Empowerment or Immiseration? The Pill and a Century of Unwed Childbearing

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Abstract

Prominent theories posit that fertility control liberalization contributed to rising unwed childbearing, an immiseration effect. This view is challenged by studying local oral contraceptive sales and fertility data surrounding the pill's introduction in Sweden. I present a model where women's demand for premarital sex is a function of customs for preventing unwed birth and equilibrium determined promiscuity norms. These factors jointly determine past unwed birth and demand for contraceptive innovations. Sales data confirm 19th Century unwed birth to be a positive and highly robust predictor of the pill's adoption. The theory motivates an empirical model which is used to estimate how pill use shaped unwed birth. The data reveal how the pill's diffusion reduced unwed childbearing among teens, consistent with the model predictions. The rising share of births occurring out-of-wedlock is driven by a decline in marital childbearing that coincided with the pill's introduction but is uncorrelated with the extent of pill use in a market, consistent with an empowerment effect.

JEL Codes: J13, N3, O33, Z10

Keywords: oral contraception, the pill, out-of-wedlock birth, premarital sex, Swedish fertility, teen childbearing

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1 Introduction

There are few more compelling examples of technology as liberator than "the pill,"an innovation which promised women control over their fertility and their sex lives. This promise stood at odds with centuries of custom and severe social sanctions levied against unwed women. In the absence of effective contraception, social stigma and custom became important checks on non-marital fertility, achieved at the price of curtailed sexual freedom and severe punishments against women who deviated from chastity norms. The European fertility transition and modern economic growth transformed Swedish society in myriad ways over the 19th and early 20th century. Yet, adoption of the 20th century's most important technological advance was shaped less by contemporary labor and marriage market conditions than by out-of-wedlock birth (OWB) from a century earlier.[1] In liberating women from unwanted birth, the pill reshaped fertility patterns which had characterized the Swedish demographic landscape for three hundred years in less than three decades.[2]

This view of the pill as liberator runs counter to prominent economic theories such as Akerlof, Yellen, and Katz (1996), hereafter AYK. Fertility control liberalizations, the pill being a prime example, may have an immiserating effect on women who do not to adopt them according to AYK.[3] AYK describe a channel through which the pill's diffusion could lead to increased unwed birth, reduced marital births, and an increase in the share of births occurring out-of-wedlock. The rising share of unwed birth among young women observed in the U.S. as well as Sweden after the pill's introduction is cited as evidence in support of AYK's model and the implied immiserating effects of the pill.

The view that fertility control liberalization can be harmful to certain women is countered by Chiappori and Oreffice (2008). They argue that when improvements in fertility control are available to all women, as was the case in Sweden with the pill, they will unambiguously improve all women's welfare, irrespective of whether they use the pill or not. The marriage market model they develop posits that the pill reduced the likelihood of costly unplanned pregnancies. This raises the utility of single women and hence the reservation utility of all women via an empowerment effect. The equilibrium outcomes Chiappori and Oreffice describe are driven by all women's access to the pill versus certain women's pill

[1] The Economist (1999) declared the pill the most important scientific advance of the 20th century.

[2] Frykman (1977) maps of 19th and early 20th century unwed childbearing across Swedish communities noting the high degree of persistence over time. Gustav Sundbarg, the father of Swedish population statistics, traced similar patterns in unwed birth across Swedish regions back through the 17th century, see Sundbarg (1910).

[3] As the pill spreads, women who use the pill may engage in sex without promises of marriage in the case of pregnancy, while women who have a strong preference against using the pill may no longer be able to obtain such promises. These women face the decision of abstaining from sex or risk bearing children outside of marriage in the case of pregnancy. Some of these women will continue to have sex outside of marriage, as before the pill, but now they will bear the costs of unplanned pregnancy outside of marriage, whereas before the pill their children would be born within marriage.

use per se.[4] Although both AYK and Chiappori and Oreffice emphasize how the pill substitutes for marriage as a means of reducing the expected costs of unplanned pregnancy, the models provide very different assessments of the pill's impact on women's wellbeing and the mechanisms behind declining marital childbearing. The novel pill use data and analysis I present will allow for a better understanding of how the pill shaped young women's childbearing and the likely welfare effects this contraceptive innovation had on a generation of Swedish women.

Although the model I develop incorporates elements of AYK and Chiappori and Oreffice my focus is quite different. I emphasize how courting customs and equilibrium determined social norms shaped OWB in 19th century Sweden. The model formalizes literatures from biology, demography, ethnography and history which emphasize social control as a means of regulating OWB and describes how these same constraints shaped the adoption of the pill.[5] In the spirit of AYK, the model motivates a specific type of preference heterogeneity with deep historical roots. The model predicts a positive correlation between past OWB and adoption of the pill in the short-run. This prediction is borne out in the data and shown to be highly robust to the inclusion of an extensive set of contemporary and historical factors and restrictions on the channels through which past OWB operate. In this regard, OWB is unique among historical factors in predicting the pill's adoption. The model also generates predictions regarding how the strong positive correlation between past OWB, pill use, and contemporary OWB evolve over time that vary depending on the driving force at work. Evaluating the theory with respect to data on pill use and teen OWB over four decades points to a quantitatively important role for customs and social norms in shaping demand for the pill.[6]

My emphasis on the social determinants of historical illegitimacy and the pill's adoption provides a modern day parallel to a broader literature which has emphasized cultural factors as drivers of changing fertility control behavior in 19th Century Europe.[7] Spolaore and Wacziarg (2021) emphasize cultural

[4]Chiappori and Oreffice discuss multiple extensions which introduce heterogeneity in costs of pill use. One such cost could be a preference or disutility associated with using the pill, similar to that discussed by AYK. My empirical analysis will consider these types of preference costs and more standard pecuniary aspects of access to the pill. The empirical analysis is closely aligned with the discussion of alternative costs in Chiappori and Oreffice.

[5]Emphasizing the fertility decisions of the young and unmarried in my model is broadly consistent with the facts surrounding pill use across Scandinavia where access to the pill was generally unrestricted. Socialstyrelsen (1984) document how teens and women in their early twenties accounted for over half of pill users in Sweden, similar to evidence from Norway presented by Skjeldestad (1994).

[6]The period of study comes well after Sweden entered an era of low fertility and high economic growth. This poses a challenge to models where traditional beliefs hinder the adoption of contraception, the onset of the fertility transition, and the transition to a modern growth steady state. Such models predict that once a transition to a low fertility high growth steady state is underway traditional beliefs no longer influence fertility control. See Prettner and Strulik (2017) or Baudin (2007) for examples.

[7]The Princeton European Fertility Project emphasized cultural and linguistic factors as drivers of changing 19th Century fertility behavior in Europe in contrast to economic factors. See Pollak and Watkins (1993) for a broader comparison of this literature with the economic analyses typified by Schultz's (1985) seminal study of wage shocks in 19th Century Sweden.

factors in driving fertility control adoption among married households in 19th Century Europe. Quantifying a robust positive relationship between past OWB and pill demand broadens the domain of this literature to incude the fertility behavior of unmarried women and extends its range to modern day fertility control innovations.[8]

Swedish demographers and ethnographers have long conjectured that persistent OWB patterns were an outcome of diverging social norms across communities, in parallel to early theories of culture which focused on the regulation of sex and reproduction.[9] My model formalizes the role of customs and social norms, making explicit what economists from Malthus to Marshall have recognized, while generating testable predictions about how past OWB influenced the pill's spread across Swedish localities.[10] Fernandez (2011) notes the dearth of studies on how cultural factors influence fertility control adoption, an important mediating channel through which culture could shape women's fertility and labor supply.[11] Although AYK and others describe how contraceptive innovations may shape social norms pertaining to premarital sex, Fernandez (2011) suggests culture and contraceptive adoption exert a joint influence on each other.[12] This paper models and empirically quantifies the other side of this feedback mechanism.

Social norms are difficult to quantify, a problem that is even more acute when studying behavior from past centuries. My model links social norms to an observable proxy, OWB. Extensive empirical evaluation of the model makes a persuasive case for the hypothesized channel in the theory being consistent with the data.[13] Introducing heterogeneity in the impact of past OWB across markets strengthens the case for social norms as the mechanism through which OWB shapes pill demand.[14]

The importance of historical OWB in predicting the pill's diffusion has no obvious precedent in economic theories of contraceptive adoption, such as Easterlin and Crimmins (1985) or Michael and Willis (1976), nor the broader economic literature on technology adoption following Grilliches (1957).

[8]OWB has not been well understood within the historical demographic literature. According to Shorter (1973), unwed birth in 19th Century Europe was "as puzzling to historical demographers as the making of gold once was to alchemists."Studies of the European marriage pattern (EMP) such as De Moor and Van Zanden (2010) have also emphasized non-marital childbearing.

[9]Gustav Sundbarg, the father of Swedish population statistics, traced persistent differences in OWB back through the 17th Century and attributed this phenomenon to differences in 'public mood' transmitted across generations within communities. See also Malinowski (1927) for an early study of culture and sexual behavior.

[10]Marshall's (1922) *Principles of Economics* notes "Society exercises pressure on the individuals by religious, moral and legal sanctions....To its [population] influence, often unavowed, sometimes not even closely recognized, we can trace a great part of the rules, customs and ceremonies that have been enjoined in the Eastern and Western world by law-givers, by moralists, and those nameless thinkers, whose far-seeing wisdom has left its impress on national habits."

[11]See Fernandez and Fogli (2006, 2009).

[12]Greenwood and Guner (2010) and Fernandez-Villaverde, Greenwood and Guner (2014) present a quantitative model of contraceptive innovations and social norms among the young and unmarried.

[13]This includes specifications that allow for unobserved fixed characteristic across markets.

[14]For example, communities where a higher fraction of the population is born outside the community at the turn of the century, and hence were less socialized in local norms, and potentially less likely to transmit such norms to future generations, have a significantly weaker correlation between historical OWB and pill adoption, consistent with the channel I model.

The empirical analysis presented in the first part of the paper establishes a robust relationship between historical OWB and demand for the pill a century later, outlining a theory whereby equilibrium determined promiscuity norms shape the initial correlation and evolution following the pill's introduction. In contrast to Skinner and Staiger (2007, 2015) and sociological studies following Coleman, Katz and Menzel (1966) on social norms among physicians, my theory emphasizes the impact of social norms on patient behavior and demand for medical innovations versus their supply. My theory of contraceptive demand does not preclude the possibility that the empirical model developed in the second part of the paper could be motivated by alternative theories.[15] Instead, the theory presents a mechanism which reflects a consensus across multiple literatures as to the important role of social constraints in shaping historical OWB in Sweden which is used to better understand the social forces which shaped the pill's adoption. My theory finds support in the empirical facts and lays the groundwork for an empirical model which can be used to estimate the pill's impact on non-marital childbearing, as well as many other potential behavioral margins, in order to push the theoretical and empirical debate about the pill's impact on women's lives closer to the data.

Few empirical studies have estimated how young women's marital and non-marital childbearing responded to the pill's introduction, nor the differential influence of the pill on these types of fertility.[16] Goldin and Katz's (2002) pathbreaking study exploits survey evidence from the U.S. to characterize pill use among single women, amply documenting the limitations of these surveys.[17] Given this dearth of data, Golden and Katz (2002) devise an empirical approach which uses cross-state, cross-cohort variation in legal access to contraceptive services to generate reduced form estimates of the effect of legal access to the pill on women's marriage and career decisions. This study has served as an empirical roadmap for an extensive reduced form literature which has explored the effect of legal access to the pill on a variety of outcomes.[18] Data limitations and legal reforms which condition on marital status have made empirical evaluation of theory difficult, leaving unresolved the overall impact of the pill on women's welfare.

The empirical model I develop in the second part of the paper relies on a fundamentally different source of variation than Goldin and Katz (2002) and the extensive literature which exploits binary legal access indicators to proxy for pill use across different cohorts of women. I utilize direct data on actual

[15] Whether the empirical facts I outline could be compatible with alternative theories of peer-to-peer networks, in the spirit of Rogers (2003) is beyond the scope of this paper, and similarly defining how the empirical predictions of such a model whould differ from the model I present remains for future research.

[16] Guldi (2008) is an important exception which focuses on access to the pill and abortion among minors.

[17] Unmarried women were excluded from the National Fertility Survey (NFS).

[18] See work on the pill and childbearing, as in Bailey (2010), employment, as in Bailey (2006) and Bailey, Hershbein and Miller (2012), children's life circumstances, see Ananat and Hungerman (2012), and savings and retirement, see Lindo et al (2020).

pill sales across 70 geographically defined local markets spanning multiple years after the pill's approval for contraceptive use, replacing two treatments with hundreds of potential treatments from which to estimate the pill's effect on unwed teen birth. The theory developed in the first part of the paper motivates using historical OWB to isolate a source of predetermined latent demand for the pill that is arguably exogenous to contemporary marriage and labor market shocks. This analysis is complemented by two parallel analyses that use alternative sources of variation in pill sales, one based on supply-side variation in teen's access pharmacies, similar in spirit to Card (2001), Duflo (2001), and examples from the fertility control literature such as Bailey (2013), the second a simulated instrument approach commonly used in regional analyses such as Blanchard and Katz (1992).

From the point of view of my model and the theories discussed above there is no distinction between the pill or abortion as the driver of fertility changes. As an empirical question, this distinction has been important in the interpretation of reduced form estimates. The parallel empirical literature on the fertility effects of abortion following Levine et al (1999) include several important contributions which assess the role of abortion and the pill in tandem. Guldi (2008) finds significant fertility declines among white teens in response to the pill and abortion access, and mixed evidence among non-whites. A recent study by Myers (2017) argues estimated fertility effects of the pill are sensitive to how abortion access is taken into account. Including extensive controls for legal access to abortion, she finds no evidence legal access to the pill reduced young women's childbearing.[19]

Myers (2017) conjectures increased sexual activity may counteract any fertility reductions brought about by the pill. Increased sexual activity among the unmarried after the pill is predicted by my model, but this increase in sexual activity is bounded in the short-run such that it should not raise the unconditional probability of unwed birth. The model and the data place restrictions on the elasticity of demand for premarital sex in the short-run such that the the unwed birth rate should not increase in response to a decline in the conditional probability of an unwed birth. More women will have sex outside of wedlock after the pill's introduction, but the restrictions on the model that generate the positive correlation between historical unwed birth and the pill's adoption also constrain the sexual activity channel to not be too large; increased sexual activity should not dominate the first-order reduction in unwed birth in the short-run. To what extent this is the case is an empirical question. The empirical analysis in the second part of the paper clearly points to the pill having a negative effect on unwed teen childbearing, an effect which is robust to the inclusion of alternative controls and the estimation of alternative models which rely different sources of exogenous variation in pill sales to identify their

[19]The empirical models I estimate include extensive controls for the provision of OB/GYN care in hospitals and women's access to physician staffed fertility clinics to account for any liberalization of abortion access which may have occurred before the national ban on abortion in Sweden was lifted in 1975.

impact on teen OWB. Regardless of the model, the data make clear that the pill was a powerful force for reducing childbearing among unwed teens.

Alternative empirical models contribute to a better understanding of how latent demand factors and supply-side variation shift pill use and fertility among women in Sweden. My theory formalizes mechanisms which have been argued to be important in shaping 19th Century unwed childbearing in Sweden and makes novel predictions about the pill's spread that are supported in the data. The extensive empirical validation of the model reveals historical OWB to be a unique and quantitatively important predictor of the pill's adoption, consistent with the predictions of the theory. The empirical model exploits this robust empirical relationship to elaborate an explicit causal chain that runs from latent demand shifters, to pill use, and ultimately unwed childbearing among teen girls. These estimates confirm the predictions of the theory along yet another dimension, and in the process provide a means of assessing competing theories surrounding the welfare effects of contraceptive innovations. The data are clear, the mechanisms of immiseration AYK describe do not align with the data.

The paper proceeds with a discussion of the data used in the analysis and the Swedish historical and contemporary institutional setting. Section 3 presents the model. Empirical evidence establishing the robust link between historical OWB and the pill's adoption in the short and long run is presented in Section 4. Section 5 exploits the mechanism described in the theory to motivate an empirical model where historical OWB instrument for a source of latent demand for the pill. A parallel model is also presented which uses teen's access to pharmacies at the time of the pill's introduction to instrument for supply-side variation in pill use. Section 6 reports reduced form and full model estimates relating the pill's diffusion to changes in unwed birth among young women in Sweden. Section 7 concludes.

2 The Data and Institutional Background

2.1 Pill Sales and Historical Illegitimacy Data

This paper is among the first to use the *Swedish Drug Market* (SDM) publication to quantify sales of the pill. The SDM provides direct data on contraceptive sales proximate to the pill's introduction, geographically disaggregated by market starting in 1970. Markets in the SDM coincide with Statistics Sweden's (SCB) labor market definitions (A-region). Labor markets incorporate multiple municipalities (kommun), that together define a local labor market inclusive of commuting communities.

Pill sales varied significantly across markets, as seen in Figure 1 panel A. Further details on oral contraceptive sales are presented in the bottom panel of Figure 1. The share of fecund females using

the pill on an annual basis is also computed using the price of the leading brand to convert total sales into annual doses.

The sales data reveal the pill's rapid spread. Sales data suggest a quarter of the fecund female population was using the pill by 1970, consistent with estimates from the Swedish Board of Health and Welfare (1984). Although I cannot quantify teen pill use directly, Swedish Board of Health and Welfare (1984) also estimate that half of teens were using the pill by 1979.[20] Other studies, such as Skjeldestad (1994) and Sjövall (1972), have also argued that pill use skews heavily toward teens. The sales data confirm Swedish survey evidence on the pill's widespread use; in less than five years the pill had become the third most popular method for preventing pregnancy behind condoms and coitus interruptus according to Lewin (2000).[21]

Data on the share of births ocurring out-of-wedlock, the OWB share, is first reported by towns and rural areas in the 1860 Statistical Yearbook. 1910 is the latest period consistent historical illegitimacy is reported before it is omitted from Statistical Yearbook publications. Statistical Yearbook data comes from population censuses performed every decade, and supplemented by data from local church books. Church books contain extensive birth, death, and marriage records in addition to the minutes of home interrogations conducted by local priests. The 1900 census resulted in discrepancy of only 310 missing individuals in the Church records of a total population of just over 5 million. The dual collection of population statistics, and the high level of agreement between these measures argues for the reliability of the birth statistics used here.[22] Alternative OWB measures are presented in the empirical analysis. Summary statistics for these measures as well as additional historical and contemporary controls are reported in the Appendix.

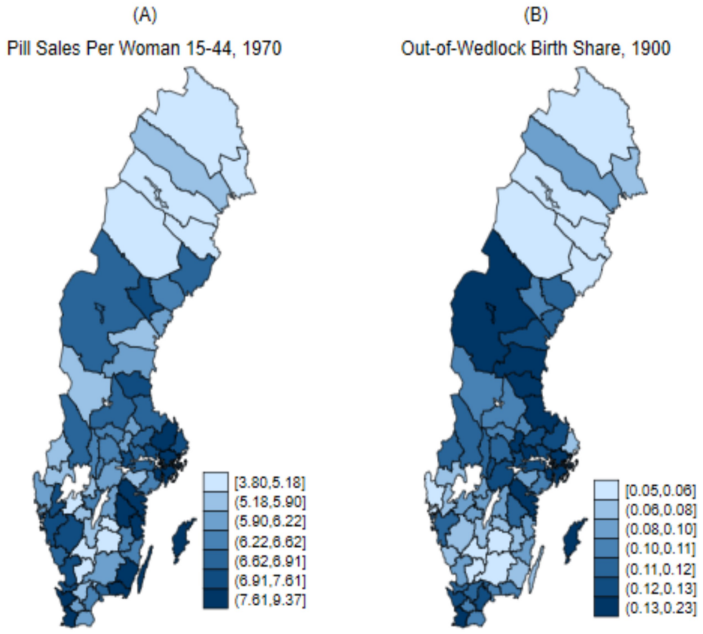
The OWB share in 1900 varied significantly across markets, as seen in Figure 1 panel B. This had been the case since the very first population statistics were collected; the map of OWB shares plotted in Figure 1 panel B looks very similar for other time period, as seen in the Appendix. The positive association between OWB shares in 1900 and pill use seven decades later is apparent in the maps in panels A and B of Figure 1. Stockholm, the largest city in Sweden, has the highest rate of pill use per woman, yet the second largest city, Gotheburg, is not among the top ten pill use markets. This parallels

[20]Sales data come with inherent limitations, foremost a lack demographic information on the pill users. Estimating demand by age, marital status, or educational background is not feasible. A lack of disaggregated survey data and the absence of prescription drug registries which could be linked to demographic data during the period of study preclude the construction of age or marital status specific pill use measures.

[21]Lewin (2000) suggests that while the use of condoms was widespread but the diaphragm's popularity was limited. Similarly, use of the IUD was rare during this period. The underlying data from Folkhalsomyndigheten, used by Lewin (2000), is not available to construct teen specific contraceptive use data and no recurring surveys on contraceptive use exist during this period.

[22]Myrdal (1968) argues that high historical rates of OWB in Sweden, relative to other countries, was due in large part to better measurement in the Swedish population statistics.

Figure 1: Pill Use and Out-of-Wedlock Birth (OWB) Across Markets and Summary Statistics



(C) Pill Sales and Teen Fertility, 1966-1974

Year	Total Sales 1000 SEK SEK	Leading Brand Name (Market Share)	Monthly Price SEK	Women Using Pill Annually Share	Teen Unwed Births per 1000 Teens (s.d.)	Teen Marital Births per 1000 Teens (s.d.)
1966	7,840	Conluten (38.5)	4.55	9.2	24.5 (6.7)	15.0 (4.9)
1967	11,755	Conluten (28.5)	4.06	15.5	24.7 (7.0)	12.7 (4.4)
1968	10,277	Conlunett (23.5)	3.01	18.3	22.6 (6.6)	9.0 (3.8)
1969	16,014	Conlunett (28.8)	3.02	28.2	19.5 (5.8)	6.9 (3.0)
1970	14,948	Follinyl (27.3)	2.94	26.7	19.8 (5.9)	6.3 (2.9)
1971	13,785	Follinyl (33.0)	2.94	24.6	21.5 (5.6)	5.1 (2.7)
1972	14,697	Follinyl (36.9)	3.27	23.6	21.6 (5.3)	3.9 (1.7)
1973	12,986	Follinett (25.6)	3.28	20.7	20.2 (5.7)	3.3 (1.5)
1974	14,079	Follinett (31.9)	3.50	20.9	20.8 (5.5)	3.1 (1.4)

Note: Panel (A): Sales in SEK of the pill per woman aged 15-44 in 1970 mapped by market. Sales data are from *Swedish Drug Market: Statistical Survey of Registered Pharmaceutical Specialties in Sweden.* Dark blue indicates greater sales per woman. Panel (B): Share of births out-of-wedlock in 1900 constructed from *Befolkning Statistisk Arsbok 1900.* Darker blue indicates greater share of births ocurring outside of wedlock. Panel (C): Details on annual pill sales from the *Swedish Drug Market* publication and summary statistics on births per woman aged 15-19 by marital status and market from SCB.

the relatively low historical OWB rates seen in this highly populous market in the West of Sweden. The model developed in the next section aims to understand the strong correlation between OWB shares in 1900 and the pill's adoption many decades later. This highly robust empirical relationship will provide the means to identify predetermined differences in latent demand for the pill in order to estimate how the pill shaped unwed childbearing among teens.

2.2 The Contemporary Institutional Setting

Since the 1950s, Swedish women as young as 15 enjoyed universal access to contraceptive services and birth control without regard to marital status or parental consent. The laws regulating the sales of

contraceptives did not differ by jurisdiction, and were set by national regulatory bodies. A national sex education curriculum and publicly operated network of maternal health clinics provided information about contraceptives and supplied diaphragms since the 1950s as well. The medical sector was highly regulated and operated almost entirely by public entities. The Riksförbundet för Sexuell Upplysning (RFSU), an advocacy group, kept a list of doctors known to provide contraceptive services, but ceased to maintain their referral list by the mid-1960s, citing universal willingness among physicians to provide contraception.[23] A highly regulated retail pharmacy sector offered the same assortment of contraceptives, at the same prices, throughout the country.[24] Liberal contraceptive access did not extend to elective abortion, which remained illegal until 1975.[25] These institutional features shaped the pill's widespread adoption in Sweden. From a practical perspective, the institutional setting also mitigates concerns regarding confounding factors. The universal legal access to contraceptive services women in Sweden enjoyed is closely aligned with the assumptions in Chiappori and Oreffice (2008), while the broader institutional setting led to a high degree of homogeneity across legal, medical, and educational environments as well as the retail pharmacy sector. In this unique environment, differences in demand are arguably of first order importance in understanding differences in pill use across markets.

2.3 The Historical Institutional Setting

Illegitimacy differed dramatically across Swedish communities since the very first population statistics were collected, motivating Sundbärg's (1910) division of Sweden into distinct demographic regions. A single characteristic that drives illegitimacy is difficult to discern. High rates of illegitimacy were seen north and south of the Limes Norrlandicus, along coasts as well as plains.[26] Mining and industrial regions had relatively high rates of illegitimacy, but other areas with high illegitimacy were primarily agrarian. Heckscher (1949) argued that urbanization explained OWB patterns, but Frykman (1975) shows how areas with high illegitimacy had population densities no different from central Småland, an area of persistently low illegitimacy. A series of land reforms, begun in the 18th Century, disrupted rural communities making it difficult to monitor and enforce norms related to sex and marriage among the young. Growing resource extraction industries in the middle of Sweden led to an influx of single

[23] See Linner (1967).

[24] Private insurance was rare; prices were set nationally by the Board of Health and Welfare, and these prices accurately reflected consumer cost. Advertising by pharmaceutical companies to consumers was prohibited.

[25] Lack of disaggregated abortion data precludes an analysis of abortion demand. The only Scandinavian country to legalize abortion before Sweden was Denmark, in October of 1973. Non-emergency healthcare in Denmark was limited to legal residents, precluding Swedish women from travelling to Denmark for abortion without established residence.

[26] The Limes Norrlandicus is a biological and climate border which marked the northern limits of settlements during the middle ages.

men who lived largely outside social controls.[27]

Biologists, demographers, ethnographers, historians and statisticians have put forth many theories for these patterns, but the central role of social constraints in regulating reproduction in 19th Century Sweden is a point of agreement.[28] Evolutionary biologist Bobbi Low (1990) described the setting, "19th Century Sweden represents an extreme of societal constraints on people's reproduction: highly monogamous, little remarriage, essentially no divorce, and a low rate of illegitimacy."[29]

Legal, financial, and social sanctions against women who engaged in pre-marital sex were extensive, including death in some circumstances.[30] "Churching" required unmarried mothers to confess their transgressions in conjunction with religious ceremonies designed to publicly humiliate them.[31] The church imposed fines and work levies on women who conceived children in relationships that did not lead to marriage and denied religious burial on these grounds.[32] The red whore cap was a means of public humiliation and economic segregation. Folk customs attributed the consequences of poor nutrition among children or livestock to whores, effectively banning many women from working near children or livestock, and relegating them to low wage field work.[33]

While the church strictly forbid sex outside of marriage, agrarian society was more permissive. Courting customs were a check on illicit sex and a means for enforcing marriage among the young. Sweden had several distinct customs, as discussed by Wikman (1937), but all of them carried with them severe penalties for women who violated local norms. Regions or social groups that were tolerant of pre-marital sex within *nattfrieri* (night courtship) were strictly opposed to loose sexual relations. Families played an important role in monitoring courting behavior in the south, a role filled by gangs of young men in the north.[34]

[27] A regression of OWB rates in 1910 on fixed effects for communities where the enskifte and lagaskifte land reforms were carried out most extensively, as described by Helmfrid (1961, p. 127), and a fixed effect for the three counties where the forestry industry employed 7 percent or more of the rural population are positive, highly significant in the case of forestry employment, and significant at the 10 percent level for the land reform measure.

[28] See Low (2000), Santow (1993), Sklar (1977), Frykman (1975), Wohlin (1915), and Sundbarg (1907,1910).

[29] Frykman argues that Low is wrong in her characterization of the illegitimacy rate being low and cross-country data bears out his criticism, as noted by Myrdahl (1968) and Sklar (1977). According to Tillhagen (1983) illegitimate births accounted for 2.5 percent of births in 1750, but steadily increased to 9 percent in 1850, 13 percent in 1900, and 15 percent in 1910.

[30] A woman who engaged in sex outside of marriage was a *hora* (whore). Unmarried women whom engaged in *lönskaläge* (affairs with unmarried men) or *enkelt hor* (with married men) were subject to punishment under the law. See Chapters 2 and 13 of the Giftermålsbalken and Chapter 17 of the Strafflagen.

[31] Confession as penance for unlawful intercourse was abolished in 1855 but continued to be practiced into the 20th Century in some parts of Sweden. These ceremonies culminated in absolution, but women who confessed illicit sexual behavior would never regain their status and sat apart from the community during church services.

[32] Tillhagen (1983) discusses how this resulted in women's bodies being smuggled into the churchyard for burial after dark on the north side of the church.

[33] Rickets (*horeskäver*) was commonly believed to be caused by whores.

[34] Tillhagen (1983) notes that in parts of western Sweden as well as Dalarna and Norrland night courship customs continued on well into the 20th Century.

Customs differed by region. According to Frykman (1975) punishments against women were more severe in southern Sweden, while monitoring and custom enforcement was stronger north of the limes norrlandicus. Other women were often monitors of sexual behavior; married women inspected single women's breasts in conjunction with tending to geese to determine if they had given birth or were pregnant.[35]

Young women faced a pernicious double standard: on one hand the church strictly forbid sex outside of marriage while more permissive local customs rooted in ancient traditions allowed sex within certain social constraints. By the turn of the century agrarian traditions were under pressure from both the church and developing industry. Control over the sexual behavior of the young and unmarried weakened as enclosure uprooted rural communities and the population movements which fueled early industrialization and urbanization left many outside the control or protection of traditional customs.

Early explanations of divergent fertility patterns in Sweden made little reference to contraception. Contraception, or anything that hindered *naturens gång* (nature's way) was widely viewed as a sign of moral weakness and forbidden by both the church and the state. The agrarian society that typified Sweden relied heavily on social control as a substitute for contraception. Fertility control entailed customs that promoted abstinence via long engagements and late marriage.[36] Although family planning and the spread of neo-Malthusian ideas among intellectual circles was underway in Europe during the 1870's the spread of contraceptive technologies was limited.[37] Anecdotal and quantitative evidence led Frykman (1975) and Santow (1993) to conclude that knowledge about coitus interruptus was widespread by the late 19th Century, consistent with the 1936 Population Commission, while familiarity with condoms, diaphragms and other methods for limiting fertility were minimal.[38] Tillhagen (1983) argues that those born as late as the 1930s had practically no knowledge of fertility control beyond interrupted intercourse. This is not surprising, as it was illegal to provide knowledge about contraceptive techniques or publicly sell contraceptives until 1938.[39]

Lacking measures to prevent conception, abortion was a perilous prospect. Since the 13th Century Västergötland Law abortion had been forbidden under threat of severe penalty. The criminal code of 1734 placed abortion on par with infanticide and made it punishable by death.[40] By 1890 the maximum

[35]Such monitoring had been used to catch child murderers since the Middle Ages.

[36]Nils Wohlin (1915) emphasized marital delay and abstinence in his analysis of the extremely low marital fertility rates on Gotland.

[37]Technical contraceptive measures that preceded the pill were a very recent phenomenon in Sweden according to Frykman (1975).

[38]Although coitus interruptus was well known by 1900, it should be noted that women may have had limited control over its use. Knowledge of the technique does not assure that it was used.

[39]Knut Wicksell pamphleted and lectured on contraception and was denounced as an "apostle of promiscuity" and jailed for spreading birth control propaganda.

[40]Punishment was carried out in public. Tillhagen (1983) graphically recounts an execution for a woman involved in

sentence had been reduced to six years of penal servitude.[41]

Knowledge of abortifacients was rudimentary as reflected in the home remedies believed to induce abortion.[42] In the last half of the 19th Century provincial doctors were required to perform autopsies of suspected suicides. Hedren's (1901) review of these autopsies revealed attempted abortion was widespread; from 1851 through 1900 an increasing number of suicides were committed by unmarried pregnant women, increasing quickly after 1870. The majority of women captured in the suicide statistics were in the final stages of pregnancy; ninety percent of these suicides occurred due to poisoning, usually by phosphorous.[43] Physical trauma and poison were the remedies for unwanted pregnancy, the consequences of which were often fatal.

2.4 Teen Childbearing Data and the Pill

The theory developed in the next section will link the social forces which shaped historical OWB behavior with pill demand across markets. The theory will be used to motivate an instrumental variables model to estimate how the pill altered teen childbearing in order to assess theories about how the pill altered childbearing and women's welfare. I focus on the fertility of teenagers using publicly available data from SCB birth registers that report births by mother's age and marital status. Births to married and never married teens are then expressed relative to the total teen population residing in a given market by year.

Linking market level fertility with pill sales reveals how the pill's spread across markets and time shaped teen childbearing within and outside of marriage. Figure 2 panel A groups teen fertility data across high and low pill sales markets and plots their evolution over time.[44] Before the pill the teen OWB share (red dash, right axis) and the OWB rate per 1000 teens (blue lines, left axis) were identical in high and low pill use markets, as were marital fertility rates (grey lines, left axis). OWB rates (blue) were increasing in lockstep across low and high pill use markets while the share of teen births ocurring outside of wedlock (red) were stable. After the pill is introduced, denoted by the solid vertical line in panel A, a large gap emerges between teen OWB rates in high and low pill sales markets. Unwed births decline rapidly in high pill sales areas (dark blue) while they continue to rise in low pill sales markets

three abortions in Vasterbotten in 1839, as recalled by a woman who was eight years old at the time; beheading and burning at the stake were common punishments.

[41]The law was further liberalized 1921.

[42]Tillhagen (1983) describes how most contraceptives and abortifacients were just common protections against 'evil' repurposed for protection from unwanted birth. Measures included phosphorous, arsenic, quicksilver, ergot, saffron and strong laxatives like aloe.

[43]Matches containing phosphorous were banned in 1901 due to their use in abortions, which in many cases were fatal to women.

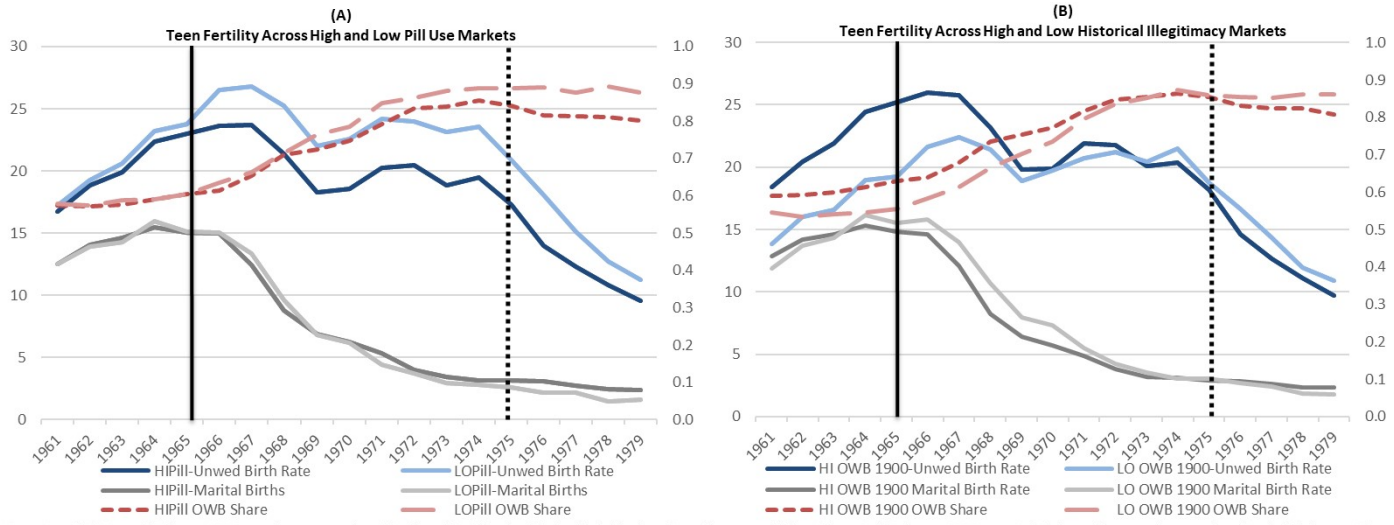
[44]High pill sales markets have average pill sales per woman above the median of the average pill sales per woman from 1970-74 of 5.35 SEK per woman aged 15-44. Low pill sales markets are defined as having average pill sales below the median.

before a more modest decline.

Teen fertility data reveals how the pill's introduction coincides with a rapid decline in the marital birth rate (grey lines) that is much larger than the decline in OWB rates (blue lines). Marital births decline from 15 per thousand to three in ten years. This steep decline is nearly identical in low and high pill sales markets, as the overlap between the grey lines in panel A illustrates. The steep decline in marital birth drives rising OWB shares (red dash) in panel A. This increase is greatest in low pill sales markets (light red dash), a consequence of the gap between OWB rates (blue lines) which emerges after the pill.

Using pill sales to group fertility data and understand the pill's impact on teen childbearing does not suggest that pill sales were correlated with increasing unwed birth in absolute or relative terms. Instead, the data point to the pill's differential spread being associated with a reduction in OWB among teens and its introduction driving a steep inframarginal decline in marital births. A simple difference-in-differences (DD) estimator which compares the non-marital fertility effects of the pill across low and high pill sales markets before and after the pill, but before the legalization of abortion in 1975 (dashed vertical line), yields an estimated decline of 2.81 (0.75) births per thousand teens in high pill sales areas over an above the decline experienced by teens in low sales areas (robust standard errors in brackets). Marital birth estimates are not significantly different from zero, -0.2 (0.66), while the OWB share is estimated to decline by two points, -0.02 (0.01), and is significant at the 10 percent level.[45]

Figure 2: Teen Fertility Across High and Low Pill Sales and High and Low Historical Illegitimacy Areas



Note: Panel (A) Unwed births per 1000 teens by year are plotted in above (dark blue) and below (light blue) median pill use areas (left scale); marital births per 1000 teens in high/low pill use markets are plotted in dark/light grey. The share of births occurring out-of-wedlock (right scale) are plotted in dashed dark/light red for both high/low pill use areas. High pill use indicates average pill use per woman aged 15-44 during the period 1970-74 being above the median value of 5.35 SEK per woman year; low pill use indicates areas where pill use per woman was below median. **Panel (B)** plots the same data series grouped with respect to whether the out-of-wedlock birth (OWB) rate in 1900 was above or below ten percent in 1900, the median. **Data:** Pill use data is computed from the *Swedish Drug Market* publication and population and birth data are from SCB.se and historical unwed birth data comes from SCB (1904).

The empirical analysis in the second half of the paper reinforces the descriptive comparison of high

[45]See the Appedix for details and further regression results.

and low pill sales areas in Figure 2 panel A. The sales data counter AYK's predictions regarding the pill's contribution to increased unwed birth and reveal how a uniform marital birth decline shaped the upward trend in the OWB share after the pill. The data suggest that the mechanisms linking the pill to increasing shares of unwed childbearing among teens should operate via inframarginal factors, such as an increase in all women's reservation utility in the spirit of Chiappori and Oreffice (2008), versus mechanisms that depend on the degree to which the pill is adopted in a market. At the same time, marginal increases in pill sales have a clear negative impact on unwed birth rates, as indicated by the cross-sectional analysis.

High and low pill sales markets were identical before the pill, with unwed teen births trending upwards in parallel and the differential adoption of the pill created a wedge between high and low pill sales markets. While the mechanisms AYK hypothesize may be at work, empirical support for their quantitative importance is difficult to disentangle from other aggregate shocks, at least in the case of marital childbearing, and the strong negative relationship with unwed birth clearly contradicts AYK's predictions. A more favorable interpretation of AYK with regard to Figure 2 panel A may argue that the pill led to increased inequality in the circumstances of birth across Swedish markets; although fewer unwed teen births ocurred overall, they became concentrated in low pill sales markets. In this interpretation, the pill introduced inequality among markets that had been similar, a difference of degree in the immiserating effects of fertility control liberalization hypothesized by AYK.

Does such a story align with the preference channel highlighted in the model in the next section which motivates using historical OWB shares to proxy for persistent differences in preference factors? Using historical OWB shares to group teen fertility data, as in Panel B, leads to a different interpretation of the data. Panel B depicts the evolution of teen childbearing across high and low italicshistorical illegitimacy markets, my proxy for persistent preference factors.[46] Communities that had above median share of OWB in 1900 have much higher rates of unwed birth among teens (dark blue, left axis) relative to communities with low OWB in 1900 (light blue) before the pill is introduced. OWB shares (dark and light red dash, right axis) reflect these differences in OWB rates among teens, as marital birth rates are roughly the same across both types of markets. The unwed fertility behavior of teens in the early 1960s closely adheres to the unwed birth patterns Sundbärg (1910) traced back through the 17th Century. When the pill is introduced the wedge between teen unwed birth rates across markets is quickly erased. Although unwed childbearing was more than 25 percent greater in high historical illegitimacy markets when the pill was introduced, by 1970 unwed birth rates are identical. The data illustrate how

[46]High and low historical illegitimacy is defined as above or below the median OWB share in 1900 (0.1025), corresponding to just over ten percent of births occurring outside of marriage.

a generation of teenage girls used the pill as a means to counter the constraints of custom that had shaped nonmarital fertility patterns among their mothers, grandmothers and great-granmothers.[47] The pill's adoption closed a gap in non-marital fertility that had persisted for centuries in five short years.

Through the lens of historical illegitimacy the pill is a liberator, erasing centuries of persistent inequality in the circumstances of birth across markets in less than a decade. This historical view casts contraceptive technology as an equalizer, rectifying a source of inequality that had left an imprint on over a century of Swedish fertility. This interpretation of the data argues against both the letter and the spirit of AYK. Not only is the theoretical focus on the pill as a driver of increased OWB after legalization misplaced, but a historical perspective on the preference factors which were important in shaping the pill's adoption suggest the pill was a force for fostering equality in the circumstances of birth, a liberation technology writ large.

3 A Model of Demand for Pre-Marital Sex

Capacity to monitor sexual activity and enforce traditional agrarian courting customs differed across communities, as did adherence to the abstinence norms promoted by the Church. My model formalizes these social constraints on fertility. Conditional on engaging in premarital sex, the probability of an OWB in community j, p_j, is a summary statistic that captures the shotgun marriage norms in AYK, facets of public mood as hypothesized by Sundbarg (1907, 1910), and other customs for coercing the young to marry in the case of pregnancy. The efficacy of interrupted intercourse practices in market j and other controls exerted by social, religious, and familial actors over the young for the purpose of preventing nonmarital birth are also captured by the p_j parameter.[48] In addition to the risk of having an OWB, with direct cost C, women engaging in sex outside of marriage, denoted by the share n_j, incur a psychic cost for deviating from abstinence norms, γ_j. This cost is a function of the share of women adhering to the abstinence norm in community j, the share $1 - n_j$.[49] Women choose whether to engage

[47]DD estimates using historical illegitimacy rates to define treatment groups in lieu of observed pill use generate similar estimates with regard to the pill's effects on teen childbearing. OWB among teens in high historical illegitimacy areas declined by 3.16 (0.72) births per thousand teens, over and above the declines observed among teens in low historical illegitimacy areas. Marital fertility also declined in high historical OWB areas by over one birth per thousand teens according to the DD estimate, -1.32 (0.67). The OWB share DD estimate is negative, but not significantly different than zero, -0.018 (0.013).

[48]The model does not emphasize the contraceptive information channel; although contraceptive knowledge may have varied, the measures referred to in the folk wisdom of the time were largely ineffective beyond the widespread practice of interrupted intercourse. The model does not preclude contraceptive knowledege playing a role, but this is not the primary motivation for the technology of OWB prevention.

[49]Legal, religious and community sanctions emphasize sex outside of marriage as a violation of a moral code of behavior; the psychic cost is realized when engaging in sex, regardless of whether an unwed birth occurs. The online Appendix presents an alternative model where the psychic cost is incurred only if unwed sex is detected via the occurrence of

in premarital sex to maximize their utility. If they abstain from premarital sex they receive utility V, a composite of single celibacy and sex within marriage. The value of abstaining is weighed against the joy received from engaging in premarital sex, β_i, where this taste parameter varies across women.[50] The utility of engaging (or not) in premarital sex is given by

$$U_{i,j} = \begin{cases} V & \text{abstain from premarital sex} \\ \beta_i - p_j C - \gamma_j & \text{engage in premarital sex} \end{cases}$$

Each community will have a critical threshold, β_j^{sex}, where women with larger benefits from premarital sex will choose to engage in sex and women whose benefit is less than β_j^{sex} will abstain. This threshold, β_j^{sex}, is increasing in both the psychic cost of violating abstinence norms and the expected cost of an OWB,

$$\beta_j^{sex} = V + \gamma_j + p_j C.$$

If β_i is distributed according to the cumulative distribution function $F(\cdot)$, for a given value of the psychic cost, γ_j, the fraction of women engaging in pre-marital sex will be

$$n_j = 1 - F(V + \gamma_j + p_j C).$$

Consistent with a conformity norm, the psychic cost of engaging in out-of-wedlock sex is higher if few women violate the abstinence norm.[51] If no one engages in pre-marital sex, the psychic cost may be large, $\lim_{n_j \to 0} \gamma(n_j) = \infty$. The more women whom engage in sex outside of wedlock the smaller the cost of doing the same, $\frac{\partial \gamma_j}{\partial n_j} < 0$.[52] A function that satisfies these conditions is $\gamma_j = \frac{1}{n_j}$.[53] Modelling the cost of violating chastity norms as an equilibrium outcome allows for a richer understanding of how customs and norms shape demand for new contraceptive technologies in both the short and long-run. The model predictions help discern which driving forces are compatible with the pill use data. The

an unwed birth. The model where stigma loads on OWB instead of the premarital sex decision are isomorphic, but convergence to a new equilibrium after the pill is more rapid under the alternative specification.

[50] I assume β_i shares a common distribution across communities, denoted $F(\cdot)$.

[51] If few women have premarital sex then there will be more women to punish deviators. This does not require women's sexual behavior to be observable to be punished. If more women adhere to the norm the more central the norm is to the social environment, and the greater the psychic cost to violate the norm. If none of your friends discuss the abstinence norm, because they do not adhere to the norm, it will be less costly for you to also deviate from the norm.

[52] Equilibria are not necessarily unique. If the stigma cost is infinite, the case under certain stigma functions when no one engages in premarital sex, no premarital sex is an equilibrium. Since a positive fraction of the female population engage in premarital sex in all the communities studied, as indicated by the frequency of OWB in the birth records, this type of non-uniqueness is not interesting for the study at hand.

[53] In this example γ_j decreases from ∞ to 1 as n_j increase from 0 to 1. This does not imply that all values of n_j are consistent with the decision women face for a given p_j. In particular, if the psychic cost function was set to the minimum value associated with $n_j = 1$, the expected cost of an out-of-wedlock birth, $p_j C$, may lead some women to abstain from pre-marital sex, implying $n_j = 1$ is not an equilibrium. Although the psychic cost function is defined over the interval $n_j \in [0,1]$, this does not imply that all values on the interval are equilibrium.

model provides intuition for the robust positive correlation between historical OWB and demand for the pill after legalization, as well as a set of long run predictions which can be rejected by the data.

Changes in p_j have an ambiguous effect on OWB. The direct effect of an increase in p_j is to raise OWB for a given share of the population engaging in out-of-wedlock sex. The indirect effect works in the opposite direction, reducing the fraction of the population that engages in non-marital sex,

$$\frac{\partial owb_j}{\partial p_j} = \frac{\partial p_j n_j}{\partial p_j} = n_j + p_j \frac{\partial n_j}{\partial p_j}.$$

The total response will be positive when the elasticity of the share having sex with respect to p_j, $\varepsilon_{n,p}$, is not too large.

$$\varepsilon_{n,p} = \frac{\partial n/n}{\partial p/p} > -1.$$

In the short run, when the psychic cost is fixed, $\overline{\gamma}_j$, the distribution function for women's taste for nonmarital sex and the cost of an unwed birth will determine $\frac{\partial n_j}{\partial p_j}$,

$$\frac{\partial n_j}{\partial p_j} = -f(V + \overline{\gamma}_j + p_j C) \cdot C$$

If C is large small changes in p_j lead to large changes in behavior. Similarly, where the probability distribution function, $f(\cdot)$, has large mass, changes in p_j induce large changes in the share of women engaging in premarital sex.

3.1 The Introduction of the Pill: A Short Run Analysis

Differences in p_j are motivated by local customs which shape the frequency of unwed birth among those engaging in premarital sex. The introduction of the pill put affordable and highly effective fertility control into the hands of women in every Swedish market. The pill's take-up was widespread; over a quarter of fecund females in Sweden and half of teenage girls were using the pill a decade after legalization.

The rapid take-up of the pill across markets suggests that the benefits of pill use were sizable. In the context of the model, women use the pill if the net benefit of using the pill exceeds the cost, where the probability of an OWB while on the pill is p_{pill}, and this comes at cost c_{pill}. Each community will have a net benefit criterion for adopting the pill,

$$c_{pill} < (p_j - p_{pill})\, C$$

If the net benefit condition is satisfied in community j, women will decide to engage in out-of-wedlock sex using the pill if their utility exceeds the value of abstinence,

$$V < \beta_i - \overline{\gamma}_j - p_{pill} C - c_{pill}.$$

Here $\overline{\gamma}_j$ denotes the *inherited* psychic cost consistent with equilibrium in community j before the pill. Another critical threshold, β_j^{Pill}, will determine pill adoption if $\beta_i > \beta_j^{Pill}$, where

$$\beta_j^{Pill} = V + \overline{\gamma}_j + p_{pill}C + c_{pill}.$$

Demand for the pill in market j will depend on two conditions:

$$n_j^{Pill} = \left[1 - F\left(V + \overline{\gamma}_j + p_{pill}C + c_{pill}\right)\right] \times 1\left[\text{if } c_{pill} < \left(p_j - p_{pill}\right)C\right].$$

The first term describes the share of women who would engage in nonmarital sex using the pill as a function of the inherited level of stigma, $\overline{\gamma}_j$. If $\overline{\gamma}_j$ is large, few women engage in nonmarital sex, just as in the past, and demand for the pill will be low. The second term captures the direct effect of local customs, p_j. If local customs are ineffective at preventing unwed birth, large p_j, the net benefit condition is likely satisfied; women whom engage in nonmarital sex will adopt the pill instead of relying on local custom.

In the short run, if the net benefit condition is satisfied, the critical threshold for engaging in premarital sex will decline, $\beta_j^{Pill} < \beta_j^{sex}$, and more women will engage in sex out-of-wedlock. The model illustrates how the forces which shaped past illegitimacy also shape demand for the pill. It is not OWB *per se* that causes greater demand for the pill, but differences in the degree of inherited stigmas against premarital sex, or the capacity of local institutions to prevent birth outside of marriage and in turn the net benefit of pill use, which shape the positive correlation between pill use and historical illegitimacy.

3.2 Demand for the Pill in the Long Run

The psychic cost of nonmarital sex is an equilibrium outcome. As the pill supplants traditional means of preventing unwed birth this will have different implications on demand for the pill in the short run (out of equilibrium) versus the long run (new equilibrium). Even the most effective traditional technolgy, $p_j^{\min}$, will be supplanted by the pill if $c_{pill} < \left(p_j^{\min} - p_{pill}\right)C$.[54] In this case, any women whom engages in sex outside of wedlock will opt to use the pill and the decision problem women face will no longer depend on local technologies, p_j, but instead the universal technology of the pill p_{pill}.

If the adoption of the pill is universal, the model predicts convergence in the psychic cost of premarital sex across markets, $\gamma_j \to \gamma_{pill}$, and in turn the threshold for engaging in sex outside of marriage:

$$\beta^{LR} = V + \gamma_{pill} + p_{pill}C + c_{pill}.$$

[54] Positive pill use is observed in all markets.

β^{LR} does not depend on local customs, p_j, or past stigma, γ_j. In the long run, the share of women engaging in premarital sex will not depend on the historical constraints which shaped past OWB and initial demand for the pill. Demand for the pill will converge and the positive correlation between past illegitimacy and pill demand will disappear as the share of women engaging in sex before marriage no longer depends on local constraints. In the new equilibrium, unwed birth will not be significantly correlated with past OWB; this convergence in pill demand and unwed birth is specific to the driving force of local customs, p_j. Heterogeneity in the value of abstinence or unwed birth costs generate different long run predictions, as discussed in the Appendix. The model illustrates how tradition can be supplanted by technology. Illegitimacy from a century earlier exerts a strong influence on initial adoption of the pill, but the model predicts that this will dissipate, consistent with the data.

4 Empirical Analysis of Historical Illegitimacy and Pill Use

Pill use per woman differed significantly across markets, see Figure 1 panel A, and these differences were highly persistent; a regression of ln pill use per woman aged 16-40 from 1970-74 on a full set of labor market fixed effects yields an R-squared of 0.80. These persistent components of pill use across markets are closely correlated with historical illegitimacy sixty, seventy, or more than a century earlier. Regressing the fixed component of ln pill use from 1970-74 on the ln OWB share in 1900 yields an R-squared of 0.32; a third of the permanent variation in pill use is captured by variation in OWB from the turn of the century. The empirical analysis presented in this section explores to what extent this strong correlation is consistent with the predictions of the model in the short- and longrun. I account for alternative contemporary and historical factors which have been discussed in the empirical pill literature and historical analyses of unwed birth in Sweden. What emerges is a positive, significant and highly robust relationship between past illegiimacy and the pill's adoption. The strong and highly robust correlation between historical illegimacy and pill use, and historical illegitimacy and out-of-wedlock childbearing among teens erodes over time. This is consistent with the model predictions; once the pill supplants informal local technologies for preventing unwed birth, stigmas against sex outside of marriage should converge along with contraceptive use and unwed birth across markets. Persistent illegitimacy behavior which had persisted for over a century before the pill is introduced is erased within three decades, reinforcing the convergence this contraceptive innovation brought about, as illustrated in Figure 2 panel B.

4.1 Historical OWB and Pill Use in the Short Run

Initial adoption of the pill is strongly correlated with historical illegitmacy regardless of whether controls for economic, demographic, epidemiological and supply side factors are taken into account. This is the case across many alternative specifications reported in Table 1. Demand for the pill per fecund female in market j at time t is regressed on a time invariant measure of past OWB and a full set of time fixed effects. In the bottom panel contemporaneous economic, demographic and epidemiological factors which vary by market over time are also taken into account.[55] Robust standard errors, clustered at the market level, are reported throughout.[56]

The baseline specification in the first column of Table 1 reveals a large, positive and highly significant elasticity of pill take-up to the historical unwed birth share; a ten percent increase in OWB in 1900 translates into a three percent increase in pill sales..[57] The inclusion of controls for labor market conditions, income inequality, and a host of marriage market and demographic factors yields a similar elasticity estimate of 0.23 (0.05), as seen in the bottom panel.[58] Most contemporaneous factors are not significant predictors of pill use, with the exception of male income inequality, population density measures, and RFSU consultations per woman. Greater male income inequality is associated with lower demand for the pill, while more populous areas have greater demand for the pill. More suprising is the fact that the greater are RFSU clinic consultations the lower is pill use.[59]

[55]Historical OWB and all of the control variables are measured at the market level with the exception of lagged venereal disease (VD) which varies by county. There are 70 markets and 24 counties in Sweden. See the Appendix for further summary statistics. Time fixed effects capture aggregate trends in demand for the pill. Omitting these fixed effects has little impact on the estimated coefficients. Estimating the model for each year instead of pooled OLS yields similar estimates with regard to the influence of OWB.

[56]Clustering by county to allow for arbitrary correlation at the market level, within county, in the unobservables does not alter the results.

[57]A linear in levels model yields similar result with a coefficient estimate on OWB in the parsimonious model of 0.25 (0.06).

[58]The extensive controls in the bottom panel of Table 1 include controls for contemporaneous economic factors (women's labor force participation (LFP), mean income by gender, male income inequality (ratios of the 70th to the 30th percentiles of the income distribution), specific income sources), marriage market factors (share of women unmarried, women's age by marital status, sex ratio of the single population), demographic measures (population density), epidemiological shocks (VD prevalence), and supply side characteristics (RFSU clinic consultations per woman) in addition to year fixed effects. The lagged fraction of the population that has VD per 1000 of the population captures the prevalence of VD in the county. VD includes congenital or acquired syphilis, gonorrhea, or cancroid. Unlike other contemporaneous controls, VD measures vary at the county level, not the more disaggregated market level. In alternative specifications, not reported here, I control for other moments of the income distribution including median income measures and ratios of the 70th to the 30th percentiles of the income distribution for the whole population, the ratio of male to female income, and other source incomes; the coefficient on unwed births is unchanged. Alternative specifications that take into account migration, using the share of the population that is foreign born, as well as differences local schooling systems, such as the share of high school students enrolled in programs that qualify them to attend university yield similar results. Accounting for additional characteristics of married women in the locality, such as the share with two or more children, does not affect the coefficient on unwed births.

[59]The RFSU operated three clinics during this period, and they functioned in part to support the research efforts of the RFSU in recruiting women to participate in contraceptive trials. These clinics provided contraceptive services to women,

Table 1: Pill Demand 1970-1974 and Alternative Historical Illegitimacy Measures

Ln OWB Measure:	1900 per Birth	1900 Ex. Engage	1900 per Woman	1910 per Birth	1860 per Birth	1900 Weighted	1963 2-Stage
Parsimonious Models							
Ln OWB	0.31***	0.30***	0.18***	0.28***	0.25***	0.20***	0.38**
	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.12)
R-square	0.34	0.33	0.18	0.32	0.27	0.35	
Extensive Contemporaneous Controls							
Ln OWB	0.23***	0.22***	0.18**	0.20***	0.19**	0.19***	0.25***
	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.07)
Female LFP	0.75	0.75	0.81	0.71	0.95*	0.74	3.40
	(0.43)	(0.43)	(0.46)	(0.43)	(0.45)	(0.40)	(4.04)
Female Income	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Male Income	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Male Inequality	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Farm Income	0.01	0.01	0.02*	0.02*	0.02*	0.02	0.24**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.08)
Forestry Value	0.07	0.07	0.09	0.07	0.06	0.06	0.53
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.40)
Single Share	0.76	0.82	1.14	0.80	1.18	0.22	-1.77
	(0.63)	(0.62)	(0.67)	(0.62)	(0.67)	(0.72)	(7.21)
Single Age	0.07	0.08	0.10	0.06	0.09	0.08*	-0.21
	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.55)
Married Age	-0.04	-0.05	-0.09	-0.05	-0.03	-0.03	-1.42**
	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.49)
Sex Ratio	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)
Pop Density	0.02***	0.02***	0.02***	0.02***	0.02***	0.01**	0.20***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)
Pop Density Sq	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***	-0.19***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
RFSU Consults	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***	-0.09***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
VD Lag	0.08	0.21	0.04	0.14	0.02	-0.12	2.39
	(0.19)	(0.18)	(0.18)	(0.16)	(0.17)	(0.17)	(2.08)
R-square	0.60	0.60	0.56	0.59	0.56	0.69	

Note: Dependent variable is ln pill demand per woman 16-40; year FE and clustered s.e. (market level) in brackets. Income and demographic factors are per 16-40 pop. Male inequality is 70:30 pctile ratio of income. Population density is per square km; square density divided by 100. Age and marital status are for the fecund female pop. VD per 1000.
N=350,* p¡0.05, ** p¡0.01, *** p¡0.001

A strong positive correlation between past illegitimacy and pill take-up is seen for all historical OWB measures. In column 2 births to engaged mothers are excluded from the 1900 OWB measure; the estimated elasticities are little changed in either the parsimonious or extensive specifications. This suggests that differences in the timing of birth after engagement across markets is not driving the strong association between illegitimacy and pill demand.[60] Measuring unwed births per 1000 women instead of per 100 births yields a positive and highly significant coefficient estimate, 0.18 (0.05). Likewise, measuring illegitimacy in 1910 or 1860, the latest and earliest years for which comparable data is reported, lead to similar strong positive correlations.

The sixth specification, titled 1900 weighted, is a weighted version of the baseline model where weights are proportional to the population of fecund females in each market from 1970-74. The large, positive, and highly significant estimate implies a ten percent higher rate of OWB in 1900 leads to two percent greater predicted pill sales per woman. The final specification restricts the channel of influence through which past OWB operates via a two stage model where OWB in 1963 is predicted using OWB in 1900; persistent differences embodied in historical illegitimacy measures are restricted to work through illegitimacy patterns observed just prior to the pill's legalization. The coefficient in the second stage, 0.38 (0.12), is large, positive, and highly significant. Illegitimacy at the turn of the century is a strong predictor of illegitimacy before legalization, with an F-statistic of 73.24 in the extensive model. Regardless of how or when illegitimacy is measured, and across many alternative specifications that include many contemporaneous controls, the correlation between historical illegitimacy and take-up of the pill is large, positive, and highly significant.

4.1.1 Placebo Tests

Model predictions are specific to contraceptive innovations. If the use of medicine more generally is correlated with past illegitimacy this would be a direct challenge to the mechanism in the model. A series of placebo tests are estimated, replacing demand for the pill in the baseline specification with measures of demand per adult for antibiotics, nonprescription analgesics, cough medicine, and multivitamins. Coefficient estimates in the placebo regressions are not significantly different from zero for any of the other drug classes; vitamins (-0.19 (0.10)), cough medicines (-0.17 (0.09)), and antibiotics (-0.17 (0.09))

but this was not their primary purpose from the perspective of the RFSU. Geographically these clinics were limited to Stockholm and Gothenberg. Alternative specificatons where the existence of a local RFSU chapter is used as the control yield similar estimates regarding the association between past illegitimacy and pill use.

[60]Engagements were viewed as contracts of equal or greater importance than marriage; betrothals were formally registered and announced by the church often years in advance of marriage. From the perspective of the model, births to engaged women were quite different from other nonmarital births. Births to engage women accounted for roughly five percent of nonmarital births in 1900.

are negatively correlated with OWB in 1900, while analgesics (0.09 (0.09)) are positively correlated with historical illegitimacy.[61] The lack of significant or systematic correlation between historical illegitimacy and other types of drug demand provides support for the hypothesizd mechanism described in Section 3.

4.1.2 Alternative Historical Factors

Illegitimacy is unique among historical factors in consistently predicting the pill's adoption. Table 2 explores to what extent past economic, religious, and social indicators mitigate the influence of past illegitimacy. Regardless of whether historical factors are restricted to operate through past illegitimacy (partialling out), as in the top panel of Table 2, or are allowed to directly influence pill sales, as in the bottom panel, unwed birth remains a powerful predictor of contraceptive technology adoption.

Past OWB has a persistent social component. Although economic and marriage market conditions also influence unwed birth, as in Ragan (2019), taking these factors into account does not qualitatively or quantitative alter conclusions regarding the influence of historical illegitimacy on the pill's adoption. To evaluate whether past economic and marriage market factors drive the strong relationship between OWB in 1900 and pill adoption, I regress OWB on the sex ratio, women's wage rate, the gender wage ratio, and the urbanization rate, all from 1900, and recover the residuals from this regression. Both Hecksher (1949) and Willis (1999) emphasize these factors as determinants of unwed birth. First stage estimates confirm Hecksher's (1949) conjecture that increased urbanization was correlated with higher rates of OWB. After partialling out the economic and marriage market factors on 1900 OWB, the residuals capture a component of unwed birth that is unrelated to past economic an marriage market conditions by construction. This component of past unwed birth is a highly significant predictor of pill use, 0.21 (0.05). When past marriage market and economic factors are included directly, as in the bottom panel, only the historical female wage is significantly correlated with pill demand, a correlation which is not robust to the inclusion of other historical factors, as seen in the last column. While economic and marriage market conditions influence illegitimacy in 1900, these factors are not driving the strong correlation between OWB in 1900 and the adoption of the pill.

I account for the presence of religious minorities (Catholics, Mission, and Pentecostals in 1930) to capture their influence on OWB in column 2 of Table 2, but these populations are quite small. Over 95

[61] These drugs are selected due to the fact that they are also largely demand driven. The lack of significant correlation between historical illegitimacy and other classes of drugs holds more generally as well.

Table 2: Pill Demand and Historical Illegitimacy: The Role of Alternative Historical Factors

Partialling Out Alternative Historical Factors				
	Economic	Religious	Marriage and Education	All
Ln OWB 1900	0.21***	0.22***	0.24***	0.28***
	(0.05)	(0.05)	(0.07)	(0.07)
All Baseline Controls	Yes	Yes	Yes	Yes
R-square	0.58	0.59	0.57	0.57
Direct Controls for Alternative Historical Factors				
	Economic	Religious	Marriage and Edu	All
Ln OWB 1900	0.21***	0.23***	0.24**	0.18**
	(0.05)	(0.05)	(0.08)	(0.07)
Urban:Rural Pop	-0.04			-0.06
	(0.08)			(0.10)
Female:Male Pop	0.00			0.00
	(0.00)			(0.00)
Female:Male Wage	0.22			-0.39
	(0.43)			(0.62)
Ln Female Wage	-0.46**			-0.19
	(0.15)			(0.26)
Catholic Share		-0.02		-0.02
		(0.03)		(0.03)
Mission Share		-0.00		-0.00*
		(0.00)		(0.00)
Pentecostal Share		0.00		-0.00
		(0.00)		(0.01)
Prohibition Support 1922		-0.56***		-0.27
		(0.12)		(0.02)
Age at First Marriage			0.03	-0.00
			(0.02)	(0.03)
Share Any Edu 1930			0.00	-0.00
			(0.00)	(0.00)
Share HS Edu 1930			0.01	-0.00
			(0.01)	(0.01)
All Baseline Controls	Yes	Yes	Yes	Yes
R-Squared	0.64	0.68	0.60	0.70
Clusters	70	70	70	70
N	350	350	350	350

Note: Pill use per woman is regressed on 1900 OWB and the full set of contemporaneous controls included in Table 1. Robust s.e., clustered at the market level, reported in brackets. Wages are from Bagge et al (1935). Religious minority shares reflect membership relative to the population, coefficients are scaled by 100. Prohibition support measures voter support for the 1922 alcohol sales ban. Age at first marriage refers to women's average age at first marriage. Share any education and share HS refers to the share of women with any or HS education.
* p¡0.05, ** p¡0.01, *** p¡0.001

percent of Swedes were members of the Church of Sweden; to quantify religiosity for this vast majority of Swedes who I use data on support for the 1922 prohibition referendum. The temperance movement was closely aligned with the Swedish Church. While individuals had little choice with regard to their membership in the Church, the share of the population supporting the alcohol ban provides a measure of those sharing views similar to the Church. The second column of Table 2 (top panel), regresses pill sales per woman on the component of historical unwed birth unrelated to these religious measures. The coefficient estimate 0.22 (0.05) suggests religious factors are not driving the strong correlation between past OWB and take-up of the pill. This is true whether religious measures are restricted to operate through past illegitimacy (top panel), or shape pill demand directly (bottom panel).

Age of first marriage and the share of women with any or high school education are included in Column 3 to evaluate whether access to education or the timing of marriage influences past illegitimacy behavior and subsequent demand for the pill. Regardless of whether these factors are used to partial out a component of OWB in 1900 or enter the pill sales regression directly, independently or along with other historical factors (column 4) the coefficient on 1900 OWB in the pill sales regression remains positive and highly significant. Taken together, the results in Table 2 illustrate how illegitimacy is unique in consistently predicting take-up of the pill.[62]

The model emphasizes increased p_j, indicating a reduced efficacy of customs for preventing OWB and declines in γ_j, denoting reduced social stigma against premarital sex as drivers of OWB. Illegitimacy is highly persistent, but it is not constant. Communities with low illegitimacy in 1860 have relatively low illegitimacy rates in 1900 and 1910, but across communities there is a fanning out of unwed birth rates over time.[63] Estimating a model in differences identifies the effect of historical illegitimacy from long run changes. Studying variation across time within markets uses a very different source of variation than the model in levels, yet the empirical results are the same.[64] Communities which experienced larger

[62]The Appendix explores the role of historical characteristics and whether the strong positive relationships between OWB in 1900 and pill demand is driven by a subset of communities. A positive and highly significant relationship between OWB in 1900 and pill demand is seen across all types of markets. The relationship between past OWB and take-up of the pill is stronger in markets where alcohol prohibition was opposed (an indicator of weaker religious institutions); areas where the church was weaker experienced greater absolute and marginal take-up of the pill with respect to local OWB behavior. Religion dampened demand for the pill and the impact of OWB in 1900 on pill use. This supports a model of norm transmission such as Fernandez-Villaverde et al (2014) which emphasize the role of the church in stigmatizing pre-marital sex. Strong religious institutions, as indicated by prohibition support, blunt the effect of weak social stigmas against pre-marital sex or poor customs for preventing OWB on later demand for the pill. Contemporaneous controls are included in all specifications, but results are similar if omitted.

[63]See figure in the Appendix. Ragan (2019) estimates how wage shocks brought about by the European grain crisis led to increased non-marital childbearing. Such shocks could induce changes in promiscuity norms as communities move from low illegitimacy (strong promiscuity stigma) to high illegitimacy (weak promiscuity stigma) equilibria. Alternatively, enclosure and the spread of railroads eroded the ability of communities to monitor the behavior of the young and enforce marriage in the case of pregnancy. Through the lens of the model this may be interpreted as increases in p_j. See Helmfrid (1961)

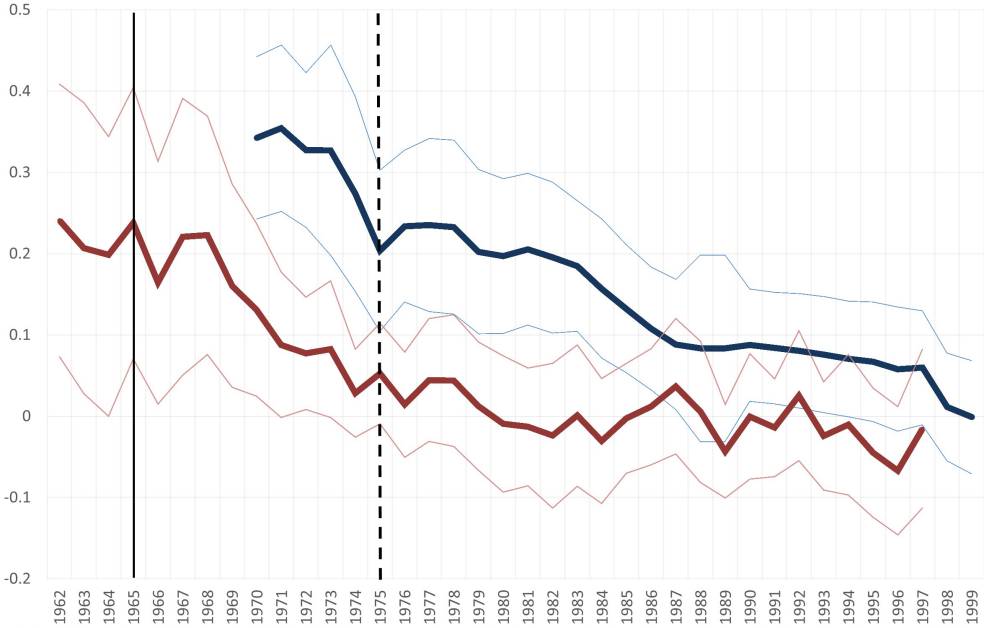
[64]See Appendix for a model description and results. This approach mirrors Algan and Cahuc (2010).

increases in nonmarital birth over the last half of the 19th Century, indicating weakened stigmas against promiscuity or diminished community capacity to prevent unwed birth, experienced greater demand for the pill. A model in differences makes clear how strong associations between past illegimacy and pill use are not solely driven by fixed geographic market characteristics.

4.2 Historical OWB and Pill Use in the Long Run

Positive pill use is observed across all markets. This has implications for the model's long run predictions. If the pill supplants both effective (small p_j) and ineffective (large p_j) customs the positive association between pill use and past illegitimacy should erode over time. This long run prediction about pill use and in turn the occurrence of unwed births across markets is unique to the driving force of heterogeneous unwed birth prevention technologies (p_j).[65]

Figure 3: Historical Illegitimacy, Contemporary Pill Use and Teen Unwed Birth Over Four Decades



Note: Estimated coefficient on ln OWB in 1900 from regressions of the ln teen out-of-wedlock birth share (red) and ln pill use per 15-44 woman (blue) with associated CI (90 %). The first full year of pill access is denoted by a solid vertical line; abortion legalization/universal subsidies on oral contraception are denoted by the dashed vertical line. Ln teen birth share is approximated with the ASINH of the ratio to avoid dropping observations where no unwed births occurred. By 1998, the ratio was undefined in some markets due to no teen birth.

Long run correlations help discern which of the driving forces in the model are consistent with the data. Figure 3 plots coefficients on OWB in 1900 from regressions of the teen unwed birth share and pill use per woman on the historical illegitimacy measure. Before the pill is available, coefficients on historical illegitimacy are positive and significant predictors of unwed teen birth, just as seen in Figure 2 panel B. The pill's introduction coincides with a steep decline in the estimated coefficient in the

[65]Models of heterogeneity in the value of abstaining (V_j) or the cost of unwed birth (C_j) predict heterogeneity persists since the arrival of the pill does not alter the intrinsic value of abstinance or the cost of an OWB. See the Appendix for further details.

following year when birth events would be realized, followed by a gradual decline over the following decade. Already by the time abortion is legalized in 1975, the coefficient on historical illegitimacy is no longer statistically significant and point estimates oscillate around zero until the end of the century.

Pill sales and historical illegitimacy follow a similar pattern. Market level data is first reported in 1970, and the strong positive correlation between pill use and historical illegitimacy declines rapidly in the decade and a half that follow. The coefficent on OWB in 1900 is statistically no different from zero within 25 years of legalization. In a world where local customs are supplanted by universal technologies equilibrium stigmas converge. The data are consistent with the model predictions. Pill demand and teen unwed birth shares are strongly correlated with historical illegitimacy before the pill, consistent with patterns Sundbarg (1910) argued existed since the 17th Century. Yet, within three decades of the pill's introduction, these correlations had eroded and a defining relationship in Swedish historical demography ceased to exist.

5 Implications of the Theory for Empirical Studies of the Pill: An Application to Teen Unwed Birth

The correspondence between historical illegitmacy and pill sales mapped in Figure 1 is highly robust. Section 3 describes a mechanism through which this correlation can be understood, highlighting heterogeneity in unmarried women's capacity to control fertility and equilibrium determined stigmas against pre-marital sex. These factors have been emphasized in studies of Swedish fertility, but my model elaborates a structure that can explain persistet illegitimacy across markets before the pill as well as the strong positive correlation between past illegitimacy and sales of the pill in the decade after legalization. Below I elaborate how the theory can be used to inform an IV model where the share of births out-of-wedlock in 1900 isolates a source of latent demand for the pill that is arguably unrelated to contemporaneous shocks to demand for children among teens around the time of the pill's introduction. Using historical illegitmacy to isolate a source of exogenous variation in pill sales, I can estimate how unwed teen birth responded to the pill's introduction. I focus on unwed teen birth, but the empirical approach could be applied to other behaviors such as the career and marriage decisions emphasized in Goldin and Katz (2002).

5.1 Unwed Birth and the Pill: Two Difference-in-Differences Analyses

The theory predicts that a reduction in the conditional probability of unwed birth reduces unwed childbearing in the shortrun. The pill's introduction is a prime example of such a change in the probability of a birth event conditional on engaging in pre-marital sex. Pairing rich data on pill sales with teen childbearing data I can quantify how the pill shaped non-marital childbearing among Swedish teens. Figure 2 illustrated how unwed teen birth rates differed across high and low pill sales and historical illegitimacy markets before and after the pill. Similar groupings of the fertility data allow estimation two alternative difference-in-differences (DD) models. These DD analyses truncate the pill sales and historical illegitimacy data into two high-low groups (above-below median) framing the key empirical conclusions in the DD coefficient plots depicted in Figure 4.

5.1.1 A Time Varying Difference-in-Differences Model

Coefficient estimates from a time varying DD model based on grouping of high and low pill sales markets are plotted in Figure 4 (left panel A). Coefficient estimates are reported relative to the 1965 base year:

$$ln(TeenOWB_{i,t}) = \alpha + \Sigma_{t=1961}^{1974}\beta_t HighPillSales_i + \gamma_t + \eta_i + \epsilon_{i,t}. \quad (1)$$

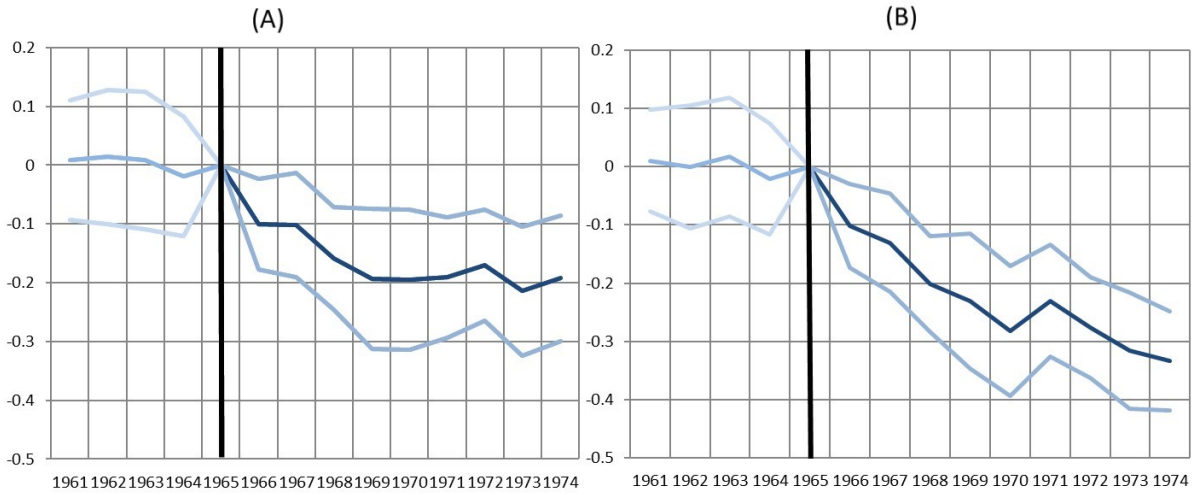
β_{1961}-β_{1964} coincide with placebo treatments, while β_{1966}-β_{1974} estimate relative teen unwed fertility effects associated with residing in high pill sales markets. The analysis illustrates how high and low pill use areas were similar before the pill, but high pill sales markets experienced sharp fertility declines relative to low pill sales markets after the pill's introduction.[66] While suggestive of the pill playing a role in unwed teen fertility declines, one may be concerned that other contemporaneous shocks may have driven women and teens' demand for bearing children outside of marriage as well as their decision to adopt the pill. This makes interpretation of the DD coefficient difficult; greater pill sales may reflect greater demand driven by contemporaneous demand shifters, factors which may have also shifted demand for unwed childbearing.

5.1.2 An Instrumented Difference-in-Differences Model

To isolate variation in pill use driven by persistent latent demand factors emphasized by the theory and empirical analysis in the previous section I instrument for pill sales with the historical OWB share. The

[66]See Appendix for similar DD coefficient plots from a parallel analysis of the teen unwed birth share and ln marital births per 1000 teens. The teen OWB share DD coefficients are negative, but only significantly different from zeron from 1969 onward. Marital births among teens are not significantly different across low and high pill use markets before the pill, and this is generally also the case after the pill is introduced, wth the exception of 1971 when the high pill use markets have significantly higher marital births than low pill use markets.

Figure 4: DD Coefficient Estimates of the Pill's Impact on Ln OWB per 1,000 Teens



Note: Panel (A) DD coefficient estimates from regression of ln OWB per 1000 teens on an indicator for above median pill sales markets 1970-74 interacted with year indicators. See Equation 1 in Section 5.1.1 for details. **Panel (B)** DDIV coefficient estimates from a regression of ln OWB per 1000 teens on an indicator for above median 1900 OWB share markets interacted with year indicators. See Equation 2 in Section 5.1.2 for details. (*Sources:* SCB and *Swedish Drug Market* (1970-74).)

intuition of the historical illegitimacy instrument is supported by the theory and its close correlation with pill sales. Coefficient estimates reported in Figure 4 (right pane B) come from the following specification:

$$ln(TeenOWB_{i,t}) = \alpha + \Sigma_{t=1961}^{1974}\beta_t HighOWB1900_i + \gamma_t + \eta_i + \epsilon_{i,t}. \quad (2)$$

As before, β_{1961}-β_{1964} coincide with placebo treatments, but now β_{1966}-β_{1974} estimate relative fertility effects associated with residing in high historical illegitimacy markets after the pill's introduction. Historical illegitimacy conditions are unrelated to teen OWB trends before the pill, as illustrated by the placebo coefficients, but after legalization a strong negative correlation emerges.[67] The DD estimates depicted in Figure 4 support the identifying assumptions of the models developed below, revealing no significant association between changes in teen fertility before the pill with residing in either a high pill use or high historical illegitimacy market. The figure also provides support for the causal mechanism underlying the reduced form and IV models, revealing significant fertility declines across high observed pill use and predicted pill use markets after the pill's introduction. In this regard, Figure 4 can also be seen as providing support for the theory by confirming the model predictions regarding the pill's negative impact on unwed childbearing.

[67]See Appendix for similar instrumented DD coefficient plots from a parallel analysis of the teen unwed birth share and ln marital births per 1000 teens. The teen OWB share coefficients are negative, but only significantly different from zeron from 1970 onwards. Marital births among teens are not significantly different across low and high pill use markets before the pill, and this is generally also the case after the pill is introduced, wth the exception of 1969 when the high pill use markets have significantly lower marital births than low pill use markets.

5.1.3 Interpreting the DD Estimates

Interpreting the DD estimates as average causal effects (ACE) hinges on the parallel trends assumption being satisfied, as illustrated in Figure 2.[68] Interpreting the instrumented DD coefficients in Figure 4 panel B as convex combinations of ACEs requires an exclusion restriction. The Online Appendix presents extensive correlations between historical illegitimacy and *changes* in teen fertility, marriage, education, and employment measures from before the pill. None of the measures indicate a significant or systematic association with historical illegitimacy before the pill; placebo regressions reported in the Appendix and the pre-pill placebo coefficients plotted in Figure 4 illustrate the lack of correlation between illegitimacy in 1900 and changes in unwed teen birth before the pill's introduction, consistent with the exclusion restriction. Communities with greater pill use experience larger reductions in unwed birth according to the DD and instrumented DD estimates. Although theory has emphasized mechanisms where liberalized fertility control contributes to increasing unwed birth, the DD estimates in Figure 4 clearly argue against the quantitative importance of such mechanisms. The data clearly points to greater take-up of the pill leading to large and significant declines in unwed childbearing among teens.

5.2 Defining the Instrument

The theory in Section 2 argues that OWB in 1900 is correlated with differences in latent demand for contraceptive innovations such as the pill. Here I describe how the empirical relationship the theory predicts can be used to define an instrument which uses these predetermined differences in pill sales to estimate the pill's effect on unwed teen childbearing. OWB in 1900 is fundamentally different from the binary *legal access* treatments common in the empirical pill literature. The theoretically motivated instrument sidesteps many issues related to policy endogeneity while providing a rich source of variation in treatment intensity across markets. Instead of two treatments my analysis employs 70 different treatment assignments associated with historical illegitimacy conditions.

The model and empirical relationship documented above motivate using the interaction of the pill's legalization and illegitimacy conditions in 1900 as an instrument to isolate exogenous variation in pill use among young unmarried women. Time variation comes from the legalization of the pill, common across communities. Cross-section variation comes from historical illegitimacy patterns. The instrument

[68] Parallel trends in fertility before the pill's legalization across both high and low actual and predicted pill use markets is consistent with Figure 2; low and high actual pill use markets were identical along many margins before the pill, while high and low predicted pill use markets evolved in parallel. The Appendix provides further details on this point.

for pill use in market i at time t is defined:

$$Z_{i,t}^{Pill} = \begin{cases} 0 & t < 1965 \\ OWB_i^{1900} & t \geq 1965 \end{cases}$$

The identifying assumption requires *changes* in unwed birth from before until after the pill to be unrelated to the *level* of illegitimacy in 1900 except through take-up of the pill. Identification does not hinge on a lack of correlation between the instrument, $Z_{i,t}^{Pill}$, and the level of teen fertility, but instead comes from the correlation between the instrument and *changes* in fertility from before until after the pill. On a practical note, the instrument is defined using ln OWB in 1900, but the estimates are similar when OWB is expressed in levels.

5.3 The Reduced Form Model

The reduced form model regresses ln unwed teen fertility (per woman or as a share of all teen births) in market i and year t on the instrument for pill sales in the previous year, $Z_{i,t-1}^{Pill}$:

$$Ln(UnwedTeenBirth_{i,t}) = \alpha + \beta_{RF} Z_{i,t-1}^{Pill} + \gamma_t + \eta_i + \epsilon_{i,t}.$$

Table 3 reports estimates of β_{RF} that are negative and highly significant across all measure and specifications.[69] This is the case when a parsimonius model with year and market fixed effects is estimated as well as when supplemental controls related to abortion provision, education attainment, and demographic trends are included in the analysis.[70] In the parsimonious model, where only year and market fixed effects are included, a ten percent increase in the historical illegitimacy share would lead to a four percent greater decline in unwed teen childbearing after. Including abortion controls, trends in female education enrollment, and population density trends does not alter the estimate, as the coefficient is little changed and still highly significant. The pills impact on the ln teen unwed birth share is also negative and highly significant at the one percent level, consistent with the pill reducing the relative ocurrence of unwed childbearing in both the parsimonious and extensive models.

[69]The estimates reported in Table 3 are comparable across specifications in the sense that they are estimated on the same sample years. Reduced form estimates which include the years after the pill's introduction but before pill sales data is reported by market (1970) can be found in the Appendix.

[70]One channel to abortion access under the national ban required the approval of two physicians. I capture variation in abortion access by quantifying women's access to OBGYN care (OBGYN care places per woman aged 15-44) and the number of physician staffed fertility clinics in the county. Trends in young women's education attainment are captured by computing growth in education enrollment by market from the 1960 and 1965 census waves and assigning dummies to markets in different quartiles of this disribution which are used to estimate differential trends across these markets. Population density is computed in 1965 and quartile dummies defined across markets to create similar trend dummies.

Table 3: The Elasticity of Unwed Teen Birth to Pill Use

Dependent Variable:	Ln Unwed Births per 1000 Teens		Ln Teen Unwed Birth Share	
Reduced Form: Ln Unwed Teen Birth and the Ln OWB Share in 1900				
Ln OWB Share 1900	-0.431***	-0.422***	-0.104**	-0.100**
X (Pill Legal=1, else 0)	(0.0443)	(0.0529)	(0.0334)	(0.0337)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Additional Trends:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
R-squared	0.791	0.797	0.895	0.908
Instrumental Variables (IV): Unwed Birth Share in 1900				
Asinh Pill Use per Woman	-1.664***	-2.113***	-0.447***	-0.588***
in the Previous Year	(0.356)	(0.485)	(0.136)	(0.181)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Additional Trends:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
First Stage: Predicting Asinh Pill Use With Ln OWB Share in 1900				
Ln OWB Share 1900	0.256***	0.194***	0.256***	0.194***
X (Pill Legal=1, else 0)	(0.052)	(0.039)	(0.052)	(0.039)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Trends in Pre-Pill Characteristics:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
F-statistic	24.14	24.89	24.14	24.89

Note: All specifications are weighted by the population of women age 15-19 and include year and market fixed effects. Robust standard errors, clustered by market, reported in brackets. Ln pill use is approximated by the inverse hyperbolic sin so as to be defined at zero; pill use is zero before the pill's introduction. Education growth quartiles are computed from 1960 to 1965 using census data on the share of women 16-19 not in the labor force due to education. Population density quartiles are computed relative to the prime age population of women and men aged 15-44 by market in 1965. OBGYN hospital care per woman (15-44) and physician staffed family planning clinics are computed by county and year. N=560 and p-value less than 0.05 (*), 0.01 (**), or 0.001(***).

5.4 The IV Model

The theory predictions are further confirmed by estimates from regressions of unwed teen fertility (per teen or as a share of all teen births) in market i and year t on the inverse hyperbolic sin of pill sales per woman during the previous year, *t-1*:

$$Ln(UnwedTeenBirth_{i,t}) = \alpha + \beta_{IV} asinh(Pill_{i,t-1}) + \gamma_t + \eta_i + \epsilon_{i,t}.$$

The inverse hyperbolic sin function is similar to the ln function but defined at zero. Since sales of the pill were zero before legalization I use this measure so as to avoid dropping observations from the pre-legalization period. Table 3 panel 2 reports estimates of β_{IV} that are negative and highly significant. The functional form of the estimating equation implies β_{IV} is an elasticity. In the parsimonious model, where only year and market fixed effects are included, a ten percent increase in pill sales per driven by variation in past unwed birth would lead to a sixteen percent greater decline in teen childbearing. Including abortion controls, trends in female education enrollment, and population density trends leads to similar large, negative, and highly significant estimates. The pills impact on the teen unwed birth share is also negative and highly significant, consistent with the pill reducing unwed childbearing among teens in both absolute and relative terms.

5.5 A Supply-Side Instrument

The theoretically motivated IV model exploits predetermined demand-side variation for the pill, in keeping with AYK's emphasis on demand factors as the drivers of rising unwed birth in the face of fertility control liberalization. The theory and empirical analysis I present argue against the quantitative importance of the mechanisms AYK postulate. This conclusion is confirmed by a supply-side IV analysis. Estimating alternative models also assuages possible concern that negative weighting of treatment responses induced by instrumenting may shape the sign of the coefficient estimates on pill sales reported in Table 3. A parallel analysis, reported in Table 4, exploits teen's proximity to pharmacies in 1965, the first full year of treatment, to identify a source of exogenous variation in the supply-curve for the pill across markets:

$$Z_{i,t}^{Pharmacy} = \begin{cases} 0 & t < 1965 \\ Ln(TeenWeightedPharmacyAccess_i^{1965}) & t \geq 1965 \end{cases}$$

This type of supply-side instrument is common in economic studies of fertility control access, as in Bailey (2013), and the literature on returns to education discussed in Card (2001). The teen weighted pharamacy access measure is constructed by computing the number of pharmacies per geographic area

in each of over a 1,000 municipalities in 1965, and then weighting these local pharmacy density measures by the teen population in each municipality and aggregating up to the market level.[71] The specifications estimated in Table 4 are identical to those reported in Table 3, replacing $Z_{i,t}^{Pill}$ with $Z_{i,t}^{Pharmacy}$. The reduced form and IV estimates reported in Tables 3 and 4 are estimated over the same sample, so as to be comparable.

The supply-side instrument confirms the strong negative relationship between pill sales an unwed childbearing among teens. This is seen both in the reduced form estimates which regress fertility directly on the pharmacy density instrument, in the top panel of Table 4, as well as the full model estimates reported in the middle panel. Accounting for variation in abortion provision and trends in education and population density lead to larger unwed fertility effect estimates. The IV coefficient estimate on ln pill sales is large, negative, and highly significant, suggesting a ten percent increase in pill sales in a market would lead to a thirteen to twenty percent decline in unwed births among teens, quantitatively similar to the elasticity estimates found using demand variation. The share of births outside of wedlock also responds negatively to pill sales, though the coefficient in the parsimonious IV specification is only significant at the 10 percent level, or the five percent level when extensive controls are included. The supply-side instrument yields results that are similar to the demand-side instrument, while generating similarly strong first stage estimates which confirm teen's access to pharmacies as an important mediator of the pill's spread.

Supply-side instrument estimates argue against theories which have pointed to fertility control liberalization as a driver of rising out-of-wedlock birth and confirm the predictions of the theory described in Section 3 using a very different source of variation in pill sales. The strong negative relationship between pill sales and unwed teen birth is robust to alternative empirical models. An analysis using a simulated instrument based on fixed sales shares across market and aggregate date on pill sales back through 1966 generates similar negative and highly significant reduced form estimates with regard to the pill's impact on unwed births. The strong negative relationship between the pill's diffusion and unwed birth among teenage girls in Sweden seen in Tables 3 and 4 argues for the pill's profound importance in shaping teenage childbearing, and challenge theories which have argued that the pill and fertility control liberalization more generally have harmed young women.

[71] Further details regarding the construction of the instrument can be found in the Appendix and Ragan (2023).

Table 4: The Elasticity of Unwed Birth to Pill Use: A Teen Pharmacy Access Instrument

Dependent Variable:	Ln Unwed Births per 1000 Teens		Ln Teen Unwed Birth Share	
Reduced Form: Unwed Birth and Teen Pharmacy Access in 1965				
Ln(Teen Pharmacy Access	-0.075***	-0.100***	- 0.012*	-0.016*
in 1965) X Pill Legal	(0.013)	(0.013)	(0.006)	(0.007)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Additional Trends:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
R-squared	0.762	0.781	0.889	0.905
Instrumental Variables (IV): Predicting Pill Use With Teen Pharmacy Access in 1965				
Ln Pill Use per Woman	-1.381***	-2.133***	-0.226	-.377*
in the Previous Year	(0.426)	(0.587)	(0.122)	(0.158)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Trends in Pre-Pill Characteristics:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
First Stage: Predicting Pill Use With Teen Pharmacy Access in 1965				
Teen Pharmacy Access	0.524***	0.043***	0.524***	0.043***
	(0.013)	(0.010)	(0.013)	(0.010)
OBGYN Hospital Care per Woman		Yes		Yes
Physician Staffed Clinic Controls		Yes		Yes
Additional Trends:	None	Edu Growth	None	Edu Growth
		Pop Density		Pop Density
F-statistic	17.50	19.35	17.50	19.35

Note: All specifications are weighted by the population of women age 15-19 and include year and market fixed effects. Robust standard errors, clustered by market, reported in brackets. Asinh denotes the inverse hyperbolic sine function, similar to ln but defined at zero. Pill use is zero before the pill's introduction, so use of the asinh reduces the loss of data during this period. Education growth quartile trends are computed from 1960 and 1965 census data according to the change in the share of women 16-19 not in the labor force due to education. Population density quartiles are computed relative to the prime age population of women and men aged 15-44 by market in 1965. OBGYN hospital care per woman (15-44) and physician staffed family planning clinics are computed by county and year. N=560 and p-value less than 0.05 (*), 0.01 (**), or 0.001(***).

5.6 Marital Childbearing, Teen Marriage, and the Pill

The model and empirical analysis has focused on unwed childbearing as a means to evaluate theories of fertility control liberalization. AYK motivate their analysis with empirical obserevations regarding declining marital childbearing coupled with a rising share of unwed births, Chiappori and Oreffice (2008) focus primarily on marriage behavior.

Yet, and their predictions for unwed childbearing also generate predictions for how the pill will alter marital childbearing. The data and empirical approach I present could also be applied to the analysis of marital childbearing.

A more thorough analysis of marriage market responses to the pill is undertaken in Ragan (2024), but here I investigate marital fertility among the young along with a brief analysis of marriage before and after the pill's introduction. the data make clear that the strong negative correlations seen in the unwed birth data are not apparent when evaluating marital childbearing. Simple DD estimates of the pill's impact on the inverse hyperbolic sine (asinh) of marital birth per teen based on the same market groupings of above or below median pill sales or OWB in 1900 yield insignificant estimates that differ in sign across the alternative market groupings, unlike the consistent negative estimates of the pill's impact on ln unwed teen birth.[72] Using observed pill sales to group markets, as in Figure 2 panel A, yields an estimate of 0.045 (0.078) on the post-pill high pill use market indicator. An alternative grouping based on OWB in 1900, as in Figure 2 panel B, yields a coefficient on the post-pill high illegitimacy market indicator that is negative -0.134 (0.77), and marginally significant at the ten percent level. A market grouping based on the teen's pharmacy access in 1965, the supply-side instrument, yields a positive coefficient estimate on the post-pill high pharmacy access markets indicator of 0.093 (0.078) that is not significantly differet from zero. Time varying DD coefficients reveal a similar lack of significant correlation between marital fertility and observed pill use, or the supply- and demand-side instruments discussed above.[73] The data do not indicate that marital births among teens were significantly correlated with the extent of pill use across markets, contrary to the predictions of AYK. The steep decline in marital births was relatively uniform across markets and was not significantly correlated with observed pill sales,

[72]The inverse hyperbolic sine is similar to ln but defined at zero. I use this transformation of the data instead of ln to avoid losing observations after the pill's introduction when some markets experienced no marital births among teens already in the decade after the pill's introduction.

[73]See the Marital Fertility Appendix for further details and coefficient plots. A time varying DD coefficient estimates from a version of the empirical model in equation (1), where the inverse hyperbolic sine of teen marital births per 1000 teens replaces the non-marital birth measure, oscillates around zero, and is significantly greater than zero in one year, but no different from zero in any other period. Panels B and C of the Appendix figure on Marital fertility replicate this estimation using historical illegitimacy and pharmacy access groupings interacted with year indicators, as in equation 1. Estimates are not significantly different from zero in most years, although significantly less than zero in 1968 when using historical illegitimacy to group markets, and significantly greater than zerio in 1971 when using pharmacy access.

nor the underlying supply- or demand-side shifters which are significant predictors of pill sales across markets. This uniform decline in marital birth is consistent with the empowerment effect Chiappori and Oreffice (2008) describe.

6 Conclusion

The last century has witnessed large shifts in the technological frontier of fertility control. These changes have inspired competing theories and divergent predictions about the influence of these innovations on unwed childbearing and more general conclusions regarding the role of fertility control as a driver of female immiseration or empowerment. These theories have emphasized how the pill's introduction marked a change in the economic environment and women's contraceptive choice sets. These stylized models stand in stark contrast to the extensive empirical pill literature which has tracked the real world diffusion of the pill, exploiting the piecemeal nature of policies which have restricted women's access to the pill; available in some states to certain women, often conditional on marital status. Exploiting this policy variation has made the simultaneous evaluation the pill's impact on childbearing in- and out-of-wedlock difficult. Relying on treatments defined with regard to legal access to the pill among some populations and reduced form analyses where certain women are not extended access to the pill, or marginal changes in policy, hinge on identifying assumptions that are not well aligned with the economic environment described by theory. These are important distinctions. Chiappori and Oreffice (2008) describe general equilibrium effects which could be difficult to discern in response to narrow policy reforms that target a small population of women. Relying on the intensity of treatment to quantify for the pill's impact may lead to a conclusion that the pill had little effect, when, in fact, the pill's empowerment effect may be quite large and infra-marginal in nature. Similarly, theories which emphasize the role of demand-side variation, as in AYK, may be difficult to align with the supply-side variation emphasized in the empirical literature. This disconnect has made it difficult to assess competing theories. My analysis helps fill this gap, clearly arguing against the pill sowing female immiseration, but consistent with the pill as an engine of empowerment.

In pushing theory closer to the data this paper invites a re-examination of the quantitative effects of the pill along margins beyond unwed teen fertility. A better understanding of the impact of this technological advance will expand the stylized facts which can inform theory and quantitative studies. The theoretically motivated empirical model I pair with rich data on pill sales provides a promising new path for estimating the impact of the pill on a host of behaviors. The elasticities of teen childbearing to pill sales which I estimate are large, negative and highly significant. These estimates reflect the reality

of the pill's rapid spread among Swedish teens, as described by Socialstyrelsen (1984), and argue for the importance of large reforms to quantify the impact of large changes in the economic environment. Swedish medical literature, see Sjövall (1972), documented the pill's outsized effect on teen childbearing; a half-century later economists may also reassess the pill's impact and understanding of how universal access to the means of fertility control and innovations such as the pill influence young women's fertility and all women's well-being.

I place the pill's introduction in historical perspective. The empowerment the pill promised young women in Sweden was not only the power to time fertility or prevent unwed birth. The pill was a means to undo centuries of inequality in the circumstances of birth documented since the 17th Century. I draw on multiple literatures which emphasize the important role of social constraints in regulating non-marital fertility in 19th Century Sweden. My model and empirical analysis suggest that fertility control technology can supplant persistent social norms in regulating sexual activity among the young. Decades of detailed sales data provide extensive empirical support for the model. Linking 19th Century fertility behavior with demand for modern modes of fertility control marks a new phase in the demographic transition literature, carving out a place for unmarried women, and reframing a historical debate regarding the social and economic drivers of contraceptive technology adoption in the modern era. Most importantly, my empirical analysis lifts the potential importance of fertility control liberalization as an economic force, mirroring the conclusions of Goldin and Katz (2002) in a new setting.

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Table 5: Summary Statistics

	Mean	Std. Dev.	Min	Max
Pill Demand	9.61	1.70	3.64	14.86
1910 Historical Factors				
Out-of-Wedlock Births (per 100 Births)	12.34	4.01	6.11	27.90
Out-of-Wedlock Births (per 1000 Women)	6.02	2.01	2.81	12.94
Urban to Rural Ratio (x100)	24.97	31.68	0	183
Female to Male Sex Ratio (x100)	103	3.68	95	114
Female to Male Wage Ratio (x100)	60.1	4.08	50	69
Woman's Wage (Ore per Day)	161.5	19.9	125	225
Other Historical Factors				
Out-of-Wedlock Births 1860	7.98	3.08	3.98	26.33
Out-of-Wedlock Births 1900	10.13	3.18	5.29	24.64
Unengaged Out-of-Wedlock Births 1900	9.04	2.85	4.99	21.79
Prohibition Opposition in 1922	0.44	0.19	0.18	0.81
Women's HS Attainment 1930	0.35	0.23	0.16	1.35
Pentecostal Church Percent 1930	0.76	0.38	0.17	2.02
Out-of-Wedlock Births 1963	12.42	4.58	4.58	30.06
1970-1974 Contemporaneous Factors				
Women's LFP Rate	0.64	0.05	0.53	0.79
Working Women's Mean Labor Income	214.9	63.18	122.7	357.2
Men's Mean Labor Income	256.4	38.1	170.4	384.6
Male Income Inequality (70:30)	2.66	0.72	1.63	9.90
Agriculture Income	4.2	2.4	0.3	14.5
Value of Forestry	0.7	0.4	0.0	1.7
Population Density	5.2	11.8	0.1	83.4
Single Women's Mean Age	21.7	0.47	20.8	23.4
Married Women's Mean Age	31.1	0.52	29.9	32.7
Unmarried Male to Female Sex Ratio (x100)	91	17	60	125
Share of Women Single	0.55	0.08	0.36	0.66
Venereal Disease	0.05	0.09	0.01	0.92

Note: Statistics are based on unweighted market level observations, with the exception of pharmacy density and VD which are county level measures and several historical factors such as male to female wage ratios based on county level agricultural day rates in Bagge et al,1935. HS attainment is the share of women over 15 with a high school degree in 1930. Pentecostal is the percent of the population classified as members in 1930. Prohibition opposition is the share of votes cast against the 1922 ban on alcohol. Mean incomes are for those aged 16-64 in 100s SEK. Women's income is for working women. Population density variables are per square km and pop16-40. The sex ratio is the ratio of women to men16-40. Pharmacy density is per 1000 square kilometers. VD is cases per 1000 of the population aged 16-40.

Table 6: Heterogeneity in Pill Demand Response to Historical Out-of-Wedlock Birth

	(1)	(2)	(3)	(4)	(5)	(6)
High OWB 1910	0.19***					
	(0.06)					
Low OWB 1910	0.24*					
	(0.09)					
North Limes Norrlandicus		0.15***				
		(0.04)				
South Limes Norrlandicus		0.15**				
		(0.05)				
Low Share Local Born			0.13***			
			(0.04)			
High Share Local Born			0.21***			
			(0.05)			
Highly Urbanized				0.14***		
				(0.04)		
Least Urbanized				0.15***		
				(0.04)		
Early Marriage					0.15***	
					(0.04)	
Late Marriage					0.18***	
					(0.05)	
Oppose Prohibition						0.24***
						(0.05)
Support Prohibition						0.15***
						(0.03)
All Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
F-Statistic	1.40	0.04	5.59	0.24	1.48	10.23
R-squared	0.56	0.55	0.58	0.55	0.54	0.60
N	350	350	350	350	350	350

Note: Pill demand per woman is the dependent variable. Standard errors are clustered by market and reported in brackets. 1910 OWB is measured per 100 births. High OWB denotes above average OWB markets. Limes Norrlandicus denotes a biological boundary and the northern limit of medieval society in Sweden. Highly urbanized refers to areas with above average urbanization while least urbanized indicates markets with below average urban share. Low/high local born indicates whether a community has a below or above median share of the population born within the county. Early marriage refers to communities where women married younger than the national average. Support prohibition indicates communities where at least half of voters supported the 1922 referendum to ban alcohol sales. F-statistic reports the F-test that coefficients are identical across groups.
* p¡0.05, ** p¡0.01, *** p¡0.001

Table 7: Pill Demand and Historical Illegitimacy: Long Run Differences

	Logs		Levels	
Δ OWB 1860-1910	0.17**	0.15*	0.18**	0.15**
	(0.07)	(0.05)	(0.05)	(0.06)
Historical Trends:				
Δ Sex Ratio			0.01	0.01
			(0.03)	(0.02)
Δ Urbanization Rate			0.72	-2.56
			(1.94)	(1.58)
Δ Birth Rate			2.39***	1.35***
			(0.52)	(0.41)
R-Squared	0.16	0.51	0.33	0.55
N	350	350	350	350

Note: OLS regression of pill use per woman age 16-40 (1970-74) in log or levels on log or level changes in unwed births per 100 births. Changes in pill use are identical to levels as births. Changes in pill use are identical to levels, as use is zero prior to 1964. Changes in unwed births are measured per 100 births. Birth rate is defined as 100 times births divided by the population of women. Market level data for sex ratios, urbanization, and birth rates are not available in 1860. Trends are computed from 1900-1910. All specifications are clustered by market. are unweighted. * p¡.05, ** p¡.01, *** p¡.001

7 Historical Appendix

7.1 Fertility Control: Coitus Interruptus and Abortion

The agrarian society that typified Sweden in the 19th century relied heavily on social control as a substitute for contraception. Reduced coition through prolonged abstinence and late marriage was the main means of fertility control, but methods for preventing conception or inducing abortion played a role. Early explanations of divergent fertility patterns in Sweden made little reference to contraception.[74] Although family planning and the spread of neo-Malthusian ideas among intellectual circles was underway in Europe during the 1870's the spread of contraceptive technologies was limited.[75]

Detailed historical analysis of contraceptive practices is scant. The lack of attention paid to contraception in 19th century historical studies may be due to widely held views of family planning as a sign of moral weakness. This view was codified in the anticontraceptive laws of 1910. From 1911 until 1938, it was illegal to provide knowledge of contraceptive techniques or publicly sell contraceptives "intended for immoral use or to prevent the results of sexual intercourse." Knut Wicksell pamphleted and lectured on contraception and was denounced as an "apostle of promiscuity" and jailed for spreading birth control propaganda.

Quantitative evidence from Gotland suggests that interrupted intercourse had been practiced among married couples since the 1700's and throughout the rest of Sweden by the end of the 19th century.[76] Anecdotal and quantitative evidence also leads Frykman (1975) and Santow (1993) to conclude that knowledge about coitus interruptus was widespread by the late 19th century or earlier.[77] These conclusions are supported by the findings of a survey conducted by the Swedish Population Commission undertaken during the early 1930s which found that knowledge of coitus interruptus was widespread, while familiarity with condoms, diaphragms and other methods for limiting fertility were minimal.[78]

The regulation of abortion has a long history in Sweden.[79] The 13th century Västergötland Law forbade any form of induced abortion under threat of severe penalty. The criminal code of 1734 placed abortion on par with infanticide and made it punishable by death. In 1864 and again in 1890 the law was liberalized, and the maximum sentence for abortion was reduced to six years of penal servitude. The law was further liberalized 1921.

Although knowledge of abortifacients was rudimentary, many women attempted to use home remedies to induce abortion.[80] In the last half of the 19th century provincial doctors were required to perform autopsies of suspected suicides and evidence from these autopsies shows that attempted abortion was widespread according to Hedren (1901). From 1851-55 through 1901 an increasing number of suicides were committed by unmarried pregnant women. These suicides increased quickly from 1870 onward, although they showed little systematic variation by region. The majority of women captured in the suicide statistics were in the final stages of pregnancy and their suicides occurred by poison, ninety

[74] Nils Wohlin (1915) emphasized marital delay and abstinence in his analysis of the extremely low marital fertility rates on Gotland.

[75] Technical contraceptive measures that preceded the Pill were a very recent phenomenon in Sweden according to Frykman (1975).

[76] See Carlsson (1966) and Gaunt (1973).

[77] Frykman (1975) provides an account, of an exchange between a mother, and her son of around 20 which occurred in 1916. The mother implores her son to be careful while visiting a dance that evening saying "Olle, my dear, I tell you: don't let it drip where it sits unprotected." Her son, recently returned from military service, responds, "Oh no, Mum! I'll push all of it up their arses!" Frykman argues coitus interruptus was known to both the mother's and son's generation.

[78] Although coitus interruptus was well known by 1900, it should be noted that women may have had limited control over its use. Knowledge of the technique does not assure that it was used. The occurrence of out-of-wedlock birth may be seen as reflecting social norms regarding responsibility more than knowledge about the art of interrupted intercourse.

[79] The lack of geographically disaggregated abortion data precludes a study of abortion demand.

[80] Informal measures included phosphorous, arsenic, quicksilver, ergot, saffron and strong laxatives like aloe.

percent of which occurred due to phosphorous.[81]

8 Model Appendix

8.1 Stigma as a Function of OWB

Consider an alternative model where out-of-wedlock births are stigmatized. Stigma, μ_j, would be a function of the frequency of OWB in a community, $n_j p_j$, but this stigma would be incurred only when an unwed birth is realized. The problem would become

$$U_{i,j} = \begin{cases} V & \text{abstain from premarital sex} \\ \beta_i - p_j C - p_j \mu_j & \text{engage in premarital sex} \end{cases}$$

Consider a stigma function analagous to the chastity norm ($\gamma_j = \frac{1}{n_j}$) described in the main text where the share of women engaging in non-marital sex is replaced with the number of out-of-wedlock births, $\mu_j = \frac{1}{p_j n_j}$. By substituting the OWB stigma function into the problem it is apparent that the stigma associated with the chastity norm is isomorphic to stigma defined over OWB in the pre-pill period.

When the pill is introduced women will use the pill if the net benefit of using the new technology exceeds the cost, but now this benefit also includes avoiding the stigma of an unwed birth as determined by the inherited stigma, μ_j,

$$c_p < (p_j - p_p)(C + \mu_j)$$

and the value of using the pill and engaging in out-of-wedlock sex exceeds the value of abstinence,

$$V < \beta_i - p_p(C + \mu_j) - c_p.$$

This will lead to a critical threshold in each community, $\beta_j^{Pill,\mu} = V + p_p(C+\mu_j) + c_p = V + p_p C + \frac{p_p}{p_j}\frac{1}{n_j} + c_p$, that will determine demand for the pill. The key difference is that inherited OWB stigma is scaled by p_p. Analagously this could be rewritten in terms of the chastity norm,$\gamma_j = \frac{1}{n_j}$, which would be weighted by $\frac{p_p}{p_j} < 1$. Hence, inherited OWB stigma should have a relatively small influence on pill demand compared to the model where the stigma is associated with premarital sex and $\beta_j^{Pill} = V + \frac{1}{n_j} + p_p C + c_p$. In the long run, after the pill has supplanted the local technology, and the norm has adjusted to the new equilibrium this type of stigma function will also converge in the long run.

Demand for the pill will depend on two conditions:

$$n_j^{Pill} = \left[1 - F\left(V + \gamma_j + p_p C + c_p\right)\right] \times 1\left[\text{if } c_p < (p_j - p_p) C\right].$$

The properties of the stigma against unwed birth would be similar to the promiscuity norm; if everyone in your community has an unwed birth there is no stigma associated with you also having an unwed birth. The critical value for engaging in premarital sex is analagous to the promiscuity sanction but for a constant rescaling of the value of chastity, V, and the cost of an out-of-wedlock birth, C:

$$\begin{aligned} \beta_j^* &= V + p_j\left(C + \mu_j\right) = V + p_j C + p_j\left(\frac{1}{p_j n_j} - 1\right) \\ &= V + p_j(C-1) + \frac{1}{n_j} = V + p_j(C-1) + \left(\frac{1}{n_j} - 1\right) + 1 \\ &= \underbrace{(V+1)}_{V^*} + p_j \underbrace{(C-1)}_{C^*} + \gamma_j = \beta_j^{sex}. \end{aligned}$$

[81] Matches containing phosphorous were banned in 1901 due to their use in abortions, which in many cases were fatal to women.

8.2 Differences in the Value of Abstinence

Consider a version of the model where local customs for preventing unwed birth are constant across markets, $p_j = p$ for all j. Instead, the value of abstinence varies across communities, denoted by V_j. Non-marital fertility in community j, $owb_j^{Abstinence} = pn_j^{Abstinence}$, are completely driven by differences in the share of women whom choose to engage in pre-marital sex, n_j. The share of women engaging in pre-marital sex would be given by

$$n_j^{Abstinence} = 1 - \Phi\left(V_j + \gamma_j + pC\right)$$

Increases in the value of absitnence have a negative effect on the OWB rate. An increase in V_j reduces OWB in the short-run, as well as in the long-run as the equilibrium stigma increases.

If the pill's efficacy, p_{pill}, and cost, c_{pill}, are such that $(p - p_{pill})C > c_{pill}$ the pill will be adopted by all women who choose not to abstain from non-marital sex, regardless of the community that they live in. If this condition is not satisfied no one will adopt the pill, as this condition does not vary across communities. If the pill satisfies the cost effectiveness criterion, short-run demand will be determined by

$$n_{j,pill}^{Abstinence} = 1 - \Phi\left(V_j + \gamma_j + p_{pill}C + c_{pill}\right)$$

Differences in the value of abstinence will generate a positive correllation between illegitimacy rates in the past and adoption of the pill in the short-run.

Since V_j and γ_j are positively correlated, an implication of the stigma function being an decreasing function of n, persistent differences in demand for the pill will remain in the long-run. Unlike the model of heterogeneous local technologies for OWB prevention, where the pill supplants local customs, differences in the value of abstinence persist after the pill is introduced. This leads to persistent differences in sexual activity, social sanctions and demand for the pill across communities that are correlated with historical illegitimacy patterns.

Changes in the cost of the pill will only alter local demand for the pill through the sexual activity margin so long as the uniform adoption criterion is satisfied, $(p - p_{pill})C > c_{pill}$. If the pill is adopted by any unmarried woman, it will be adopted by all unmarried women engaging in sex outside of marriage. The introduction of a universal subsidy on the pill, reducing the cost of pill use from c_{pill} to $c_{pill}^{'}$, will only increase demand for the pill through the sexual activity channel alone, so long as the adoption criterion was satisfied at the initial cost, c_{pill}. If the initial adoption criterion was not satisfied, changes in the cost of using the pill may have no impact on pill demand, if the uniform adoption criterion is not satisfied, or in the case that the uniform subsidy is satisfied, this will result in adoption by all unmarried women engaging in sex across all communities.

8.3 Differences in the Cost of Unwed Birth

Consider a version of the model where the cost of OWB varies across communities, denoted by C_j. Customs for preventing unwed birth as well as the value of abstinence are constant, hence $p_j = p$ and $V_j = V$ for all j. When unwed birth cost vary across communities, the share of women engaging in pre-marital sex prior to the pill is given by the expression

$$n_j^{Cost} = 1 - \Phi\left(V + \gamma_j + pC_j\right).$$

Since the probability of an unwed birth is the same across communities, differences in sexual activity completely determine differences in OWB. Increases in the cost of non-marital fertility, C_j, have an unambiguously negative effect on OWB. An increase in C_j reduces OWB in the short-run as well as in the long-run when stigma increases reinforcing this effect.

When the pill is introduced, short-run demand will be determined by two expressions, both functions of C_j,

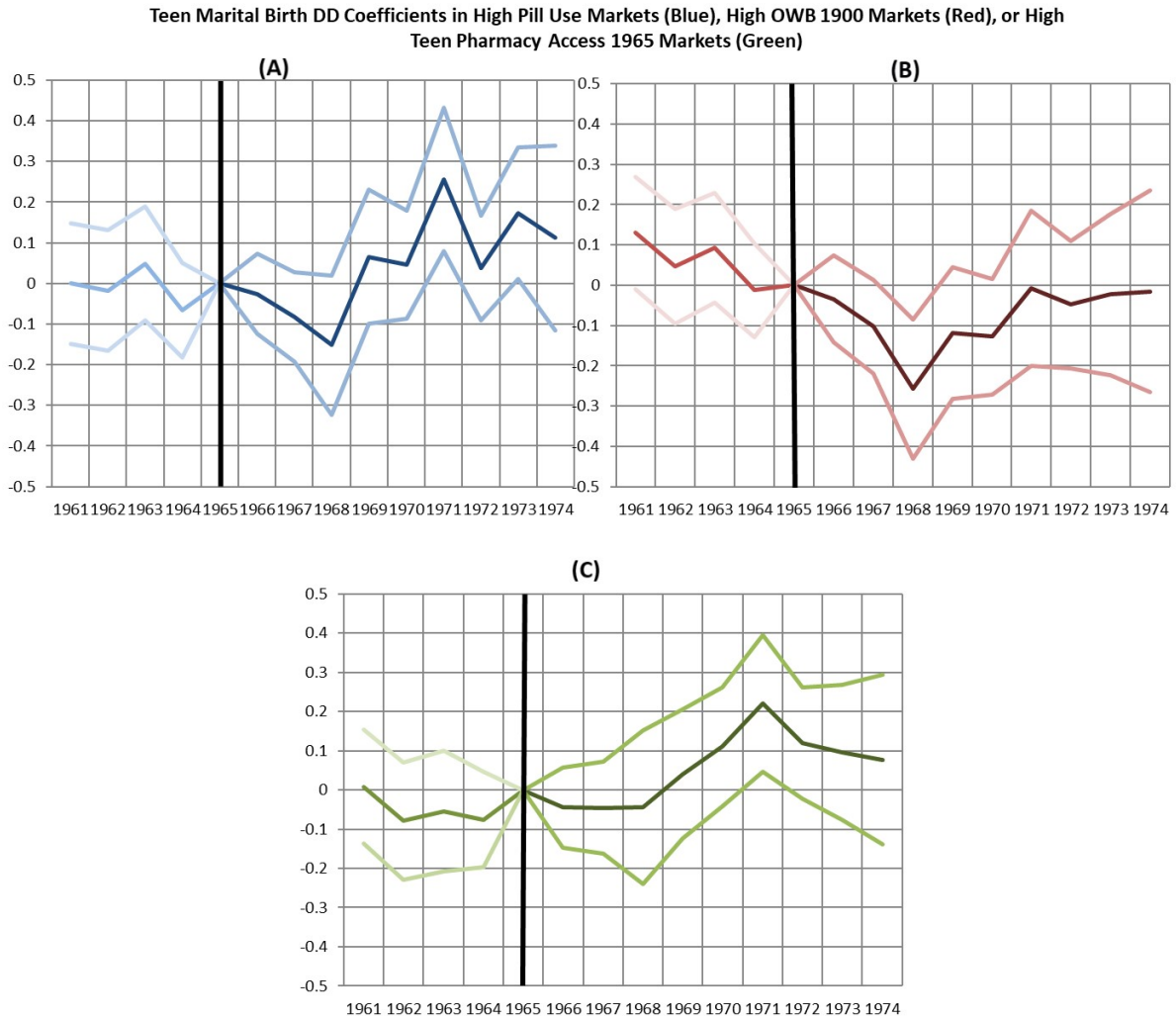
$$n_{j,pill}^{Cost} = [1 - \Phi\left(V + \gamma_j + p_{pill}C + c_{pill}\right)] \times 1\left[\text{if } \frac{c_p}{(p - p_{pill})} < C_j\right]$$

The first term captures variation across communities in the share of women engaging in pre-marital sex when using the pill. The second term captures whether the benefit of using the pill exceed the cost. C_j works in opposite directions with respect to demand for the pill in each of these terms. In the first term, a higher cost of realizing an unwed birth reduces the share of women engaging in sex outside of marriage while on the pill and hence demand for the pill. The second term illustrates how communities where the costs of unwed birth are high, and where illegitimacy in the past was low, will be the most likely to adopt the pill. If the adoption of the pill is not universal, that is if $(p-p_{pill})C_j < c_{pill}$ for some j, we will observe a particular type of community level selection into pill use. Communities where the benefit of using the pill will be greatest relative to the cost, large C_j, will adopt the pill, but these same communities will also have relatively low latent demand for the pill as compared with communities that have smaller costs of unwed childbearing and in turn more women engaged in sexual activity. As the cost of using the pill declines more and more communities will adopt the pill versus the traditional technology.Communities that adopt the pill when the price is high will consume very little of it compared to communities which adopt the pill only once the cost is sufficiently low. If the pill was costly when introduced, we would see many communities where historical illlegitimacy was high not adopting the pill at all, this could be a force that may lead to a negative correlation between historical illegitimacy and pill adoption. If the price of the pill were to fall there would be small demand increases in communities where the pill was already in use while there would be large changes in demand for the pill in communities which did not initially adopt the pill. Generally we would expect to see a positive correlation between changes in demand and historical OWB around a price decline, and hence a stronger positive relationship between pill demand and historical illegitimacy after a decline in the cost of using the pill if differential costs were the driving force behind pill adoption patterns. Hence one may see a large price responsiveness to the pill induced by large demand markets shifting from the traditional technology to the pill when the price of the pill falls.

If the efficacy and cost of the pill are such that $(p - p_{pill})C_j > c_{pill}$ for all j, then the pill will be demanded by all women engaging in non-marital sex across all markets. If adoption is universal, the share of women whom would engage in pre-marital sex using the pill will be positively correlated with the share of women whom would engage in pre-marital sex without the pill, and in turn past unwed births. This short-run positive correlation between low pill demand and low historical OWB will persist in the long-run as heterogeneity in C_j exerts an influence on demand for sex and in turn pill use among the unmarried. If probabilities and costs are such that selection into pill use is universal, demand for the pill would be determined solely by the latent demand for pre-marital sex. This demand would be positively correlated with demand for sex under the old technology, and in turn the historical OWB rate. This positive correlation between OWB and pill use would also be observed in the new long-run equilibrium, just as in the model with differing values of abstinence.

9 Marital Fertility Appendix

Figure 5: DD Coefficient Estimates of the Pill's Impact on Marital Births per 1,000 Teens



Note: Panel (A) DD coefficient estimates (β1961-β1974) as defined in Equation (1) and 90% confidence intervals from a regression of the inverse hyperbolic sine of marital births per 1000 teens on an indicator for whether average pill use per woman (1970-74) was above the median average pill use. The vertical black line indicates the first full year of pill treatment. **Panel (B)** Identical to Panel (A) but where the market grouping indicator is defined by above median OWB Share in 1910. **Panel (C)** Identical to Panel (A) but where the market grouping indicator is defined as above median teen pharmacy access in 1965. (*Sources:* SCB, *Svensk Farmacevtisk Matrikel 1965,* and *Swedish Drug Market* (1970).)