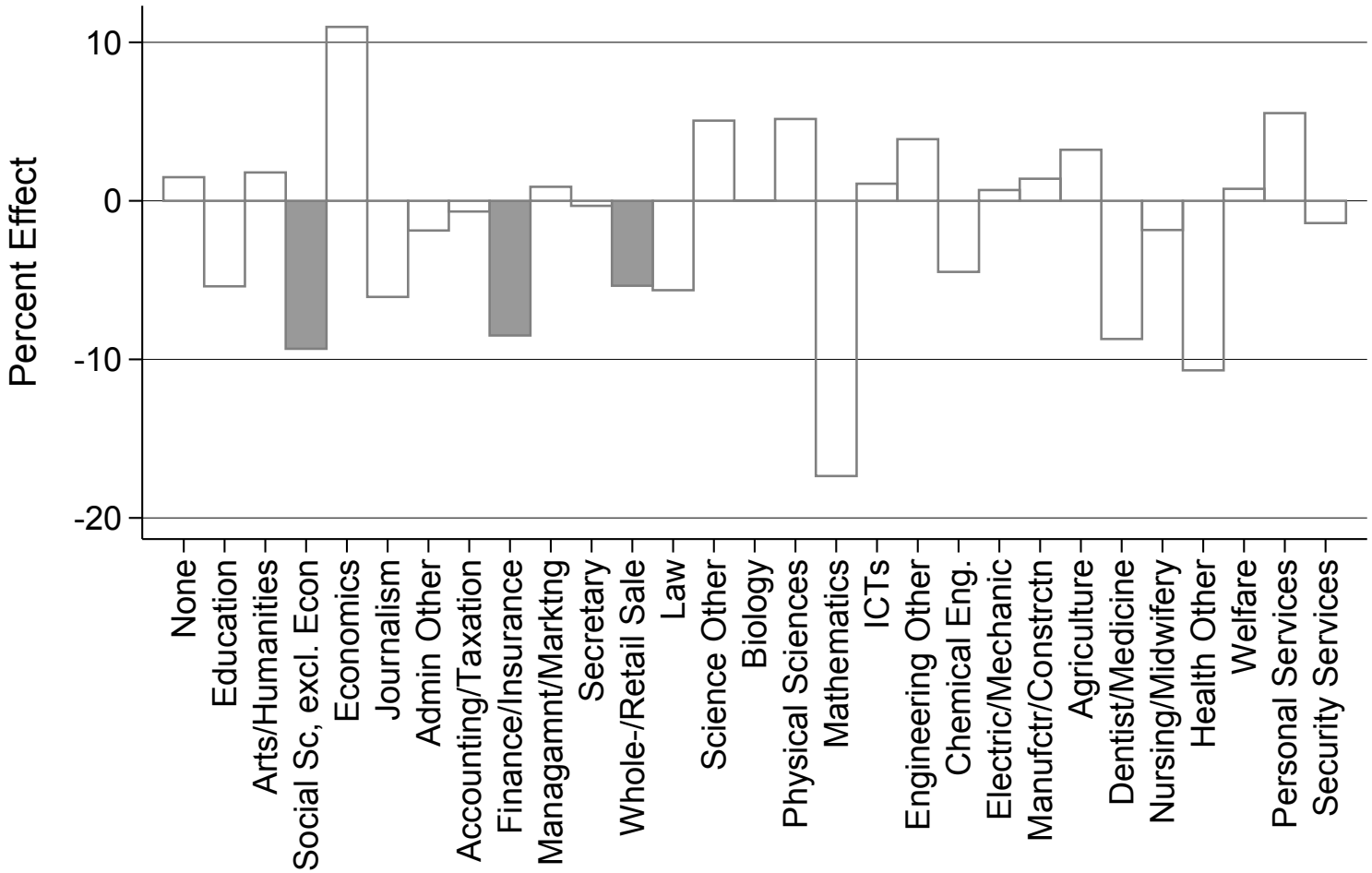
Men: Narrow Field (highest compl, pct.)



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Effect of Co-Twin's Gender: First Parity

	Next	Field-Specific STEM		STEM in First	STEM in Highest
	Birth	Enroll-ment	Comple-tion	Enroll-ment	Comple-tion
	(1)	(2)	(3)	(4)	(5)
Panel A: Female Twins ($N = 4,730$)					
Co-Twin Brother	-0.48*	-1.95**	-2.05***	-0.79	-1.79***
	(0.29)	(0.90)	(0.68)	(1.50)	(0.64)
Same Sex Baseline	42.0	8.5	5.4	26.1	4.7
Percent Effect	-1.1	-23.0	-37.9	-3.0	-37.7
Panel B: Male Twins ($N = 4,832$)					
Co-Twin Sister	-0.58*	3.14*	1.46	2.56	1.32
	(0.31)	(1.68)	(1.54)	(1.72)	(1.52)
Same Sex Baseline	40.2	37.8	26.4	48.1	25.5
Percent Effect	-1.4	8.3	5.5	5.3	5.2

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Effect of Co-Twin's Gender: Any Parity

	Next	Field-Specific STEM		STEM in First	STEM in Highest
	Birth	Enroll-ment	Comple-tion	Enroll-ment	Comple-tion
	(1)	(2)	(3)	(4)	(5)
Panel A: Female Twins ($N = 12,755$)					
Co-Twin Brother	-1.32**	-1.56***	-1.40***	-2.81***	-1.26***
	(0.60)	(0.51)	(0.38)	(0.82)	(0.36)
Same Sex Baseline	24.1	8.0	4.7	23.3	4.3
Percent Effect	-5.5	-19.6	-29.9	-12.1	-29.6
Panel B: Male Twins ($N = 13,067$)					
Co-Twin Sister	-1.83***	2.89***	1.28	2.10**	1.71*
	(0.61)	(0.97)	(0.89)	(0.99)	(0.88)
Same Sex Baseline	23.6	37.2	26.0	46.1	24.9
Percent Effect	-7.8	7.8	4.9	4.6	6.9

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The Effect of an Older Sibling's Gender

	Field-Specific		College	
	Enrollment (1)	Completion (2)	Enrollment (3)	Completion (4)
Sample of Second-Born Women				
First-Born	-0.29**	-0.17*	-0.21**	-0.20***
Brother	(0.12)	(0.09)	(0.09)	(0.07)
Same Sex Baseline	7.8	4.1	3.9	2.5
Percent Effect	-3.7	-4.1	-5.4	-8.1
Sample of Second-Born Men				
First-Born	2.37***	1.67***	0.31**	0.16
Sister	(0.24)	(0.23)	(0.14)	(0.12)
Same Sex Baseline	39.0	27.3	9.9	6.6
Percent Effect	6.1	6.1	3.1	2.4

Note: All estimates are multiplied by 100.

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