Contraceptive Access Costs and Fertility Across the Age Profile: Evidence from Swedish Oral Contraceptive Sales

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Abstract

I estimate how the introduction of oral contraception affected fertility across the age profile and over time using Swedish sales data. I construct age-specific measures of pharmacy access along four dimensions. Access strongly predicts pill sales. Instrumental-variable estimated elasticities are large for women under age 22. Estimates decline sharply with age becoming indistinguishable from zero after the mid-twenties. Instrumental-variable estimates exceed OLS, consistent with access-cost-sensitive adopters exhibiting larger fertility responses than the average woman. Findings based on simulated sales reveal highly persistent elasticities over time, further quantifying how access costs shape contraceptive adoption and fertility when abortion is restricted.

JEL Codes: J12, J13, N34
Keywords: oral contraception, pharmacy access, contraceptive rights, Swedish childbearing

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1 Introduction

How did the pill change fertility across the age profile and over time? Immediate fertility responses remain hard to quantify with precision despite extensive empirical work establishing links between legal access to the pill and women's human capital investments and returns (Goldin and Katz, 2002, Bailey et al, 2012), labor supply (Bailey, 2006), and savings-at-retirement (Lindo et al, 2020). A central difficulty is measurement: legal-access designs don't provide direct evidence on the extent of pill use and only limited guidance on how fertility effects varied by age or over time.[1]

I estimate precise fertility elasticities to sales of the pill across the age profile and over time. I find substantial heterogeneity in the pill's power to shape fertility for the average woman as well as women whose use of the pill depended on the access costs they faced. I measure the entire universe of oral contraceptive sales and births at high resolution. I quantify how supply channels and local market structure constrained the pill's spread to isolate a causal effect of oral contraceptive sales on fertility. The findings provide detailed evidence on the pill's importance for women under-30 and how the costs of contraceptive access bind and shape the pill's fertility effects, an important insight for policy design and economic understanding of fertility control.

My empirical strategy exploits predetermined variation in access costs operating through the retail pharmacy sector. Sweden's pharmacies were heavily regulated, with most pharmacy locations determined decades before the pill's introduction. I measure four dimensions that capture both density and market structure: pharmacies per area, pharmacies per populated area, the population-weighted share of municipalities without a pharmacy (pharmacy deserts), and the share with at least two pharmacies (robust access). Because these measures are correlated, I construct an index of access using the first principal component estimated on pooled data and apply the resulting constant loadings to age-specific measures. Age-specific access-costs are strong predictors of pill sales, generating precise instrumental-variables (IV)

[1] Goldin and Katz's (2002) path-breaking analysis of cross-state cross-cohort variation in young, unmarried women's right to consent to contraceptive care presents survey data consistent with legal access leading to increased pill use, but the age-specific nature of the reforms they study narrows the scope of their analysis.

estimates that reveal large differences in the pill's fertility effects across narrowly defined age groups.

The paper makes three main contributions. First, it provides age-specific elasticity estimates which quantify how fertility responses varied among teens and women under-30. Instrumental-variables estimates imply large responses to pill sales among women under-22, with elasticities greater than one among teens, followed by rapid attenuation. Second, it interprets a pronounced gap between OLS and IV estimates through a selection lens. IV isolates variation in pill sales driven by access costs, identifying fertility responses among women whose adoption is sensitive to those costs. Larger IV estimates are consistent with access-cost-sensitive adopters exhibiting larger fertility responses than the average woman. Strong age-dependence in these patterns point to the pill's particular importance for access-cost-sensitive teens. Third, it evaluates how fertility responses evolve over time as pill sales rose and then plateaued. Because market-level sales are observed only from 1970 onward, I construct a simulated sales series using the stable cross-market distribution of pill sales and the strong relationship between sales and pharmacy access. Simulated-instrument estimates reveal highly stable fertility elasticities even as sales trends changed.

These results speak to two broader debates. For empirical work, they clarify what can and cannot be inferred from blunt proxies for legal access to contraception by quantifying how access costs map into use and fertility. For theory, the steep age gradient I estimate coupled with the stability of elasticities over time provides a set of empirical estimates to discipline models of contraceptive adoption with fixed costs, switching costs, and learning. This paper is a companion to Ragan (2025), which focused broadly on teen fertility. The present study extends the analysis by (i) estimating comparable elasticities across narrow age bins, (ii) constructing a multi-dimensional access index, and (iii) assessing the stability of fertility elasticities over time using a novel simulated sales series. The findings mark a substantial advance even relative to previous findings on teens while contributing to a growing body of work on the importance of contraceptive access costs in the US (Bailey, 2012 and 2013), Europe (Marie and Zweirs, 2025, Ragan, 2025), and policies aimed at reducing such costs (Bailey, 2012, Bailey et al, 2024, Grönqvist, 2009, Kearney and Levine, 2009, Lindo and Packham, 2017).

The paper proceeds with an overview of the institutional setting and data via an illustrative difference-in-differences (DD) comparison. Two empirical models are developed to estimate fertility effects across the age-profile: (i) an OLS model using observed sales and (ii) an IV model, with related reduced form, using the infrastructure of supply to isolate variation in sales driven by access costs. Section four develops an empirical model based on a simulated instrument to evaluate how fertility elasticities evolve over time. A discussion of the relevance of the findings is presented before the conclusion.

2 The Data and Institutional Setting

2.1 Overview

Fertility trends across broad age groups are plotted in Figure 1 around the pill's introduction. Births per thousand women for high (low) pill sales markets are plotted in dark (light) lines for three five-year age-groupings (top row).[2] The share of women using the pill (Meirik et al, 1984) and abortions per 1000 women by age (Socialstyrelsen, 1961-80) are indicated along the right axes. Vertical lines denote the pill's introduction late in 1964 (solid) and the establishment of abortion rights in 1975. Increased sales after 1975 reflect a subsidy introduced in tandem with abortion rights.

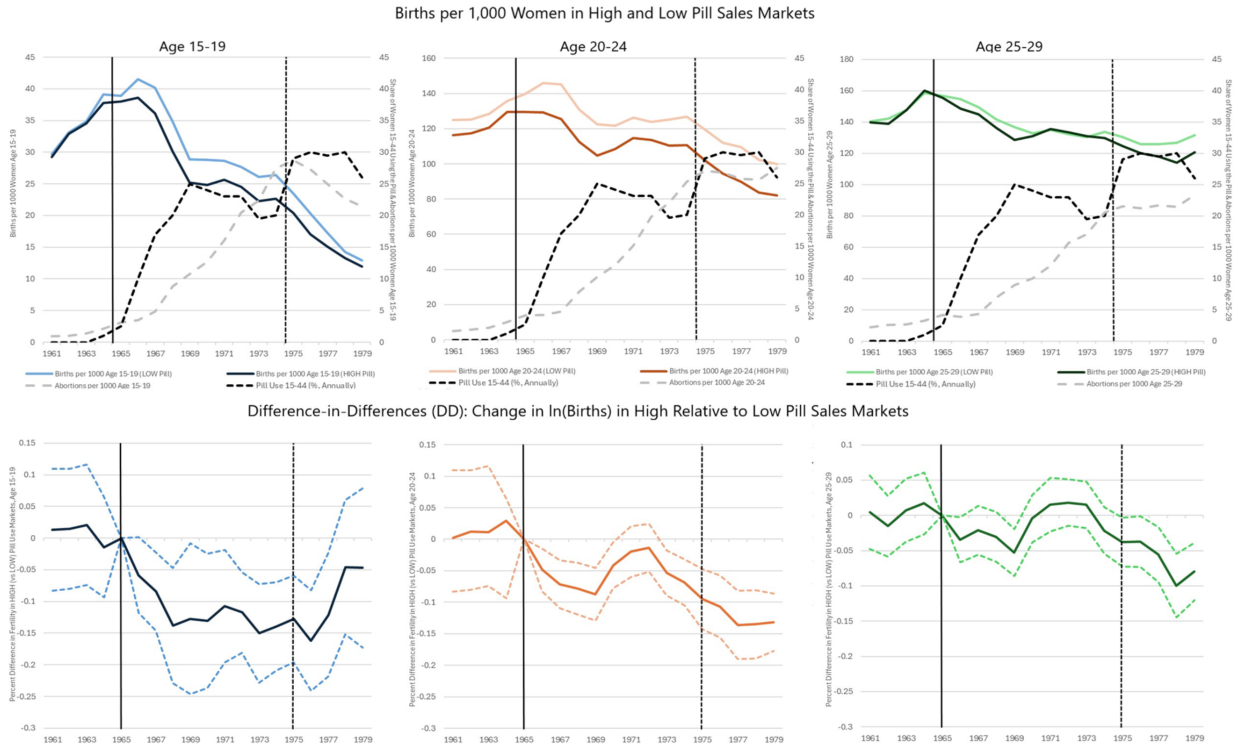
The bottom panels of Figure 1 plot time-varying DD coefficients quantifying the percent decline in fertility among women in high sales markets, relative to 1965, over and above the decline experienced by women in low sales markets.[3] The negative correlation between pill sales and teen births seen in the left panels of Figure 1 is consistent with Ragan (2025). For women aged 20-24 (middle panels), fertility trends upward in parallel before the pill. After the pill, fertility in low sales markets continues to increase, while births in high sales areas decline. A decade after the pill, fertility has fallen and the gap between

[2]High sales are defined relative to the median average sales per fecund female (15-44) from 1970-74 of 5.35 SEK per year. Sales in real 1964 SEK from *Swedish Drug Market* (SDM).

[3]Estimates for each age group follow a model where ln births per thousand women of a given age in market i at time t are regressed on a set of year and market fixed effects, and an indicator for high sales markets interacted with year dummies both before and after the pill's introduction.

high and low sales markets has grown; DD coefficients oscillate around five percent before surpassing ten percent after subsidies are introduced in 1975. For women aged 25-29, fertility is identical across markets before the pill. After the pill, fertility declines gradually, a gap opens and closes before abortion is legalized, only becoming significantly different from zero after the subsidy.

Figure 1: Fertility by Age in High and Low Pill Sales Areas and Difference-in-Differences (DD) Coefficients



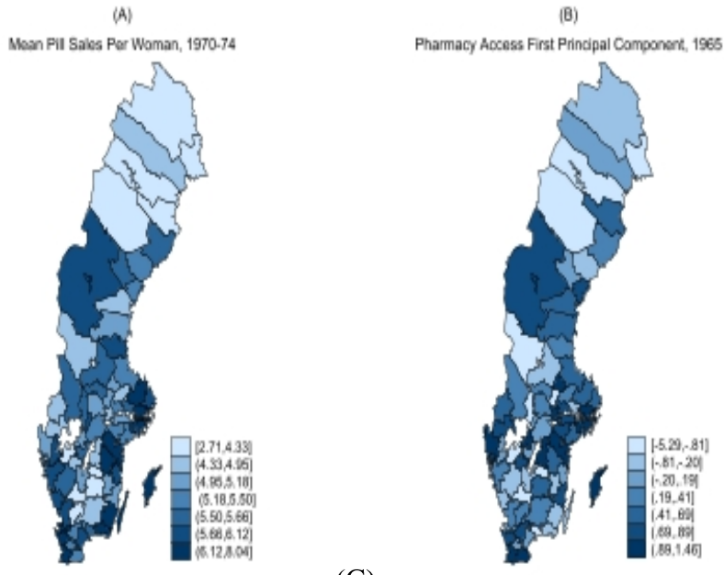
Note: The top row plots births per 1000 women in above (dark) and below (light) median sales markets for ages 15-19 in blue (left), 20-24 in red (middle), and 25-29 in green (right). The share of women using the pill on an annual basis is from Meirik et al (1984) and abortions per 1000 age group (grey dash) from Socialstyrelsen (1961-74); both follow the right axis. The bottom row plots difference-in-differences (DD) coefficient estimates and 90 percent confidence intervals from regressions of market level ln fertility on indicators for above median pill sales markets interacted with year fixed effects. The first full year of treatment, 1965, is the omitted year. Plotted coefficients indicate the percent change in fertility in high pill sales markets, over and above changes in low pill sales markets, relative to the 1965 base year.

2.2 Pill Sales

Swedish Drug Market (SDM) reports sales by drug class from 1965, disaggregated by local market from 1970. Using the price of the leading brand to convert sales into annual doses, Figure 2 panel C reports the fraction of women using the pill annually, which closely tracks estimates from Meirik et al (1984) in Figure 1. Sales data indicate substantial variation in the pill's diffusion across markets; Figure

2 panel A maps sales per fecund female (15-44) across markets from 1970-74. Women in the top ten markets (sales per woman) spent double that of women in low sales markets.

Figure 2: Pill Sales Data in Detail: Across Markets and Over Time



(C)

Summary Statistics on Oral Contraceptive Sales and Pharmacy Access 1965-1974

Year	Total Annual Pill Sales 1000 SEK	Market Share	Leading Brand Brand Name	Monthly Price SEK	Women Using Pill Annually Share (15-44)
1965	5,961	46.1	Anovlar	4.70	6.6
1966	7,840	38.5	Conluten	4.55	9.2
1967	11,755	28.5	Conluten	4.06	15.5
1968	10,277	23.5	Conlunett	3.01	18.3
1969	16,014	28.8	Conlunett	3.02	28.2
1970	14,948	27.3	Follinyl	2.94	26.7
1971	13,785	33.0	Follinyl	2.94	24.6
1972	14,697	36.9	Follinyl	3.27	23.6
1973	12,986	25.6	Follinett	3.28	20.7
1974	14,079	31.9	Follinett	3.50	20.9

Source: *Swedish Drug Market* (SDM) (Class 329 Oral Contraceptives) and Statistics Sweden.

2.3 Legal and Institutional Setting

Already decades before the pill, from the age of 15, confidential access to contraception was recognized in Swedish law (Lennerhed, 2019). This unconditional legal access was actively supported through publicly funded maternal care clinics and abortion prevention bureaus. Nurses and physicians provided contra-

ceptive services at clinics, while prevention bureaus offered contraceptive services as part of a broader mission to help women with unwanted pregnancies give birth. The advocacy organization Riksförbundet för Sexual Upplysning (RFSU) also operated a limited number of clinics.

Established law and public infrastructure facilitated the pill's spread while a national abortion ban constrained abortion access. Starting in 1938, limited exemptions for eugenic indications, rape, incest, or illness were codified in law, and expanded to cases of weakness (1950) and birth defects (1963). Petitions for abortion were usually filed by women directly (Lennerhed, 2019). In 1965, 3,969 petitions were filed by women under-30, leading to 3,071 abortions. Petitions increased as the pill spread, with 4,936 petitions and 4,263 abortions among women under-30 in 1969.

Lennerhed (2019) describes petition process for obtaining an exemption to the national abortion ban.[4] Popular TV dramatizations increased perceptions that the petition process was onerous and physicians began to side-step the process by invoking the 'two-physician rule' (Santow and Bracher, 1999).[5] This rule allowed two physicians to attest that the conditions of the abortion law were met. In practice, the rule required one of the attesting physicians to perform the abortion. The rule had been used exclusively for cases of illness or emergencies, but came to dominate abortion provision after 1969. I account for this channel, including access to physician staffed fertility control clinics and OBGYN care-capacity to capture access to physicians and medical care related to abortion.[6]

Schools also provided fertility control information. A compulsory sex education curriculum, established in the 1950s (Elwert and Lazuka, 2023), was revised by the RFSU in 1975 to reflect changing legal rights with respect to abortion. The timing of the pill's introduction a decade before the national abortion ban was lifted ameliorates many sources of potential confounding.

[4]Tydéns (2002) and Sundström (2004) elaborate how sterilization was a precondition, perceived or explicit, for petition approval in some cases.

[5]*Förrädare mördare* (1967) depicted a married couple's abortion petition, while *Var god vänta* (1970) portrayed a single woman's experience. Both were important in shaping public opinion related to abortion rights (Björklund, 2020).

[6]Further discussion of the differential impact of abortion provision across the age profile is provided in the Appendix where coefficient estimates on the abortion provision controls are presented.

2.4 Fertility and Population Data

Fertility data come from Statistics Sweden's birth registers. Births are first reported by maternal age and municipality of residence in 1961. I express births per the female population using census data from 1960 and 1965, and annual data from 1968. Missing years are linearly imputed.

2.5 Price Regulation

The price of the pill was the same everywhere, the result of uniform drug price controls introduced in the 17th century. Private insurance was rare, so prices reflected the cost of purchasing the pill. Leading brand prices are reported in the bottom panel of Figure 2. Prices display a downward trend through 1971 that reverses slightly during the last three years of the sample. The pill was expensive in the US (Bailey and Lindo, 2017), but comparable in price to two movie tickets or a bottle of wine per month in Sweden.

2.6 Retail Pharmacy Regulation

Since the 16th century, the King approved the establishment of pharmacies, a responsibility delegated to the Board of Health and Welfare before the pill's approval. Pharmacy regulation led to high persistence in service provision; pharmacies operating in 1965 had a mean establishment year of 1880, and just five percent were established in 1960 or later. Using the locations of all pharmacies operating on the first day of the first full treatment year minimizes the possibility that omitted factors may jointly drive pharmacy openings, residential sorting, and pill sales over the decade I study. Staffing, signage, and many other facets of pharmacy operations were closely regulated, ensuring a high degree of uniformity in the information available to women at the point of purchase.

2.7 Pharmacy Access Cost Index

Four measures of pharmacy access are constructed using data from Farmacevtiska Föreningen (1965). Two measures focus on pharmacy density per area, the others measure local market structure, together providing a comprehensive picture of pharmacy services provision. Pharmacy density measures share a similar form, expressing municipal pharmacy counts per the total or the tightly developed (tätort) area of each municipality weighted by the local female population of the given age group. If market i consists of N_i municipalities, pharmacy density per total area among the youngest age group is defined:

$$TotalPharmDensity_{i,1965}^{Age16-17} = \sum_{n=1}^{N_i} \frac{PharmCount_{n,1965}}{TotalMunicipalArea_n} \cdot \frac{Pop16-17_{n,1965}}{\sum_{j=1}^{N_i} Pop16-17_{j,1965}}.$$

Developed area pharmacy density replaces total municipal area with developed area.[7]

Market structure measures capture the share of women living in municipalities without a pharmacy, what Qato et al (2014) term pharmacy deserts, a facet of access density measures miss. A related concept, pharmacy vulnerability, is defined as an area served by only one pharmacy (Mathis et al, 2025). I define a complementary measure of municipalities served by two or more pharmacies, termed *robust access*. These thresholds are potentially important in the context of the present study, as privacy concerns may constrain contraceptive sales in markets where women rely on a single pharmacy to a greater degree. Both indices are then defined by interacting indicators taking on a value of 1 if the municipality satisfies the market structure definition (0 otherwise) with the market's population share in the municipality (age-specific) to generate a measure of market-level exposure. For example, the pharmacy desert index for girls age 16-17:

$$PharmDesert_{i,1965}^{Age16-17} = \sum_{n=1}^{N_i} NoPharmacy_{n,1965} \cdot \frac{Pop16-17_{n,1965}}{\sum_{j=1}^{N_i} Pop16-17_{j,1965}}.$$

Access cost components are significantly correlated. Using them together to instrument for pill sales may introduce weak instrument bias.[8] Instead of arbitrarily selecting a subset of instruments I construct

[7] See Appendix for additional details.

[8] See Appendix for additional descriptive statistics by age and for the pooled sample.

a principal component representation following Bai and Ng (2010). The first common factor (PC1) closely aligns with lower access costs, with positive loadings on the robust pharmacy market index and both pharmacy density measures, and a negative loading on the pharmacy desert index.[9] Factor loadings estimated on pooled data (age 16-29) are applied to age-specific factor measures to ensure comparability. Figure 2, Panel B, maps the pooled access cost index (PC1), illustrating the close correlation with sales per woman depicted in Panel A.

3 Fertility Responses Across the Age Profile

Age profile counterparts to the difference-in-differences estimates depicted in Figure 1 are presented in Figure 3. The top left panel plots the changes in ln fertility associated with living in a high sales market after the pill, relative to fertility changes in low sales markets, across narrow slices of the age profile. The DD model omits year interactions, instead interacting the same high sales indicator from Figure 1 with a post-pill indicator, $LegalPill_t$, for each age j:

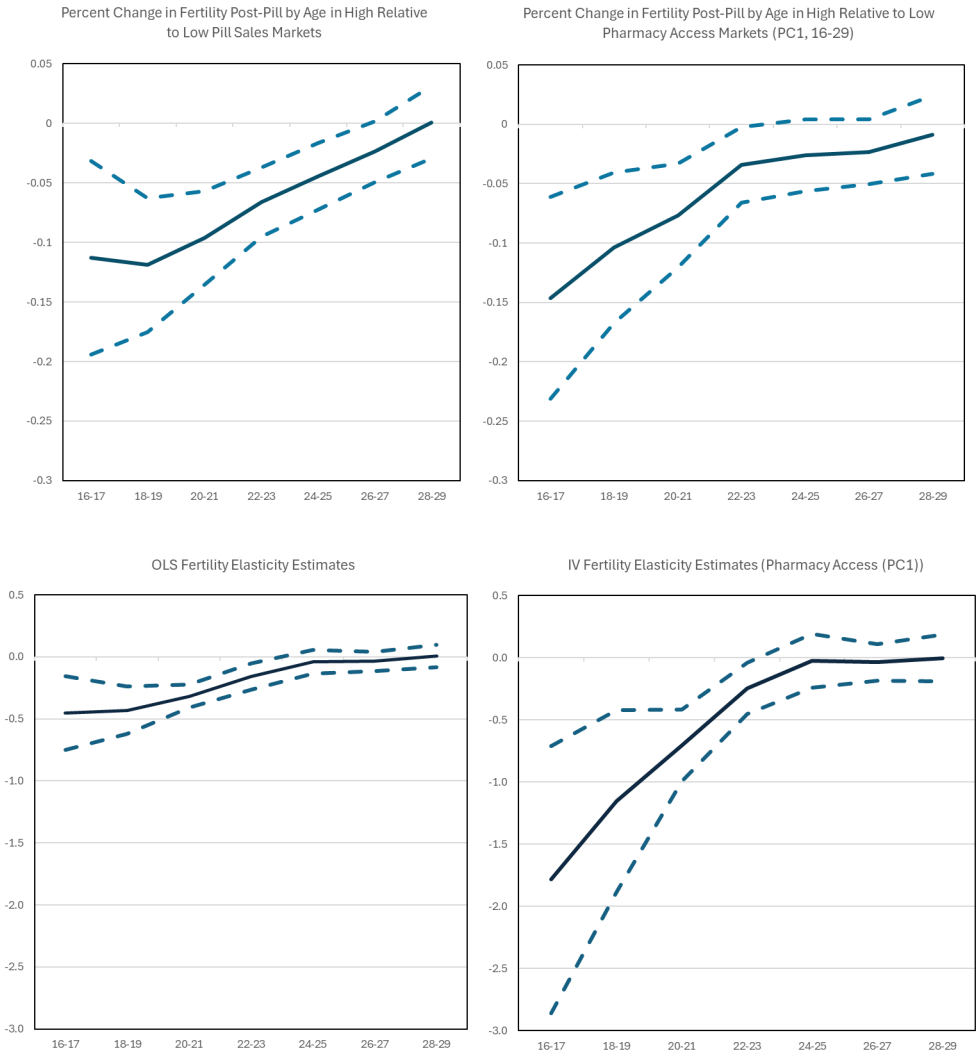
$$ln(BirthRate^j_{i,t}) = \alpha + \beta^j_{DD} LegalPill_t * HighPillSales_i + \beta LegalPill_t + \eta_i + \epsilon_{i,t}.$$

Estimates of β^j_{DD} show how teens and women in their early twenties living in high sales markets experienced fertility declines 10 percent greater than women in low sales markets. By the late twenties there is no difference in the evolution of fertility across markets. Grouping markets by pharmacy access instead of sales (top right), using the pharmacy access index to define above and below median access cost markets, reveals even larger fertility declines in low access cost markets among specific groups of teens; girls age 16-17 in low access cost markets have fertility declines 15 percent greater than girls facing higher access costs. Large fertility responses among the young lead to a steep age profile as relative fertility declines in high access markets become no different than zero already before age 24.[10]

[9] See Appendix for additional details on the principal component factor loadings.

[10] See Appendix for further details on the estimates plotted in Figure 3.

Figure 3: Fertility Responses by Age



Note: The top left panel plots DD the decline in ln births by age post-pill in high relative to low sales markets across 2-year age groups with 90 percent confidence intervals based on robust standard errors. The top right panel reports similar estimates comparing high pharmacy access markets based on the pooled first principle component analysis described in Section 2. The bottom left panel plots fertility elasticities estimated by OLS and IV (right panel). See Table 1 and Section 3.1 and 3.2 for details on the OLS and IV models and estimates.

Flatter response age-profiles to sales (top left) versus access costs (top right) align with the OLS and IV estimates plotted in the bottom panels of Figure 3. OLS elasticity estimates (lower left) link fertility changes to variation in sales per woman, in contrast, IV estimates (lower right) rely on just that part of sales predicted by access costs. More steeply sloped IV elasticity age-profiles among the young relative to the OLS illustrate the importance of access costs in shaping the pill's fertility effects among younger women, a point reinforced by the difference-in-differences analyses in Figure 3.

3.1 The OLS Model

The OLS model regresses births per woman (ln) on lagged sales per fecnd female (asinh).[11] Year and market fixed effects, γ_t and η_i, are included as well as time-varying reproductive care controls and differential trends for each quartile of the population density distribution included in $X_{i,t-1}$:

$$ln(BirthRate^j_{i,t}) = \alpha + \beta^j_{OLS} asinh(PillSales_{i,t-1}) + \beta^j X_{i,t-1} + \gamma^j_t + \eta^j_i + \epsilon^j_{i,t}.$$

Estimates of β^j_{OLS} reveal large fertility elasticities to pill sales per woman among teens 16-17 and 18-19, as seen in the coefficient estimates reported in Table 1 (Panel 1). A ten percent increase in sales per fecund female is associated with a 4.5-4.3 percent decline in births among teens, and a three percent decline among women age 20-21. The gradual decay in elasticity estimates from age 16 to 21 then accelerates, halving for women aged 22-23 and becoming no different from zero after age 24.

Coefficients on the reproductive care controls, in particular physician-staffed fertility clinics, reveal a distinctive age pattern associated with significant fertility declines among women from ages 22-27. The county-level clinic counts capture a main channel through which exemptions to the national abortion ban were obtained via the 'two-physician rule'. Finding a significant impact of this channel on the fertility of older women and not teens, who exhibit particularly strong responses to the pill's spread, is striking. While not causal, the age pattern suggests that abortion and the pill impacted the fertility of different populations, with the pill being particularly important for women 21 and under, while abortion exemptions via the the 'two-physician rule' had a significant effect on the fertility of older women. This pattern is also seen across the other models presented in Table 1, and the precise and highly significant estimates suggest that heterogeneity in the impact of fertility control across access the age profile is not isolated to the case of the pill.

[11] Sales are expressed as the inverse hyperbolic sine (asinh) to avoid dropping observations before the pill's introduction. The asinh is similar to ln but defined at zero. Bellmare and Wichman (2020) provide further details on asinh and ln transformations when estimating elasticities.

Table 1: Age-Specific Fertility Elasticities to Pill Sales: OLS, IV and Reduced Form Estimates

Age:	16-17	18-19	20-21	22-23	24-25	26-27	28-29
Panel 1: OLS Estimates from Regression of Ln Births Per 1000 Women on Pill Sales per Woman and Controls (Observations=560)							
asinh ($Pill_{t-1}$)	-0.453**	-0.431***	-0.317***	-0.160*	-0.040	-0.036	0.008
	(0.179)	(0.114)	(0.056)	(0.063)	(0.058)	(0.046)	(0.055)
OBGYN Capacity	4.956	-2.370	-2.881	-4.559	-2.875	-4.940*	-4.451
	(7.047)	(3.872)	(2.805)	(2.506)	(3.167)	(2.054)	(2.547)
Physician-Staffed Fertility Clinics	-0.008	-0.003	-0.003	-0.005**	-0.006***	-0.004***	-0.001
	(0.006)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.642	0.827	0.781	0.665	0.638	0.569	0.561
Panel 2: IV Estimates from Regressions of Ln Births Per 1000 Women on Pill Sales per Woman and Controls (Observations=560)							
2A: Instrument for Sales Using the Age-Specific Access Cost Index (Common First Principal Component Loadings)							
asinh ($Pill_{t-1}$)	-1.78**	-1.152**	-0.704***	-0.245†	-0.025	-0.037	-0.004
	(0.653)	(0.445)	(0.175)	(0.125)	(0.131)	(0.089)	(0.115)
asinh (OBGYN Capacity)	-12.34	-11.66	-7.86*	-5.65*	-2.69	-4.95*	-4.58
	(11.16)	(6.73)	(3.93)	(2.59)	(3.50)	(2.08)	(2.93)
Physician-Staffed Fertility Clinics	-0.005	-0.001	-0.002	-0.004***	-0.006***	-0.004***	-0.001
	(0.006)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
F-statistic	24.41	24.34	25.02	18.21	16.83	15.10	14.63
2B: Instrument for Sales Using the Ln Age-Specific Population Weighted Pharmacy Density per Total Municipal Area							
asinh ($Pill_{t-1}$)	-2.662***	-1.613**	-0.757***	-0.249†	-0.445*	-0.157	0.012
	(0.762)	(0.539)	(0.189)	(0.143)	(0.195)	(0.125)	(0.137)
asinh (OBGYN Capacity)	-23.76†	-17.58*	-8.54*	-5.69*	-7.79†	-6.37**	-4.39
	(12.74)	(8.52)	(4.26)	(2.72)	(4.22)	(2.15)	(2.78)
Physician-Staffed Clinics	-0.002	-0.000	-0.002	-0.004**	-0.005**	-0.004***	-0.001
	(0.006)	(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
F-statistic	16.05	16.05	16.42	16.56	17.69	17.46	17.47
Panel 3: First Stage Estimates Predict Pill Sales with Access Cost Indices or Local Pharmacy Density (Observations=560)							
3A: Predict Pill Sales Using Age-Specific Access Cost Indices (Common First Principal Component Loadings)							
Access-Cost Index$_{1965}$	0.056***	0.056***	0.062***	0.070***	0.069***	0.066***	0.065***
X(1 Year>=1965, else 0)	(0.011)	(0.011)	(0.012)	(0.016)	(0.017)	(0.017)	(0.017)
asinh (OBGYN Capacity)	-8.56*	-8.34*	-8.32*	-7.89*	-7.40*	-7.59*	-8.14*
	(3.51)	(3.52)	(3.39)	(3.32)	(3.34)	(3.30)	(3.33)
Physician-Staffed Fertility Clinics	0.000	-0.000	-0.000	0.000	0.001	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
3B: Predict Pill Sales Using Ln Age-Specific Population Weighted Pharmacy Density per Total Municipal Area							
ln Pharmacy Density$_{1965}$	0.039***	0.038***	0.038***	0.038***	0.038***	0.039***	0.039***
X(1 Year>=1965, else 0)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
asinh (OBGYN Capacity)	-10.38*	-10.16*	-10.10**	-9.86**	-9.38*	-9.18*	-9.17*
	(4.13)	(4.04)	(3.86)	(3.82)	(3.79)	(3.77)	(3.78)
Physician-Staffed Fertility Clinics	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)
Panel 4: Reduced Form Estimates Regressing Ln Births Per 1000 Women on Access Cost Indices or Local Pharmacy Density (Observations=910)							
4A: Age-Specific Access Cost Index (Common First Principal Component Loadings) Instrument							
Access Cost Index$_{1965}$	-0.105**	-0.072**	-0.055***	-0.026*	-0.011	-0.008	-0.005
X(1 Year>=1965, else 0)	(0.038)	(0.026)	(0.014)	(0.011)	(0.013)	(0.008)	(0.008)
asinh (OBGYN Capacity)	-2.658	-3.951	-2.347	-3.677	-1.966	-4.212*	-3.865
	(5.759)	(3.879)	(2.592)	(2.128)	(2.787)	(1.700)	(2.411)
Physician-Staffed Fertility Clinics	-0.007	-0.003	-0.002	-0.004**	-0.005***	-0.004***	-0.001
	(0.005)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
R^2	0.651	0.823	0.803	0.748	0.650	0.549	0.577
4B: Ln Age-Specific Population Weighted Pharmacy Density per Total Municipal Area Instrument							
ln Pharmacy Density$_{1965}$	-0.079***	-0.054***	-0.032***	-0.014**	-0.015**	-0.010**	-0.006
X(1 Year>=1965, else 0)	(0.012)	(0.009)	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)
asinh (OBGYN Capacity)	-0.081	-2.447	-0.892	-3.019	-2.404	-4.444**	-3.988
	(6.002)	(3.618)	(2.431)	(2.038)	(2.651)	(1.635)	(2.409)
Physician-Staffed Fertility Clinics	-0.004	-0.000	-0.001	-0.004**	-0.004**	-0.003***	-0.001
	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.654	0.828	0.803	0.747	0.657	0.553	0.578

Note: Cluster-robust (market) standard errors in parentheses. Estimates are population weighted and include year and market fixed effects, asinh of OBGYN care capacity per woman (15-44), physician staffed family planning clinic counts, and trends by quartile of the population density distribution. The inverse hyperbolic sine (asinh) mimics ln but is defined at zero. See Section 2.7 for a description of how the access cost index and pharmacy density instruments are defined. p-value < 0.10 (†), 0.05 (*), 0.01 (**), or 0.001(***).

3.2 IV Model with Age-Specific Access Costs

The age-specific access cost indices described in Section 2.7 are used to construct instruments for pill sales, denoted $Z_{i,t}^{j}$.[12] Each instrument interacts an age-specific access cost measure with an indicator for the post-pill time period:

$$Z_{i,t}^{j} = \begin{cases} 0 & t < 1965 \\ AccessCostIndex(PC1)_{i,1965}^{j} & t \geq 1965. \end{cases}$$

Time variation comes from the pill's approval. Cross-sectional variation comes from local pharmacy density and market structure measures which together define the age-specific access cost indices.

The IV builds upon an extensive empirical literature using publicly regulated infrastructure in the form of schools (Duflo, 2002) or reproductive clinics (Bailey, 2012) that shift access to schooling and contraception to isolate supply-side variation in treatment exposure. My application differs from Bailey (2012) as pharmacy location was largely determined by policy decisions undertaken decades or centuries before the pill's introduction in contrast to the Title X clinic roll-out which occurred after the pill's introduction. Such institutional features along with the inclusion of extensive time-varying controls and trends ameliorates concerns related to potential policy endogeneity.

Variation in sales driven by predetermined differences in pharmacy access costs are used to estimate causal effects.[13] This interpretation assumes that once the full set of fixed effects, reproductive care controls, and fertility trends across the population density distribution are taken into account access costs are uncorrelated with *changes* in fertility around the pill's legalization except through the pill. These assumptions cannot be tested, but pre-trend analysis argues against fertility changes before the pill being correlated with access cost measures.[14]

[12]Component weights from the pooled PC1 decomposition and summary statistics on the age specific component values are presented in the Appendix.

[13]For comparison, a similar instrument is defined replacing the multi-factor index with the single ln pharmacy density component, and estimates are reported in Table 1 (Panel 2B). These estimates provide a bridge to the analysis in Ragan (2025), albeit for different age groupings and a different functional form, where population weighted pharmacy density served as the instrument for pill sales.

[14]Changes in ln births before the pill and the pharmacy access PC1 index or any of the sub-component measures are not

IV elasticity estimates reported in Table 1 (Panels 2A and 2B) are negative, highly significant, and greater than one for girls 16-19 years. Among women age 20-21, a ten percent increase in sales from reduced access costs would lead to a 7-7.5 percent decline in births. By age 22-23 this response shrinks by a third, becoming no different from zero by age 24-25. Replacing the multi-factor access cost index with the pharmacy density component as an instrument yields even larger responses among young teens as seen in Table 1 (Panel 2B). Together, IV estimates confirm the pill's out-sized impact on young women's fertility. Estimates from Panel 2 also reinforce insights about the importance of physician-staffed fertility clinics for shaping the fertility of older women, a channel for obtaining exemptions to the national abortion ban. Both sets of estimates highlight important facets of heterogeneity across age in the impact of fertility control measures.

Turning to the first stage estimates reported in Panel 3A, recall the access cost index loads positively on both pharmacy density measures, the robust pharmacy access share, and negatively on the pharmacy desert measure. As the index increases access costs decline. First stage estimates reveal how easier access leads to increased sales. This is true both for the multi-dimensional index (Panel 3A) or the singular pharmacy density measure (Panel 3B). First stage F-statistics between 16 and 25 indicate that the instruments are strong predictors of sales. Together the estimates reinforce insights from the DD and OLS analysis regarding the pill's impact on the fertility of young women, while amplifying the importance of access costs for women under 22. It is also notable that the physician-staffed clinic index is not a significant driver of pill sales in either model, though greater provision of OBGYN Care per woman is negatively associated with sales per woman.

The final panel of Table 4 reports estimates from a reduced form (RF) model which replaces pill sales in the OLS model with the instrument, either the access cost index (Panel 4A) or the pharmacy access component (Panel 4B). The RF estimates quantify the relationship between the access cost instrument

significantly different from zero for any age group, nor do they display any pattern suggestive of access cost components being associated with declining fertility before the pill. See Appendix.

and fertility, without restricting the relationship to operate through the channel of pill sales. Coefficient estimates are negative and highly significant from ages 16-17 through 22-23 (Panel 4A), or age 26-27 when pharmacy density is the instrument (Panel 4B). Estimates become small after age 24 for both instruments. The negative coefficients on access cost are consistent with the positive first stage and negative IV estimates. The RF estimates include all post-pill years, including 910 observations, strengthening the causal interpretation of the IV elasticity estimates as they do not hinge on a subset of years when local sales are observed. The negative and significant impact of physician access among older women seen in the OLS is also seen in the RF estimates, though smaller in magnitude. This would be consistent with the inclusion of more years which predated the change in treatment praxis and also the broader medical literature in Sweden which documented a broader reliance on abortion among older women.

3.3 Economic Interpretation of IV and OLS Elasticity Estimates

The IV and OLS models are unique relative to previous medical literature from Sweden, but the analysis largely confirms insights from medical studies such as Sjövall (1972). Studying broader age groupings, Sjövall (1972) predicted that in the absence of the pill conceptions leading to birth or abortion would have grown by 40 percent among teens between 1964-69, but instead observed fertility fell sharply.[15] The modest increase in abortion among teens in the late 1960s meant that more than two-thirds of the fertility gap was driven by the pill. In this context, the elasticity estimates I find coupled with the pill's rapid spread confirm Sjövall's (1972) conjecture about the pill's particular importance for young Swedes. Furthermore, Sjövall (1972) argued that abortion was much more important for older women's fertility than the pill during the late 1960s, a finding that is largely consistent with the estimates reported in Table 1, in particular the RF estimates which include the earlier years Sjövall (1972) analyzed. Although I cannot measure abortion directly, the abortion provision channel captured by the physician-staffed fertility clinic counts suggests local abortion access was a significant determinants of fertility for women in

[15]See Sjövall (1972), Figure 8.

their mid-late twenties. This is a robust finding across the OLS, IV and RF models, and the insignificance of this channel for young women and teens is similarly striking.

While classical models allow for heterogeneous responses across observable dimensions, age in this case, responses within groups are homogeneous. OLS estimates may suffer from bias which IV can address. In this framing, differences between OLS and IV may be driven by factors such as selection bias, omitted variables, or attenuation bias, the most worrying of these leading to an upward bias in the magnitude of OLS estimates if, for example, women unlikely to have children for other reasons readily adopt the pill. Findings from Table 1 argue instead for OLS being attenuated. Yet, if attenuation bias is the main driver of the OLS-IV gap, the question remains why this gap displays such striking age-dependence instead of a proportional rescaling?

Relaxing classical assumptions regarding homogeneous treatment effects and allowing for *essential heterogeneity* (Heckman et al, 2006) can resolve this puzzle.[16] In this frame IV identifies a local average treatment effect (LATE), a weighting of heterogeneous marginal treatment effects (MTEs). Different instruments capture fertility responses of different populations. My IV places zero weight on women insensitive to access costs, in contrast to the average response estimated by OLS. The elasticity age-profile estimated by IV captures the fertility responses of women influenced to use the pill in response to changes in access costs, so-called access-cost-compliers. These access-cost-compliers are precisely the population of interest to policy-makers evaluating policy interventions that alter contraceptive access costs.

Allowing for heterogeneous treatment effects opens up possibilities for meaningful economic interpretations of the strong age-dependence of the OLS-IV gap. Young women whose pill adoption is shifted by access costs have larger fertility responses per unit of sales than the average. Adopting the pill leads to more avoided births for young cost-sensitive women relative to their older cost-sensitive counterparts.

[16]Essential heterogeneity recognizes responses to the pill are heterogeneous across women, and allows that the decision to use the pill is a reflection of each woman's partial knowledge of this idiosyncratic response.

These are meaningful economic insights that open avenues for future research to better understand how the access-cost-complier population and underlying MTE distribution evolve across the age profile. No longer a nuisance, age-dependence in the OLS-IV (ATE-LATE) gap could help us understand to what extent MTEs for woman on the margin of adopting the pill differ by age. At the earliest phases of the reproductive life-cycle, access-cost-selection into pill use is important; compliers are not random as their gains in terms of births avoided are large relative to the average. This difference dissipates sharply with age, valuable information for both policy design and economic understanding of the pill's fertility effects in settings where abortion is restricted.

4 Fertility Elasticities Over Time

Figure 1 depicted time-varying fertility responses, with women between 20-24 experiencing initial fertility declines that dissipate after five years. To understand such dynamics within a narrower age-bin framework I simulate sales for the entire 1965-74 period. The approach exploits high persistence in observed market shares (1970-74) and the strong correlation of sales with predetermined facets of pharmacy access cost.[17] First, I construct pill sales market shares based on predicted sales per woman using the pharmacy access cost index (PC1) and year fixed effects. The average of these predicted market shares (1970-74) is then used impute sales per woman using total sales (1965-74) over the entire post-pill period.[18]

This approach follows the intuition of exposure research designs where variation in exposure to a common shock drives differential impact, see Goldsmith-Pinkham et al (2020). The pill's introduction is the common shock and historically determined access costs drive differential exposure, as market shares reflect just that part of sales predicted by access costs in 1965.[19] Unlike exposure designs which rely on equilibrium determined market shares, my simulation is a function of historical policy variation embodied

[17]Market shares are highly persistent over time. From 1970-74, local market shares have an auto correlation of 0.9992.
[18]The simulated sales series is presented in greater detail in the Appendix.
[19]A parallel analysis using observed market shares 1970-74, similar to a Bartik instrument, is reported in the Appendix.

in the pharmacy access cost (PC1) index. Using predetermined variation in sales driven by past policy ameliorates potential threats to identification which may arise when contemporary equilibrium outcomes are used to identify differential exposure. Jaeger et al (2018) discuss these challenges with regard to Kearney and Levine (2015), an influential example of an exposure instrument related to teen-childbearing and the MTV program *16 and Pregnant*.[20] Such critiques are misplaced here as access costs reflect policies decisions undertaken decades before the pill's approval.

Elasticity estimates reported in the top row of Table 2 come from specifications identical to the OLS models from Table 1, with *simulated* sales per woman, $\widehat{Pill}_{t-1}$, replacing observed sales. Estimates are large, negative, and highly significant, attenuating rapidly in age to become insignificant before age 24. The additional years of fertility data and simulated sales series yield estimates that broadly confirm the IV and OLS analysis using a very different methodological approach.[21] Table 2 broadly validates the OLS, IV and DD findings.

The bottom panel of Table 2 decomposes fertility effects over time, reporting the additional impact of simulated sales on births from 1970-74. For young women, additional effects are small and insignificant, while fertility elasticities over the decade are unchanged relative to the constant elasticity specification. The only exception to this pattern is seen for women aged 26-27 who experience a small but marginally significant fertility increase five to ten years after the pill's introduction.

5 Discussion and Implications

A blizzard of changing laws, statutes, and policies governing access to contraception and abortion complicate the interpretation of US studies using legal reforms to estimate the pill's impact. Differing estimates

[20] Jaeger et al (2018) argue that defining differential impact based on viewership just before *16 and Pregnant* aired is a problematic since it is a function of socio-demographic characteristics and trends. Once accounting for these demographic factors Kearney and Levine's (2015) estimates become insignificant.

[21] The Appendix includes estimates of a similar Bartik-like model based on observed market share which also confirms the findings in Table 1.

Table 2: Time Variation in Fertility Responses: A Simulated Instrument Analysis

Maternal Age:	16-17	18-19	20-21	22-23	24-25	26-27	28-29
Constant Fertility Elasticity to Pill Sales 1961-1974							
asinh($\widehat{Pill}_{t-1}$)	-1.02*	-0.62*	-0.45*	-021†	-0.09	-0.10	-0.06
bootstrap-t	-3.21	-2.77	-3.56	-2.48	-0.85	-1.25	-0.73
Prob> $\|t\|$	(0.02)	(0.05)	(0.01)	(0.07)	(0.65)	(0.33)	(0.51)
R-squared	0.65	0.82	0.80	0.75	0.65	0.55	0.58
N	910	910	910	910	910	910	910
Allowing Time Variation: An Additional Response to Sales 1970-74							
asinh($\widehat{Pill}_{t-1}$)	-1.01*	-0.63†	-0.46*	-0.21†	-0.12	-0.13	-0.08
bootstrap-t	-2.79	-2.65	-3.40	-2.48	-0.98	-1.43	-0.95
Prob> $\|t\|$	(0.04)	(0.08)	(0.01)	(0.07)	(0.63)	(0.26)	(0.42)
asinh($\widehat{Pill}_{t-1}$)X(1969-74)	-0.08	0.03	0.11	0.11	0.12	0.12†	0.09
bootstrap-t	-0.22	0.18	0.71	1.13	1.27	1.79	1.25
Prob> $\|t\|$	(0.85)	(0.91)	(0.84)	(0.59)	(0.37)	(0.10)	(0.28)
R-squared	0.65	0.82	0.80	0.75	0.65	0.55	0.58
N	910	910	910	910	910	910	910

Note: The simulated instrument, denoted $\widehat{Pill}_{t-1}$, is discussed in Section 4 and related first stage estimates and summary statistics can be found in the Appendix. Wild cluster bootstrapped t-statistics are based on 9,999 replications. Baseline controls include year and market fixed effects. 1965 is omitted. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.10$.

and interpretations have generated debate about how legal-access is defined (Bailey et al, 2013, Bailey and Lindo, 2017, Myers, 2017). Less attention has been given to how the ambiguity legal reforms generate may hinder access to care.[22] Factors from institutional inertia to information constraints can complicate interpretation of estimates based on legal reforms. Sweden, in contrast, was an example of policy continuity before and after a routine administrative decision made the pill available to *all* women late in 1964. In this setting, with well-established contraceptive rights and infrastructure for providing contraceptive care, the pill's impact was large and unambiguous.

My findings confirm insights from Bailey's (2010) study of Comstock laws and contraceptive sales bans across broad age groups and Ragan's (2025) analysis of teenagers. Moving beyond binary indicators to quantify sales directly I estimate models that make the pill's fertility effects precise and allow comparison across younger and older women whose baseline fertility differs substantially. Yet, the most striking insights come not from comparisons of teens and women almost twice their age, but the sharp differences within groups of teens which broader comparisons miss.

Large, negative, and highly significant fertility estimates across multiple models (DD, OLS, RF, IV and simulated instruments) establish the pill's importance for young women, as well as the critical role access costs played in shaping the pill's spread. IV isolates variation in pill sales driven by access costs, identifying responses among women whose pill use is sensitive to such costs. IV estimates exceed OLS among young women as access-cost-compliers exhibit much larger fertility responses than the average woman. The data is consistent with access costs and privacy-related frictions being particularly salient for young women. This is an important observation for policy-makers as many policy-relevant counterfactuals involve access frictions.[23]

These insights are important for how economists model the mechanisms driving pill use among the

[22]Contemporary surveys document the uncertainty (Kearney et al, 2024) and misinformation (Lopes et al, 2023) women have been exposed to in the wake of recent legal decisions. Bailey and Lindo (2017) discuss these issues in the historical setting, while Bailey et al (2013) acknowledge how these frictions may lead to estimates which understate the pill's fertility effects.

[23]See for example Bailey's (2013) thorough study of Title X initiatives in the US to recent action to dismantle these programs (Kitchener, 2025).

young. Kennes and Knowles (2024) discuss the difficulty quantitative models face in matching low contraceptive use rates among young unmarried couples in the US without including a role for preference shocks.[24] My analysis provides empirical evidence on an alternative mechanism, access costs, which could play a quantitatively important role in explaining low take-up among the young, and which may be easier to align with cross-country empirical analyses than age-specific preference shifters.

My findings also validate theories of contraceptive choice with fixed costs such as Michael and Willis (1976). Their theory argues fixed costs lead women whom have already invested in legacy contraceptive technologies, likely older women, to eschew new modes of contraception. They conjecture that the pill-adoption age-profile skews heavily toward the young. Although I cannot measure pill use by age, the fertility responses I estimate are consistent with the theory.

With regard to the evolution of elasticities over time, Goldin and Katz (2002) argue that initial marital delay induced by the pill would lead to increased marriage market thickness at later ages. This secondary channel could lead to further delays in family formation and fertility among young women. This may be the case, but the data reveal little evidence of growing fertility responses over time among young women. Instead, the positive association between pill sales and fertility among 26-27 year-old women a half decade after the pill's introduction indicates how initial fertility declines among young women may be partially offset by later birth increases, consistent with the pill enabling fertility delay.

6 Conclusion

I quantify the pill's impact on fertility across the age-profile using granular data on pharmacies and sales spanning the decade after the pill's introduction and before abortion rights were established in Sweden. Age-specific access costs predict local pill sales, and fertility responses to the pill's diffusion are negative and large. Elasticity estimates are greater than unity for women aged 16-17 and 18-19, and for

[24]Such assumptions regarding preferences run counter to the high prescription rates observed among Scandinavian teens as reported in Meirik et al (1984) and Skjeldestad (1994).

women in their early-twenties between -0.25 and -0.75, becoming indistinguishable from zero after age 25. Despite a sharp trend-break as rapidly rising pill sales plateaued five years after introductoin, elasticity estimates remain stable. The only significant change in the pill's fertility effects over time is seen among older women, where simulated instrument estimates point to an increase in fertility among women aged 26-27 five years after the pill's introduction, consistent with the pill's spread leading to fertility delay. Together, the findings provide a precise and comprehensive picture of the breadth and persistence of the pill's impact on childbearing.

By elaborating the causal chain that leads from legal access to pill use and fertility outcomes, the estimates provide valuable empirical inputs to discipline quantitative models and anchor theories of fertility control adoption. Moreover, the analysis elevates the important role of access costs in understanding contraceptive choice in high-income settings. The striking gap between IV and OLS estimates is consistent with access-cost-sensitive adopters exhibiting much larger fertility responses than the average woman, a gap which is strongly age-dependent. This empirical insight is salient to contemporary policy design, for example in settings where abortion is restricted and contraceptive access costs are rising, a phenomenon recent medical studies have discussed as a potential driver of changing trends in hormonal contraceptive use across US states (Qato et al, 2024). My estimates highlight the population-level fertility impact such barriers to contraceptive access impose and how even small changes in hormonal contraceptive use can translate into large changes in fertility among women at the first stages of their reproductive lifespans.

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