Intensive and Extensive Margins of Utilization: Evidence from *in vitro* Fertilization Treatment*

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Abstract

How do increases in the accessibility of expensive medical treatments affect patients' utilization behaviour, and what are the resulting effects on healthcare costs? We investigate utilization responses on both the intensive and extensive margins to more generous coverage to state-level mandates that required private health insurance plans to cover *in vitro* fertilization (IVF) –an expensive infertility treatment. Patients undertaking IVF face high costs and low success rates, and can increase their probability of success by transferring more embryos per IVF cycle. However, this significantly increases the likelihood of multiple births, which are risky for both mothers and infants and associated with high healthcare costs. More generous coverage for IVF could reduce the number of embryos that patients wish to transfer per cycle. However, if expanded access causes extensive margin effects, drawing new patients with lower probabilities of success into the system, this could actually lead to an overall increase in embryos transferred and a corresponding increase in multiple births. We exploit variation across states and time in the generosity of mandated IVF coverage in a Generalized Synthetic Control model to empirically quantify the causal impacts of the number of covered cycles on multiple births. We find that more generous coverage increases multiple birth rates. Furthermore, we show that more generous coverage has intensive margin effects for younger patients, reducing the number of embryos they transfer, but also has sizeable extensive margin effects for older patients with lower probabilities of success. These results are mirrored by a significant decrease in adoptions to the older patients. Our findings have important implications for designing policy interventions to increase the accessibility of new expensive medical treatments.

JEL classification: I11, I13, J18.

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1 Introduction

Healthcare spending in the US has risen rapidly, from five percent of GDP in 1960 to 17.9 percent in 2016 (CMMS, 2016). Lifestyle changes and an aging population have contributed to increases in chronic illnesses such as cancer, musculoskeletal conditions, diabetes and heart disease, many of which have expensive treatment options. This raises concerns about both access to treatment as well as costs. Mandated coverage for expensive medical treatments in private health insurance plans has been used to increase accessibility of such treatments by decreasing patients' out-of-pocket costs. The generosity of mandated coverage for a treatment can have intensive margin effects on patients' utilization behaviour since mandated coverage makes the treatment more accessible to patients. However, mandated coverage can also have extensive margin effects; it makes the treatment accessible to patients who might have used a cheaper alternative in the absence of the mandated coverage. These extensive margin effects can contribute to further increases in healthcare costs. Understanding patients' behavioural responses to the increased accessibility of expensive treatments is important for the better design of such policy interventions.

Estimating causal effects on patients' utilization behaviour from increased accessibility of an expensive treatment is not straightforward. The main issue is that patients who use these treatments are a highly selective group among those who need the treatment. To overcome the selection issue, a natural experiment is needed. Mandated insurance coverage for infertility treatment provides an interesting case study in this context. Fertility problems are quite common in the US and other industrialized countries, with more than eighteen percent of US women of childbearing age reporting fertility problems in 2016 (CDC, 2015a). Increased returns to human capital investment for women have increased the expected benefits of professional degrees and time-intensive career investments, providing incentives for women to delay childbearing. (Kroeger and La Mattina, 2017). Increasingly, women have turned to infertility treatments in general, and *in vitro* fertilization (IVF) in particular for assistance. The number of IVF cycles in the US has grown five-fold during the recent two decades (see Panel (c) of Table 2).

Despite technological progress, success rates of a single IVF cycle are as low as twenty percent (CDC, 2015b). Many patients, therefore, require more than one cycle of treatment to conceive an infant successfully. The costs of one cycle of IVF can be as high as 46% of the average annual disposable income of a family in the US. (Kissin et al., 2016).[1] More aggressive treatment –implanting more embryos– increases the chances of conceiving an infant but also increases the probability of multiple births. While many families with fertility problems would welcome twin births, they can be costly and risky for both mothers and infants.[2] More than

[1]The cost of one IVF cycle for a 35 years old woman is about $14,500 (2014 US dollar) where the average cost including medication, the pre-cycle procedure is about $19,000 to $20,000 (2014 US dollars). The average total cost per infant ranges from $38,000 to $85,000 (2001 USD) (Henne and Bundorf, 2008). For further information see: `http://www.resolve.org/family-building-options/making-treatment-affordable/the-costs-of-infertility-treatment.html` and `http://ivfcostcalculator.com`. [Accessed on July 9, 2017]

[2]The average cost of a singleton birth was $27,000 in 2012, while twin and triplet births cost $115,000 and $435,000 (Lemos et al., 2013). The risks of multiple births to mothers include high blood pressure, gestational

one-third of twins and more than three-quarters of triplets and higher order multiples in the US in 2011 resulted from conception assisted by infertility treatments especially IVF (Kulkarni et al., 2013). Multiple births are then a central issue in the social benefits and costs of increased accessibility of IVF treatment.

In this paper, we empirically investigate how the generosity of mandated insurance coverage for IVF affects patients' utilization behaviour and the composition of those utilizing the treatment. We first develop a conceptual framework to show how patients' fertility together with the generosity of their insurance coverage leads to differences in utilization and the aggressiveness of treatment. We then use Detail Natality Data on all births in the US between 1975 and 2014 and exploit variation across states and time in the generosity of mandated IVF coverage. We use a Generalized Synthetic Control (GSC) model to empirically quantify the causal impacts of the number of covered cycles on the adverse outcome of the treatment measured by multiple birth rates. We further investigate the robustness of our findings from the GSC model using a Difference-in-Difference-in-Differences (DDD) model exploiting the variation in state, year and mothers' age. To shed light on intensive vs extensive margin effects of the mandated coverage, we turn to fertility clinic data from the Society for Assisted Reproductive Technologies to examine whether more covered cycles of IVF treatment affect the number of initiated cycles and the number of embryos transferred per cycle. Finally, we examine data on adoptions from the National Data Archive on Child Abuse and Neglect (NDACAN), which could be considered in some circumstances as a substitute for conceiving through IVF.

Previous work has examined the effects of the mandated IVF coverage on patients' utilization behaviour and variety of other outcomes (for instance see: Bitler and Schmidt, 2006, 2012; Schmidt, 2007, 2005; Buckles, 2008, 2013; Kroeger and La Mattina, 2017; Abramowitz, 2014, 2012). They have primarily treated mandates to cover in all states as equal. However, some states restrict mandated coverage to one cycle of treatment, while other states mandate that insurers cover more than five cycles. One justification for more generosity in this type of mandated coverage was that it might serve as a policy solution to the problem posed above - if individuals who have more generous insurance coverage for IVF transfer fewer embryos per cycle since additional cycles of treatment might be possible (Jain et al., 2002; Reynolds et al., 2003).

More covered cycles by a health insurance plan would have two competing effects. First, holding the pool of patients constant, patients face less pressure to conceive in fewer cycles. They might choose less aggressive treatment; implanting fewer embryos per cycle. This intensive margin effect would result in a decrease in the incidence of multiple births. Second, more patients will now have access to infertility treatments, so patients who would not have pursued the treatment in the absence of the insurance coverage face incentives to initiate the treatment. This extensive margin effect would lead to an increase in the incidence of multiple births, but might not change the number of embryos being transferred per woman or per cycle. The

diabetes and a higher rate of cesarean sections. The risks to infants include low birth weight, prematurity and sometimes long-term disabilities like autism and cerebral palsy (Hoffman and Reindollar, 2002; Fritz, 2002; Martin and Park, 1999; Reynolds et al., 2003).

extensive margin effect could be even more important if it led to a change in the composition of the patients seeking treatment, such that more patients with a lower probability of success initiated the treatment. If this change in composition is occurring, then we could even see an increase in the number of embryos transferred per cycle. The overall effect of more generous coverage for IVF treatment on the incidence of multiple births is then be ambiguous.

Our empirical analysis has two main findings. First, there are strong behavioural responses to increased accessibility of IVF treatment. The more cycles of mandated coverage, the higher is the multiple birth rate. The estimated effects after controlling for state level characteristics range from a 7 percent increase in multiple birth rates in states with one covered cycle to a 23 percent increase in states with unlimited covered cycles (relative to states with no coverage). Second, the overall increase in the multiple birth rate masks a reduction in embryos transferred for younger patients and an increase in embryos transferred for patients over the age of 35. This finding suggests that more generous coverage has intensive margin effects for the younger patients, but sizeable extensive margin effects for older patients with lower probabilities of success. These results are mirrored by a significant decrease in adoptions to the older patients in our sample.

Our findings suggest that increased generosity of an expensive medical treatment alone might lead to an increase in healthcare costs, through both intensive and extensive margin effects. This is consistent with other literature on incentives in the health care system. Chernew et al. (2000) suggest that in an optimal insurance plan patients should pay higher out-of-pocket costs for more expensive treatment. Einav et al. (2016) (in the case of treatments for breast cancer) and **?** (in the case of infertility treatments) both suggest that top-up pricing for more aggressive treatments could be optimal.

The remainder of the paper proceeds as follows. We describe IVF, the institutional background, and previous literature in Section 2. We present a conceptual framework in Section 3 to show how more generous IVF coverage in private health insurance plans affects patients' utilization behaviour. We then present our data and identification strategy in Section 4 and 5. We present our findings in Section 6. We further investigate the extensive margin and compositional effects of the mandated coverage in Section 7. Finally, conclude and discuss policy implications in Section 8.

2 Background

2.1 *in vitro* Fertilization (IVF) treatment

Infertility is considered to be a disease of male or female reproductive system, and is defined as the inability to conceive or carry a pregnancy to full term.[3] *in vitro* fertilization (IVF) is the most common type of Assisted Reproductive Technology (ART) used for fertility prob-

[3]The American Society for Reproductive Medicine (ASRM) and the American College of Obstetricians and Gynaecologists (ACOG) and the World Health Organization (WHO) recognize infertility as a disease.

lems.[4] IVF is the process of fertilization by extracting eggs, retrieving a sperm sample, and then manually combining an egg and sperm in vitro ("in glass"). The fertilized egg(s) –called embryo(s)– are then transferred into the woman's uterus. The first infant conceived using an IVF treatment was born in 1978 in the UK, and the first IVF birth in the US was in 1981.

The infertility treatment process begins with medical tests and advice from a patient's physician on how to conceive an infant with minimum medical intervention. The next step is usually taking infertility drugs to stimulate egg production. If these (relatively) inexpensive treatment methods are not successful, then patients are often recommended to initiate IVF treatment.

Initiating IVF treatment starts with a patient taking pre-treatment drugs that stimulate her egg production. During this period, the patient visits the fertility clinic frequently to monitor egg development. If the ovarian response of the patient is deemed to be sufficient, then she undergoes a surgical process to retrieve some eggs for insemination in the laboratory. The resulting embryos are then cultured in the laboratory for 2 to 6 days as the cells begin to divide.

At this point, the patient decides the number of embryos to transfer. The Practice Committee of the American Society of Reproductive Medicine provides guidelines on the number of embryos to transfer (Klitzman, 2016). However, given the high costs and low success rates of IVF, patients often wish to transfer more embryos to improve their odds of success, potentially leading to multiple births. Although most of these costs might be covered by insurance, and many patients with fertility problems view multiple births as a desirable outcome (Gleicher and Barad, 2009), multiple births are costly and risky for both mothers and infants.

2.2 Mandated IVF coverage in private health insurance plans

The cost of IVF treatment has led to policy interventions to improve access to this treatment. Between 1978-2005, fifteen US passed legislation pertaining to infertility treatment in employer provided private health insurance plans. In *"mandated to cover"* states, private health insurance companies are required to cover infertility treatment in all their plans.[5] In *"mandated to offer"* states, the policy requires health insurance companies to offer plans that would cover infertility treatment, but do not require that all policies sold include this coverage. The rest are *"never mandated"* states with no mandate to require health insurance companies to cover infertility treatment.

The degree of coverage in mandated states is quite heterogeneous. Some mandate to cover states do not include coverage of IVF (California, Montana, New York and West Virginia).

[4]Other forms of ART include Gamete Intrafallopian Transfer (GIFT) and Zygote Intrafallopian Transfer (ZIFT). IVF is used if these less invasive or expensive options have failed or are unlikely to work. The use of these alternatives peaked around 1990, and they are now almost completely absent from the ART market (Hamilton and McManus, 2012).

[5]Under the the Employer Retirement Income Security Act of 1974 (ERISA), self-insured firms are not subject to the mandate. It has been shown that large firms are more likely to self-insure (Gabel et al., 2003; Park, 2000). Since we do not have information on the portion of self-insurer firms, in our empirical analysis we control for the portion of individuals working for big firms defined as those with more than 500 employees.

Within the states that do require coverage of IVF, Arkansas (1987)[6] and Hawaii (1989) mandate coverage for only cycle of IVF; Connecticut (2005) mandates up to two; Rhode Island (1989) and Maryland (1985) mandate up to three; Illinois (1991) and New Jersey (2001) mandate up to four cycles; and Massachusetts (1987) has no limit. Plans also vary along a number of other dimensions, including whether unmarried women are covered, age restrictions, and restrictions on the use of donor eggs. However, these dimensions of generosity are highly correlated with the mandated number of cycles, so we treat the number of cycles as a proxy for a more general form of generosity. More detail on the mandated IVF coverage in the US is provided in Table 1.

Some insurance plans with IVF coverage offer a complete coverage while others offer partial coverage. In contrast with partial plans, complete plans cover the cost of diagnosing, drugs and pre-treatment procedure and maternal cares. Therefore, in states with mandated IVF coverage, patients still might face out-of-pocket costs.

2.3 Previous work

Our paper is related to the literature investigating effects of mandated coverage for infertility treatment on a variety of outcomes including utilization of treatment, fertility, age at first birth, time of marriage, women's choice to pursue professional careers and allocation of labor supply over life cycle (Bitler and Schmidt, 2006, 2012; Schmidt, 2007, 2005; Buckles, 2008; Kroeger and La Mattina, 2017; Abramowitz, 2014, 2012; Machado and Sanz-de Galdeano, 2015). Most of these studies use either state-year or state-year-age variations in mandated IVF coverage in respectively Difference-in-Difference (DD) and Triple Difference (DDD) frameworks.[7] Buckles (2013) uses Natality Detail Files in a DD model and finds that "strong" mandate to cover laws (those that include coverage for IVF and apply to most private firms) have a small and statistically insignificant impact on the incidence of multiple births. In addition, studies using clinic-level data find that treated patients with health insurance plans covering IVF treatment transfer fewer embryos, compared to those with no insurance coverage (Hamilton and McManus, 2012; Reynolds et al., 2003; Jain et al., 2002; Henne and Bundorf, 2008). However, much of this previous work ignores the differences in generosity within the set of states that mandate coverage for IVF. The previous literature largely treats all mandates to cover IVF as the same, when as discussed above this coverage ranges from one cycle in some states to unlimited coverage in others.

2.4 Our contribution

Our contribution to this literature is twofold. First, we study how patient's utilization responds to the *generosity* of the mandated IVF coverage. This is important for understanding the cost

[6]The year in parenthesis presents the year policy intervention to cover IVF in private health insurance plans is enacted in the corresponding state.

[7]Machado and Sanz-de Galdeano (2015) is an exception where they use a Synthetic Control model to estimate the effects of the mandated IVF coverage on timing of first births and on women's total fertility rates.

implications, since more generous coverage could affect utilization on both the intensive and extensive margins, and on the extensive margin could alter the composition of those seeking treatment. The second contribution is methodological. The DD approach used in much of the previous literature relies on the parallel trends assumption - that trends in the treatment and control states would have evolved in the same way in the absence of the treatment. While the authors of these previous papers all address the parallel trends assumption, it might be less valid in the context of state-level differences in generosity within the set of states that choose to mandate coverage of IVF. To generate causal estimates given this concern, we use a Generalized Synthetic Control (GSC), described in the Section 5. However, we also estimate DD and DDD models as robustness tests, and for easier comparability to the previous literature.

3 Conceptual framework

In this section, we build upon Hamilton and McManus (2012) to provide a simple conceptual framework to illustrate how the number of IVF cycles covered in a patient's health insurance plan and their fertility affect their utilization behaviour.

Many factors affect a patient's decision for initiating IVF treatment, as well as the intensity of the treatment if they decide to use it. First, as noted previously, per cycle costs of treatment are quite high. In addition, most of the patients need more than one cycle of treatment to result in a live birth. Therefore, patients face strong financial incentives to minimize their total treatment costs by conceiving in fewer cycles. As a result, they may transfer more embryos in a given cycle in order to improve their chances. Transferring more embryos also increases the probability of multiple births. Health insurance plans with IVF coverage reduce the out-of-pocket costs of the treatment and potentially reduce the pressure to conceive in fewer cycles, and as a result, patients with more covered cycles might decide to transfer fewer embryos in a given cycle, subsequently reducing the probability of multiple births.

Even with insurance coverage for IVF, patients still face both monetary and non-monetary costs. Required medication and pre-cycle procedures may not be covered by insurance. In addition, treatment requires a great deal of time, as well as psychological distress regarding both the success of the treatment as well as uncertainties about the health of the infant. Patients endure non-pecuniary costs before, during and after the treatment in addition to the pecuniary out-of-pocket costs of the treatment.

Assume that patients get utility from consumption (α) and having infants (b). Each patient is endowed with fixed income I. A patient makes a decision d from the options of natural conception (N), receiving an infertility treatment (IVF) and adopting an infant (A) to maximize her utility defined as:

$$\max_{d \in \{N, IVF, A\}} U(\alpha, b) = \alpha + v_d(b) \tag{1}$$

where $v_d(.)$ denotes the utility associated with choice d. b denotes the number of infants resulted from choice d. We assume that, conditional on a successful birth, patients prefer fewer infants resulting from a delivery. We therefore assume that $v_d(.) > 0$ and $v'_d(.) < 0$ for all choice of d. All patients prefer to have their own biological infant with a natural conception where $v_N(.) > v_{IVF}(.)$ and $v_N(.) > v_A(.)$.

Patients' consumption (α) is their income net of the cost of their choice d as $c = I - c_d$ where c_d is the cost associated with decision d. The cost of natural conception c_N is set to be zero. The cost of adoption is also assumed to be fixed at $c_A = \omega$. The costs of IVF treatment consists of two parts; the fixed costs of initiating a treatment (ψ) and the per cycle costs which might be covered by an insurance plan (ϕ) and is defined as $c_{IVF} = \psi + \phi$.

The more embryos are transferred, the higher is the probability of conceiving an infant, as well is the likelihood of a multiple birth. We assume that the number of infants from a cycle of treatment is $b = k\kappa$ where $k \in [1, \overline{k}]$ is the number of transferred embryos and κ is a fixed parameter denoting the probability of natural multiple conceptions. $\overline{k}$ denotes the maximum possible number of implanted embryos suggested by the professionals. We also assume that the number of transferred embryos (k) is a function of a patient's fertility $f \in [\overline{F}, \underline{F}]$ and the number of the cycles covered in their insurance plan ($\overline{r}$) and defined as $k = g(f, \overline{r})$. $\overline{F}$ and $\underline{F}$ denote the fertility of patients with respectively low and high chances of natural conception. Patients with lower fertility face incentives to transfer more embryos ($g'_f(.) < 0$) and patients with more covered cycles transfer fewer embryos ($g'_r(.) < 0$). Patients' fertility f and their insurance coverage for IVF treatment $\overline{r}$ are the only sources of heterogeneity in our model. For simplicity and with no loss of generality, we assume $k = \frac{1}{f\overline{r}}$.

We assume that the per cycle probability of conceiving an infant depends on patients' fertility and the number of transferred embryos defined as $\phi(f, k)$ where patients with higher fertility have better chances ($\phi_f(.) > 0$) and more transferred embryos improve the chances ($\phi_k(.) > 0$). For simplicity and with no loss of generality we assume $\phi(f, k) = \gamma f k$ where γ denotes the probability of a natural conception.

Figure 1 illustrates patients' choice by their fertility f. Patients with $f \in (\frac{1}{\gamma}, \overline{F}]$ are more likely to naturally conceive an infant. Patients with $f \in [\frac{1}{\gamma\overline{r}\overline{k}}, \frac{1}{\gamma}]$ would use IVF treatment. When the number of covered cycles ($\overline{r}$) increases, more patients with lower fertility would choose initiating a treatment over adopting a child. These patients would increase their chances of conceiving an infant by implanting more embryos which might result in a multiple birth. Patients with $f \in [\underline{F}, \frac{1}{\gamma\overline{r}\overline{k}})$ are predicted to opt for adoption rather than to initiate a treatment.

4 Data

We use several data sources for our empirical analysis. First, we use birth certificate data from the National Center for Health Statistics' Natality Detail Files. The data include records of live births in 51 states in the US from 1975 to 2014.[8] The data include information on age of the mother, education of the mother, race, marital status, and state of residence.[9] The data

[8] About 10% of states before 1985 report only half of their births. We double each record in such cases.

[9] The public use birth certificate data include mothers' state of residence only up to year 2004. We use the restricted access data files from 2005 to 2014.

also include information on fathers' race. An infant's year of birth, sex, birth order, plurality, birth weight and five minute APGAR score are also recorded in the data files. We aggregate the data into state-year cells for our empirical analysis.[10]

There is one record for each infant in the data file, meaning that for instance, there are three records for a triplet birth. The number of infants then over-represents the incidence of multiple births. To deal with this issue we follow Buckles (2013) and construct a weight variable by dividing one by the plurality of each infant (i.e. the weight of each infant in a triplet birth is set to be 1/3). We use these weights throughout our empirical analysis to convert the unit of analysis from infant to birth. The primary outcome variable is the multiple birth rate. Multiple births are defined as a birth which is not singleton, and our measure of multiple births gives the percentage of all births that were multiple.[11] We also use the number of infants per thousand births as an alternate other outcome variable to check the robustness of our findings. This variable sheds light on the degree of the plurality of multiple births.

Second, we use the March Annual Social and Economic Supplement of the Current Populations Survey (CPS) to control for state-level socioeconomic characteristics. We limit our study sample to working age individuals (18 to 64 years) and then aggregate the data into state-year cells and merge it with the birth certificate data. We use the percent of women of childbearing age (defined here as ages 18-49), the labor force participation rate of working age women, the percent of working age individuals working in big firms (defined as firms with +500 employees), the percent of working age individuals with private health insurance, and real average per capita income.[12]

Third, we use clinic-level data collected from 1995 to 2015 by the Society for Assisted Reproductive Technologies (SART) to study patients' utilization of IVF treatment. The data are collected within a voluntary reporting system for infertility clinics providing Artificial Reproductive Technology (ART) to collect information about utilization and outcomes of those services.[13] The data includes information on the number of clinics, the number of cycles initiated (using fresh or frozen embryos), the average number of transferred embryos per cycle (fresh or frozen) and multiple birth rates (resulting from fresh embryos) by mothers' age (below 35 years, 35-39 years and above 39 years).[14] The clinic data files are publicly available from the Center for Disease Control and Prevention (CDC).[15]

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[10]We use the birth certificate data provided by the National Bureau of Economic research (NBER). Mothers' marital status and infants' APGAR score are not reported in 1975 to 1977 data files. Also mothers' education is not reported in 2003 data file. We impute missing values in the state-year aggregated data by setting them as the average of the corresponding variable in the year before and after. For more information see: `https://www.nber.org/data/vital-statistics-natality-data.html`. [Accessed on November 13, 2018]

[11]We aggregate twins and higher-order multiple births into a single measure of multiple births since the more detailed plurality of births is not available for some years of our study.

[12]We use the CPS data from the National Bureau of Economic Research (NBER). For more information see: `https://www.nber.org/cps/`. [Accessed on November 13, 2018.]

[13]About 10% of the clinics have not reported their data.

[14]Multiple birth rates resulted from frozen embryos are not reported for some years. It would underestimate the number of multiple births, but the bias would be quite small since a relatively small share of cycles are frozen (about 20%).

[15]For more information see: `https://www.cdc.gov/art/reports/archive.html`. [Accessed on November 13, 2018]

Fourth, we use child adoption information from the National Data Archive on Child Abuse and Neglect (NDACAN) collected by The Adoption and Foster Care Analysis and Reporting System (AFCARS) from 2000 to 2014.[16] We use these data to investigate child adoption utilization as the main alternative for patients with lower chances of conceiving their own infants. The data include information on foster and adopted children as well as their adoptive and foster parents, but we use only adopted children between the ages of 0 and 5 for our analysis. The data also include information on the year and state which the adoption is finalized. For our empirical analysis we limit our study sample to 0 to 5 years adopted children and aggregate the data into state-year cells. We measure the adoption rate as the ratio of the total number of adopted children to the total number of infants born in a state-year cell (generated from the birth certificate data). Unfortunately, our adoption data does not include private adoptions (either domestic or international). However, our analyses of the effects of the insurance mandates will be affected only if the generosity of mandated IVF coverage differentially affects private adoptions versus those through the state welfare system.

5 Identification strategy

Estimating causal effects on patients' behavioural responses from the decrease in the costs of IVF treatment is not straightforward. The main issue is that the patients who use these treatments are a highly selected group among those who need the treatment. We use mandated coverage for IVF treatment in private health insurance plans as an exogenous source of variation in the accessibility of the treatment to estimate causal effects.

States mandated insurance coverage of IVF at different times. We could in principle follow the previous literature and use this state- and time-level variation to estimate the effects of the number of covered cycles on the multiple birth rate using a Difference-in-Differences (DD) framework. The estimated effects will not be interpreted as causal effects if the "parallel trend" assumption is violated. The parallel trend assumption implies that in the absence of the treatment, the multiple birth rate in the treated (more generous) and control groups (never mandated states) would have followed parallel paths over time. However, the differences in trends between states with more generous coverage and less generous coverage plotted in Figure 2 suggests that the parallel trend assumption might be violated in our context.

There are two main approaches to estimate causal effects when the common trend assumption is less likely to hold. The first approach uses a matching method to condition on pre-treatment observable characteristics (Abadie, 2005; Abadie et al., 2010, 2015). This approach helps to balance the effects of time-varying confounders between the treatment and control groups. The second approach is to explicitly model the unobserved time-varying confounders,

[16] The AFCARS is a federally mandated data collection system intended to provide case-specific information on all children covered by the Social Security Act. States are required to collect data on all children in foster care for whom the State child welfare agencies have responsibility for placement, care or supervision and on children who are adopted under the auspices of the State's public child welfare agency. The AFCARS data files are given annually to the NDACAN for distribution to the research community by the Children's Bureau. For more information see: `https://www.ndacan.cornell.edu`. [Accessed on November 13, 2018]

such as Bai (2009), who proposes an interactive fixed effect model which includes state-specific intercepts (factor loading) interacted with time-varying coefficients (latent factors). We use a Generalized Synthetic Control (GSC) framework developed by Xu (2017) to estimate causal effects of the number of covered cycles on the multiple birth rate. The GSC links the matching and interactive fixed effect methods and brings together synthetic control and interactive fixed effect models where the Difference-in-Differences model is a special case. We estimate a model of the form:

$$y_{it} = \delta_{it} D_{it} + \beta X'_{it} + \lambda'_i f_t + \epsilon_{it} \tag{2}$$

where i and t respectively denote state and time. y_{it} denotes the outcome variable in state i at year t. We use the multiple birth rate as our main outcome variable, but we also estimate the effects on the number of infants per thousand births to check the robustness of our findings. D_{it} is a dummy variable that turns on for treated state i in years following the mandated coverage enacted at time T_{i0}. We follow Schmidt (2007) and allow mandated coverage to affect multiple births with a two year delay, to account for two factors: first, infertility treatments may not lead immediately to a conception, and second, a successful conception will not translate into a birth until nine months later.

The vector X_{it} is a set of time-varying state characteristics to control for any observable differences that might confound the analysis. We include mothers' age, education, mothers' and fathers' race, infant's sex, birth weight, five minutes APGAR score as covariates. We also include state-level socioeconomic characteristics from the CPS, including the percent of women of childbearing age, the percent of college-educated women, the female labor force participation rate, the share working in large firms (more than 500 employees), the share with private health insurance, and real per capita income.

λ_i is a $(r \times 1)$ vector of state specific intercepts (factor loading). f_t is a $r \times 1$ vector of time varying coefficients (latent factors) which captures unobserved common factors. r is the estimated number of confounding factors. The factor component of the model $\lambda'_i f_t$ covers a wide range of unobserved heterogeneity where the conventional fixed effects model is a special case.[17] $\lambda'_i f_t$ absorbs all unobserved confounders that can be decomposed into a state-year multiplicative form, i.e. $U_{it} = a_i \times b_t$. It however, does not capture unobserved confounders that are independent across states. ϵ_{it} captures any remaining unobserved components that affect incidence of multiple birth.

The coefficients of interest are δ_{it}. The Average Treatment Effect on Treated (ATT) at time $t > T_{i0}$ is $\widehat{ATT}_t = \frac{1}{|Treated|} \sum_{i \in Treated} \delta_{it}$ where $Treated$ denotes treated states. We use non-parametric bootstrap of 2,000 draws to estimate standard errors.

The GSC approach estimates state-level treatment effects on each treated state semi-parametrically. More specifically, the treated counter-factual is imputed from a linear interactive fixed effect model. The number of interactive factors r, factor loadings λ_i and latent factors f_t is chosen within a cross-validation procedure which relies on the control group information

[17] For instance, for $r = 2$ if we set $\lambda'_i = (1, \alpha_i)$ and $f'_t = (\tau_t, 1)$ then $\lambda'_i f_t = \alpha_i + \tau_t$. In this case, it is reduced to a model with state and time fixed effects.

and information from the treatment group in pre-treatment periods.[18] It then imputes treated counterfactuals based on the estimated factors and factor loadings, in spirit of the weighting scheme of the original synthetic control method (Abadie et al., 2010).[19] We provide more details on the estimation strategy of a GSC model in Appendix A.

The GSC framework has several advantages relative to the original synthetic control developed by Abadie et al. (2010). First, it allows for more than one treated state with variable treatment periods. Second, making inference on the estimated effects is more reliable since the GSC framework provides estimates of the standard errors and confidence intervals.[20] Third, it provides a data-driven procedure to select the right number of factors in an interacted fixed effect model and reduces the risk of overfitting. This approach furthermore enables us to takes advantage of the long pre-treatment panel to decrease the bias of the estimated effects.

6 Results

6.1 Descriptive evidence

Table 2 presents summary statistics from all data sources used in our empirical analysis. For each data set, we divide the study period into half, and separately provide statistics for the states that never passed infertility mandates, the states that mandated to offer, and the states that mandated to cover. Panel (a) presents the summary statistics from the birth certificate data from 1975 to 2014. We divide the study period into two periods 1975-1994 and 1995-2014. After excluding observations with missing values, the total number of births is about 150 million. Mothers in more recent years are on average older, more educated, and less likely to be married. Multiple birth rates are also higher in more recent years, reflecting both the increase in infertility treatments, as well as the increase in the share of older mothers (older women are more likely to have multiple births even in the absence of infertility treatment). Multiple birth rates in states with mandated coverage of IVF are higher than both mandated to offer and never mandated states.

Panel (b) presents state-level socioeconomic characteristics from the CPS data from 1974 to 2014. Similar to the birth certificate data, we divide the study period into two periods of 1975-1994 and 1995-2014. There are not notable differences between the types of states in the share of women of childbearing age (18-49 years), but there are fewer women of childbearing age

[18]The GSC first estimates an interactive fixed effect model (Bai, 2009), using only the control states data, to get the number of latent factors r. It then estimates factor loadings for each treated state λ_i by linearly projecting pre-treatment treated outcomes onto space spanned by these factors.

[19]The original Synthetic Control method proposed by Abadie et al. (2010, 2015), matches both pre-treatment observable characteristics and outcome between a treated state and control states and constructs a "synthetic control" unit. More specifically, the synthetic control unit is a weighted combination of the control groups. The weights associated with the best pre-treatment match are chosen. The treatment effect then is the difference between the treatment and synthetic control groups at post-treatment period. To make an inference, it compares the estimated effect with the effects estimated from the placebo test where the treatment is randomly assigned to the states in the control group.

[20]The GSC estimator uses a parametric bootstrap procedure via re-sampling the residuals to obtain the standard errors of the estimated coefficients. For more details on the bootstrap procedure, see Xu (2017).

in more recent years, reflecting the ageing of the baby boom generation. Mandated states have relatively higher female labor force participation and real mean personal income.[21] Furthermore, mandated states have a higher proportion of individuals with private health insurance and working for big firms.

Figure 2 plots trends in multiple birth rates. Panel (a) plots the trend by the number of mandated covered cycles. While the multiple birth rate is increasing across all states, it is higher in the mandate to cover states than the mandate to offer and never mandated states. Panel (b) plots the trends within the mandate to cover states by year. States with more covered cycles have higher multiple birth rates. Panel (c) plots the trends within the mandate to cover states by year, relative to the timing of the mandate. The plot suggests that the mandated coverage is associated with an increase in multiple birth rates. The higher the number of the covered cycles is, the higher is the increase in multiple births. However, it is clear that some of the late-adopting states (most notably Connecticut and New Jersey) had higher rates of multiple births many years prior to the mandate. As a robustness test, we will examine each state's enactment of the mandate later in the paper.

6.2 Estimation results

Table 3 presents the estimated ATT of the number of mandated cycles on the multiple birth rate from Equation (2). Panel A presents the estimates for all mandated states. Panels B to F present the estimates by the number of covered cycles. The first column block of Table 3 presents the estimate for all mothers. Any mandated coverage of IVF is estimated to increase the multiple birth rate by 0.13 percentage point (from a mean value of 1.18%) relative to the never mandated states, or approximately an 11% increase. Column 2 adds covariates to the model, reducing the magnitude of the estimated effects to a 0.07 percentage point increase (or a 6% increase) in the multiple birth rate. Results in Panels B through F show that when broken out by the number of covered cycles, more covered cycles lead to a larger increase in multiple birth rates. Estimated effects with covariates range from a 0.08 percentage point increase (7%) in states with one covered cycle to a 0.28 percentage point increase (23%) in states with +5 covered cycles. Figure 4 plots the treated average and the estimated average for the treated states and the estimated ATT. The figure suggests that the GSC estimator works quite well in imputing treated counterfactuals to match the control group in the pre-treatment period.

Certain demographics of women are more likely to use IVF treatment, and therefore are more likely to be affected by the mandated coverage. It is known that women's age is strongly related to their fertility. As illustrated in Figure 3, the multiple birth rate increases with mothers' age, and this pattern is even stronger in recent decades. The age of 35 is known to be a turning point in women's fertility where one third of women above 35 years experience fertility problems (CDC, 2015a). Therefore women above 35 years are more likely to be affected by mandated coverage. The second column block of Table 3 presents the estimated effects for

[21]Dollar values are converted to 2007 dollars using the Consumer Price Index obtained from the Correlates of State Policy data set available from `http://ippsr.msu.edu/public-policy/correlates-state-policy`.

women aged 35 years and older. The estimated effects are much higher than those estimated for all mothers. The overall estimated effect of mandated coverage after including covariates is a 0.19 percentage point increase in the multiple birth rate (from mean 1.61%), or an increase in the multiple birth rate of about 12%. The estimated effects by the number of covered cycles range from a 0.24 percentage point decrease (14%) for states with one covered cycle to a 0.56 percentage point increase (33%) in states with +5 covered cycles.

The effects of mandated coverage might also vary by mothers' education, marital status and race. College educated women face incentives to postpone childbearing and invest in their professional careers, and are also more likely to work in jobs that offer private health insurance. Married women struggling with fertility seek infertility treatment and especially IVF more often than unmarried women, and some mandated coverage explicitly excludes unmarried women. Although white women are less likely to struggle with fertility, they are more likely to seek infertility treatments (Bitler and Schmidt, 2006). Results for college educated mothers, married mothers, and white mothers are presented in Columns 5 through 10 of Table 3. The findings for these groups is consistent with the earlier results, and effect sizes are larger for these subgroups than for the sample of all women.

The estimated effects for states with 2 (Connecticut) and +5 (Massachusetts) covered cycles are already in state level. We also estimate the effects of the mandated coverage on state levels for the other states with mandated coverage (Arkansas, Hawaii, Maryland, Rhode Island, New Jersey and Illinois). The estimated effects are quite similar to those aggregated by the number of covered cycles.[22]

Our estimates from the GSC model show that mandated coverage causes an increase in multiple birth rates, and that more covered cycles leads to larger estimated effects. This finding is consistent with our conceptual framework presented in Section 3. This finding is quite robust across different demographic groups which are more likely to use the treatment and therefore are more likely to be affected by the mandated coverage.[23]

6.3 Robustness analysis

6.3.1 Number of infants per thousand births

To investigate the robustness of our findings, we also estimate the effects of the number of covered cycles on the number of infants per thousand births. While the multiple birth rate simply tells us whether the birth was greater than singleton, this alternative outcome variable allows, for example, triplets to count more than twins. Figure C.1 plots the trends in the number of infants per thousand births, and shows that there are more infants per thousand births in states with more covered cycles. Table C.1 presents the estimated effects of the mandated coverage on the number of infants per thousand births. The overall findings are consistent with

[22]The estimations are available upon request.

[23]The estimated effects of mandated coverage on multiple births from a Difference-in-Differences (DD) framework are presented in Appendix B for comparison purposes. Table B.1 presents the estimated effects on multiple birth rate. The same general finding from the GSC model holds, but we think our GSC results are preferable, due to concerns about the parallel trend assumption for states with different numbers of covered cycles.

those from the multiple birth rate. The overall estimated effect of the mandated coverage after controlling for covariates is 7.45 percent increase in the number of "extra" infants per thousand births. The estimated effects by the number of covered cycles after including covariates range from 7.45 percent in states with one covered cycle to 23.83 percent in states with +5 covered cycles.

We also estimate the effects for mothers older than 35 years, college educated, married and white mothers. The estimated effects after including covariates are the largest for older mothers ranging from -18.85 percent in states with once covered cycle to 36.75 percent increase in the number of "extra" infants per thousand births. These estimates are relatively larger than those from multiple birth rates (respectively 14% and 33%), suggesting larger effects on higher order births for older mothers.

6.3.2 Difference-in-Difference-in-Differences analysis

To further investigate the robustness of our findings from GSC framework, we estimate the effects of the mandated coverage on multiple birth rates using a Difference-in-Differences-in-Differences (DDD) framework. Table 3 shows that the estimated effects of mandated coverage on the multiple birth rate are higher for women older than 35. In our DDD analysis we further refine the treatment group by mothers' age. We use variation in mandated coverage over state, year and mothers' age (below and above 35 years old). We estimate the following equation:

$$\begin{aligned} MultiBirth_{ita} = &\alpha_0 + \alpha_1(Cover_{it} \times Plus35_a \times Post_{it}) + \alpha_2(Cover_{it} \times Plus35_a) \\ &+ \alpha_3(Post_{it} \times Plus35_a) + \alpha_4(Cover_{it} \times Post_{it}) + \alpha_5 X'_{ita} \\ &+ \lambda_i + \lambda_t + \lambda_a + \epsilon_{ita} \end{aligned} \tag{3}$$

where i, t and a denote respectively state, time and mothers' age. $MultiBirth_{ita}$ denotes the multiple birth rate at state i, year t and age a cell. $Cover_{it}$ includes indicators that denote the number of covered cycles in mandated to cover states. It is set to zero for the never mandated states. $Plus35_a$ is a dummy variable which switches on for the cells with mothers above 35 years. $Post_{it}$ is another dummy variable switching on two years after the mandated coverage is enacted.[24] It is set to zero for never mandated states. The vector X_{ita} includes the same set of age and time-varying covariates used in the GSC analysis. λ_i, λ_t and λ_a are respectively state, time and age fixed effects. ϵ_{ita} captures any remaining unobserved factors affecting the multiple birth rate. The coefficient of interest is α_1 which captures the effect of the number of covered cycles on mothers of 35 years and older in mandated states relative to mothers younger than 35 years. The DDD analysis allows us to control for two kinds of potentially confounding trends. First, it controls for any time trends in the multiple birth rate for women of a particular age that are constant across states. Second, it controls for differences across states in the multiple birth rate that affect all mothers, possibly due to other state policies or state-level economic conditions that might affect women's fertility decisions. Data are aggregated into state-year-age

[24] The mandated coverage might not affect multiple birth rate in the year it is enacted, but can have effects with a two years lag.

cells.

Table 4 presents the estimated effects from our DDD model. To quantify the overall effect of the mandated coverage on multiple birth rate, we estimate a modified version of the model specified in (3). We define $Cover_{it}$ as a dummy switching on for mandated to cover states and zero for never mandated states. These estimates are presented in the first column. The multiple birth rate for mothers above 35 years in mandated states is 0.16 percentage point higher than that for mothers below 35 years old. The estimated effect after including covariates increases to 0.28. However, these estimates are not significant at conventional levels.

The third column presents the estimated effects from the number of covered cycles. The estimated effects range from a 1.45 percentage point decrease in the multiple birth rate in states with one covered cycle to a 2.61 percentage point increase in states with +5 covered cycles. The estimates suggest that in states with more covered cycles women above 35 years have more multiple births compared to women below 35 years. Column 4 shows that this finding is robust to including covariates.

Similar to our GSC model, we also estimate the model for college-educated, married and white mothers. The estimated effects are higher in states with more covered cycles where the effects are the highest for married mothers among the others. The estimated effects for married mothers after including covariates range from -1.10 percentage point in states with covered cycles to 1.97 percentage point increase in multiple birth rate in states with +5 covered cycles.

We also estimate the DDD model using the number of infants per thousand births. The estimated effects are presented in Table C.2. These findings are consistent with those using the multiple birth rate as the dependent variable. The more cycles are covered, the larger the effect on infants per thousand births to mothers 35 years and older compared to the younger mothers, and these differential effects are even larger among married mothers. Overall, our DDD findings are very consistent with our findings from the GSC model.

7 Extensive margin effects

How would more covered cycles translate into an increase in multiple births? Patients with more covered cycles in their health insurance plans face less pressure to conceive in fewer cycles, and as discussed above, they might decide to transfer fewer embryos in a given cycle. If mandated coverage has only intensive margin effects on patients' utilization behaviour, then we would expect more covered cycles to result in a decrease in multiple birth rates. However, since patients face fixed costs to initiate IVF treatment, then the mandated coverage might also have extensive margin effects, as more women might choose to initiate treatment. These effects could be amplified if the new patients have lower probabilities of success, and compensate for their lower fertility by transferring more embryos, resulting in more multiple births.

To investigate the extensive margin effects of the mandates coverage of IVF treatment on multiple birth rate, we use two additional data sets. First, we investigate patients' utilization behaviour using fertility clinic-level data. Second, we investigate child adoption as the main alternative to a live birth.

7.1 Evidence from IVF clinics

We use SART's clinic-level data from 1995 to 2015 to study patients' utilization behaviour and investigate whether the mandated coverage has extensive margin effects on IVF utilization. Panel (c) of Table 2 presents summary statistics for these data. We divide the study sample into 1995-2005 and 2006-2015 periods. There is an increase in the average number of clinics over time. Mandated to offer states have more clinics than the others in both periods. More than 5.6 million IVF cycles are initiated in the US during our study period, the majority of them to women over 35 years. However, these rates are higher and increasing over time in mandated to cover states compared to the never mandated states. Although there is a decreasing trend in the average number of transferred embryos and subsequently multiple birth rates for women above 35 years, the average number of transferred embryos and multiple birth rates are relatively higher in mandated to cover states. Figure 5 plots the trends in the number of cycles performed for women above 35 years and the average per cycle number of transferred embryos for women above 35 years.

To investigate the effects of the number of covered cycles on patient's utilization behaviour we estimate a Fixed Effects (FE) model specified as:

$$y_{it} = \beta_0 + \beta_1 Cover_{it} + \beta_3 X'_{it} + \lambda_t + \epsilon_{it} \tag{4}$$

where i and t respectively denote states and time. y_{it} denotes the outcome variable in state i at year t. $Cover_{it}$ is an indicator for the number of covered cycles in state i at year t. It is set to zero for never mandated states. The vector X_{it} is a set of time-varying state characteristics from the CPS described in our previous analyses. λ_t denotes the time fixed effects. ϵ_{it} captures any remaining unobserved factors affecting the outcome variable. The coefficient of interest is β_1 which captures the effects of the number of covered cycles on the outcome variable. We use the log(number of cycles), the average number of transferred embryos per cycle, and the multiple birth rate as outcome variables. It is important to note that the mandated mandated coverage date in many states falls before the availability of SART's data, meaning we are unable to perform a GSC or DDD analysis. This means that these results should be taken as suggestive evidence, and do not cleanly establish causal effects.

Our study sample includes all women who received IVF treatment between 1995 to 2015, and data are aggregated into state-year cells. The estimated effects are presented in Table 5. Panel (a) presents the estimated effects for women above 35 years old. The number of cycles performed for women above 35 years is higher in states with more covered cycles. The average number of embryos transferred per cycle for women above 35 years is also higher in states with more covered cycles, and as a result multiple birth rates are also higher. These findings are also robust to including state level characteristics. Estimates for all mandates to cover find similar effects.

Panel (b) presents the estimated effects for women younger than 35 years old. The number of cycles is again higher in states with more covered cycles, but effect sizes are much smaller than those estimated for older women. But importantly, a greater number of covered cycles is associated with a significant decrease in the number of embryos transferred per cycle, and a corresponding decrease in multiple births, showing clear evidence of intensive margin effects.

7.2 Evidence from child adoption

Individuals who are not able to naturally conceive an infant have two alternative pathways: using IVF treatment or adopting a child. More than half of the individuals who received infertility treatment also considered adoption (Chandra et al., 2005). Gumus and Lee (2012) show that one-third of individuals who consider adoption have also sought IVF treatment. Either of these choices has pros and cons. Despite technological advances, IVF treatment is still expensive and has a low probability of success. Adopting a child is also expensive and can be a long process. Furthermore, many individuals might prefer to have their own biological child. If the number of covered cycles is inducing more women over 35 to initiative IVF, we would expect that effect to be accompanied by a decrease in adoptions.

Previous work has looked at the relationship between IVF treatment and adoption. Gumus and Lee (2012) investigate effects of child adoption on IVF utilization. They find that a 10% increase in adoption leads to a 1.3%-1.5% decrease in the number of IVF cycles performed. Cohen and Chen (2010) find that mandated coverage for infertility treatment did not result in any change in child adoption in mandated states relative to never mandated states. However, the effects of the mandated coverage on adoption could be quite heterogeneous depending on the number of covered cycles and age of the adoptive mothers.

To quantify the effects on adoption from the number of the covered cycles we estimate a Fixed Effects model similar to that specified in (4). The outcome variable measuring the adoption rate is defined as the log(Number of adopted children ages 0-5/Number of newborn infants). We use NDACAN's adoption data from 2000 to 2014 for our analysis.

Panel (d) of Table 2 presents summary statistics for these data. We divide the study period into 2000-2006 and 2007-2014. During our study period, the adoption of more than 777 thousand children is finalized. The adoption rate is relatively higher in never mandated and mandate to offer states compared with mandated to cover states. More than 80 percent of the adoptive mothers are above 35 years old. Figure 6 plots the trend in the adoption rate of 0-5 years old children by women above 35 years by the number of covered cycles. The figure suggests that more covered cycles are associated with lower adoption rates.

For our estimation, we limit our sample to 0-5 years old children. We aggregate the adoption data into state-year cells and merge the state-specific data from the CPS. Table 6 presents the estimated effects from the Fixed Effects model specified in (4). Panel (a) presents the estimated effects for adoptive women above 35 years old. The estimated effects suggest that more covered cycles are associated with fewer adoptions of young children. These findings are robust to including state-specific characteristics.

Panel (b) presents the estimated effects for adoptive women below 35 years old. The estimated effects suggest a much weaker association between the number of covered cycles and adoption rate compared to the estimated effects for women above 35 years.

8 Conclusion and policy implications

How do increases in the accessibility of expensive medical treatments affect patients' utilization behaviour, and what are the resulting effects on healthcare costs? More generous coverage of IVF has been proposed as a way to induce patients to pursue less aggressive treatment by transferring fewer embryos per cycle. However, we show that coverage of more cycles is significantly associated with an increase in multiple births. Our findings from the clinic level data suggest that the overall increase in the multiple birth rate masks a reduction in embryos transferred for younger patients and an increase in embryos transferred for patients over the age of 35. This finding suggests that more generous coverage has intensive margin effects for the younger patients, but sizeable extensive margin effects for older patients with lower probabilities of success. Our analysis of adoption data mirrors these findings, as women over 35 in states with more generous coverage show a significant reduction in adoptions. Our analysis highlights the importance of extensive margin responses to increasing accessibility of expensive medical treatment through insurance coverage. Insurance coverage might decrease the aggressiveness of the treatment, but it also provides incentives to marginal patients to initiate the treatments, contributing to increases in health care costs.

As a result of these extensive margin effects, increased accessibility to expensive medical treatments without regulating the aggressiveness of treatment could impose additional burdens on the healthcare system, both in terms of costs, and in terms of adverse health outcomes. Our results are consistent with suggestions by **?** (in the context of IVF) and Einav et al. (2016) (in the context of breast cancer treatment) for either limiting the aggressiveness of the treatment or imposing a "top-up" price for more expensive treatments or a combination of both as a "value-based" policy (in the context of IVF). A top-up design internalizes the costs associated with the more expensive treatment option where insurance plans cover the cost of a baseline treatment and patients could choose to pay the incremental cost of more expensive treatment. In a value-base policy, insurance plans cover single embryo cycles but patients must pay a to-up cost for the transferring additional embryos.

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Tables

Table 1: *in vitro* Fertilization (IVF) coverage in employer provided health insurance plans

State	**Year**	**IVF coverage**		**Notes**
		Mandated to offer	Mandated cover	
Arkansas	1987		1 cycle	Lifetime $15,000 cap, min 2 years of infertility
Massachusetts	1987		No limit	No limit on the cycles or dollar lifetime cap, min one year of infertility if age ≤35 and 6 month if age >35
Montana	1987	x		
Texas	1987	x		
California	1989	x		Min 1 year of infertility
Hawaii	1989		1 cycle	Min 5 years of infertility
Rhode Island	1989		3 cycles	24-40 years old, $100,000 cap, insurer may impose up to a 20% co-payment, min 2 years of infertility
New York	1990	x		IVF excluded, 21-44 years old, must have the insurance policy at least one year before use, min 1 year of infertility if age ≤35 and min 6 month if age > 35
Illinois	1991		4 cycles	Up to 4 egg retrievals, if a live birth occurs two additional egg retrievals covered for lifetime max of 6 retrievals, min 1 year of infertility
Ohio	1991	x		IVF excluded
West Virginia	1995	x		Mandated to offer, excluded IVF since 1995
Maryland	1985		3 cycles	3 cycles per live birth with a lifetime $100,000 cap
Louisiana	2001	x		IVF excluded
New Jersey	2001		4 cycles	Min 2 years of infertility if age ≤ 35 and min 1 year of infertility if age > 35
Connecticut	2005		2 cycles	Mandated to offer since 1989, must be under 40 years with min 1 year of infertility, no more than 2 embryo implementation per cycle

Note: This table presents the mandated level of IVF coverage in private health insurance plans in the US. The "mandated to cover" states mandate private health insurance companies to cover IVF treatment in all their plans. The "mandated to offer" states require health insurance companies to offer plans that cover IVF but not requiring that all policies sold include this coverage. The rest of the states are "never mandated", with no mandate to require health insurance companies to cover IVF. [Source: RESOLVE: The National Infertility Association `http://www.resolve.org/family-building-options/insurance_coverage/state-coverage.html` [Accessed on June 15, 2017].]

Table 2: Summary statistics

(a) Natality detail files

	1975-1994			*1995-2014*		
	Never mandated	Mandated to offer	Mandated to cover	Never mandated	Mandated to offer	Mandated to cover
Multiple birth (%)	1.08	1.07	1.14	1.59	1.56	1.92
	(10.32)	(10.27)	(10.60)	(12.51)	(12.41)	(13.71)
Twin birth (%)	1.06	1.05	1.11	1.54	1.51	1.85
	(10.23)	(10.18)	(10.49)	(12.32)	(12.41)	(13.46)
Triplet or higher birth (%)	0.02	0.02	0.02	0.05	0.05	0.07
	(1.36)	(1.34)	(1.58)	(2.21)	(2.23)	(2.66)
Number of infants per thousand births	1,010.77	1,010.81	1,011.15	1,016.24	1,016.18	1,019.09
	(1.45)	(1.26)	(1.76)	(2.10)	(2.10)	(3.63)
Mean mother age	25.45	25.84	26.31	27.09	27.48	28.40
	(5.49)	(5.65)	(5.62)	(6.01)	(6.23)	(6.18)
Mothers above 35 years (%)	6.16	7.52	8.01	12.31	14.58	17.31
	(24.5)	(26.38)	(27.14)	(32.86)	(35.29)	(37.83)
Married mothers (%)	76.70	74.04	74.74	63.21	62.33	64.91
	(42.27)	(43.84)	(43.45)	(48.22)	(48.46)	(47.72)
Mothers with some college or higher degree (%)	38.79	59.47	42.53	63.64	55.50	76.02
	(48.73)	(49.09)	(49.43)	(48.22)	(49.70)	(42.76)
White mothers (%)	80.82	80.54	76.76	78.41	78.90	73.24
	(39.37)	(39.59)	(42.24)	(41.14)	(40.80)	(44.27)
First born infants (%)	34.66	36.22	34.91	32.82	33.55	31.77
	(47.59)	(48.06)	(47.67)	(46.95)	(47.21)	(46.56)
Mean birth weight of infants (KG)	3.36	3.35	3.35	3.31	3.31	3.32
	(0.66)	(0.64)	(0.65)	(0.63)	(0.60)	(0.64)
Number of births	37,086,355	25,581,835	10,783,230	41,149,716	27,553,999	10,766,541

Note: This table presents summary statistics from birth certificate data from the National Center for Health Statistics' Natality Detail Files. The sample includes infant records from all births in 51 states of the US between 1974 and 2014. The "Mandated to offer" states include Montana, Texas, California, New York, Ohio, West Virginia and Louisiana. The "Mandated to cover" states are Arkansas, Hawaii, Connecticut, Rhode Island, Maryland, Illinois and New Jersey and Massachusetts. The rest of the states are grouped as "Never mandated". The weights constructed as described in Section 4 are used to calculate statistics in this table. Standard deviations are presented in parentheses.

(b) Current Population Survey (CPS)

	1975-1994			*1995-2014*		
	Never mandated	Mandated to offer	Mandated to cover	Never mandated	Mandated to offer	Mandated to cover
Women of child bearing age (18-49 years) (%)	39.14	39.05	38.63	36.58	36.69	36.60
	(1.47)	(1.50)	(1.28)	(2.36)	(2.49)	(2.02)
Female labor force participation rate (%)	65.71	60.03	66.59	73.44	68.29	73.51
	(6.46)	(7.45)	(5.72)	(4.80)	(4.51)	(3.14)
Employee in firms of of +500 employee (%)	15.78	14.58	17.22	15.20	14.17	15.83
	(2.36)	(1.84)	(2.70)	(2.59)	(1.90)	(2.65)
Private insurance(%)	76.83	72.56	80.32	72.81	67.18	75.09
	(5.76)	(4.94)	(5.89)	(6.08)	(4.68)	(4.98)
Real average per capita income (2007$)	26,626	27,339	27,647	34,913	35,114	36,678
	(3,862)	(3,208)	(3,968)	(3,336)	(3,164)	(4,816)

Note: This table presents summary statistics of the state level socioeconomic characteristics from the Current Population Survey (CPS) from 1974 to 2014. The sample includes working age individuals (18 to 64 years). Standard deviations are presented in parentheses.

(c) Society for Assisted Reproductive Technologies (SART) clinic data

	1995-2005			*2006-2015*		
	Never mandated	Mandated to offer	Mandated to cover	Never mandated	Mandated to offer	Mandated to cover
Average number of clinics	5.01	17.23	8.14	8.15	22.45	9.65
	(5.30)	(17.48)	(7.64)	(5.79)	(22.40)	(8.83)
Cycles for women above 35 years (%)	45.53	51.01	53.65	46.52	50.83	57.12
	(7.70)	(8.07)	(8.81)	(8.92)	(11.25)	(7.68)
Average number of embryos for women above 35 years	1.73	2.50	2.88	0.66	0.99	1.74
	(1.19)	(1.14)	(0.67)	(0.83)	(0.89)	(0.58)
Multiple birth rate for women above 35 years (%)	13.33	15.40	20.24	3.37	4.74	10.83
	(9.76)	(8.72)	(6.87)	(6.35)	(6.36)	(9.85)
Total number of cycles	333,289	293,761	275,764	468,497	490,557	3,771,656

Note: This table presents the summary statistics from the IVF clinics in the US from the Center for Disease Control and Prevention (CDC). The data are at the clinic level and include all the IVF cycles performed between 1995 and 2015 in 51 states in the US. Standard deviations are presented in parentheses.

(d) National Data Archive on Child Abuse and Neglect (NDACAN) adoption data

	2000-2006			*2007-2014*		
	Never mandated	Mandated to offer	Mandated to cover	Never mandated	Mandated to offer	Mandated to cover
Log(Number of adopted children/	1.35	1.46	1.18	1.62	1.60	1.23
Number of new born infants)	(0.49)	(0.40)	(0.45)	(0.46)	(0.65)	(0.52)
Number of adopted children	90,910	62,368	24,995	137,697	76,682	26,186
Number of new born infants	14,845,748	9,927,909	3,938,724	17,101,656	11,177,601	4,241,417
Mean age of adopted children (year)	2.75	2.72	2.87	2.64	2.64	2.71
	(1.46)	(1.45)	(1.40)	(1.44)	(1.42)	(1.42)
White adopted children (%)	48.08	31.57	29.40	51.72	30.12	40.35
	(49.96)	(46.48)	(45.56)	(49.97)	(45.88)	(49.06)
Adopted boys (%)	51.30	51.64	50.80	51.58	51.69	51.47
	(49.98)	(49.97)	(49.99)	(49.97)	(49.97)	(49.98)
Mean age of adoptive mothers	40.78	42.76	41.76	41.33	42.14	41.99
	(6.99)	(6.83)	(6.90)	(7.12)	(7.00)	(6.97)
Adoptive mothers above 35 years(%)	78.81	84.75	82.72	79.66	82.30	82.79
	(40.86)	(35.95)	(37.80)	(40.25)	(38.17)	(37.75)
White adoptive mothers (%)	67.63	43.47	45.02	69.52	47.96	54.88
	(46.79)	(49.57)	(49.75)	(46.03)	(49.96)	(49.76)
Mean age of adoptive fathers	42.96	44.50	44.47	43.52	44.09	44.52
	(6.83)	(6.18)	(6.29)	(6.66)	(6.45)	(6.27)
White adoptive father (%)	59.20	37.73	38.27	59.71	40.73	45.56
	(49.15)	(48.47)	(48.60)	(49.05)	(49.13)	(49.80)

Note: This table presents summary statistics from adoption date from the National Data Archive on Child Abuse and Neglect (NDACAN). The data includes information on 0 to 5 years old children adopted in 51 states in the US from 2000 to 2014. The adoption rate is defined as the ratio of the total number of adopted children to the total number of births. Standard deviations are presented in parentheses.

Table 3: Estimated Average Treatment Effect on Treated (ATT) of number of cycles on the multiple birth rate from Generalized Synthetic Control model

Sample	*All mothers*		*+35 years mothers*		*+College mothers*		*Married mothers*		*White mothers*	
		Covars		Covars		Covars		Covars		Covars
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
***A.** All mandated states (Number of cells: 1,720)*										
ATT	0.13***	0.07**	0.24**	0.19**	0.11***	0.13***	0.22***	0.10***	0.16***	0.10***
	(0.01)	(0.02)	(0.11)	(0.08)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Mean	1.18		1.61		1.28		1.28		1.18	
	(0.34)		(0.64)		(0.41)		(0.46)		(0.38)	
***B.** 1 covered cycle (Number of cells: 1,110)*										
ATT	-0.11*	0.08	-0.32*	-0.24	-13*	-0.04	-0.13*	-0.06	-10*	-0.07
	(0.06)	(0.04)	(0.15)	(0.16)	(0.07)	(0.04)	(0.07)	(0.03)	(0.03)	(0.04)
Mean	1.19		1.66		1.02		1.28		1.18	
	(0.25)		(0.54)		(0.15)		(0.31)		(0.26)	
***C.** 2 covered cycles Number of cells: 900)*										
ATT	0.16	0.16	0.23	0.15	-0.38	0.18	0.40	0.29	0.05	0.01
	(0.11)	(0.13)	(0.27)	(0.27)	(0.25)	(0.14)	(0.24)	(0.18)	(0.13)	(0.15)
Mean	1.50		2.25		1.60		1.65		1.50	
	(0.23)		(0.51)		(0.52)		(0.30)		(0.24)	
***D.** 3 covered cycles Number of cells: 1,036)*										
ATT	0.17***	0.09*	0.52***	0.52***	0.20***	0.11*	0.24***	0.12**	0.22***	0.07**
	(0.01)	(0.03)	(0.13)	(0.13)	(0.07)	(0.05)	(0.07)	(0.05)	(0.01)	(0.02)
Mean	1.16		1.61		1.29		1.24		1.14	
	(0.22)		(0.51)		(0.30)		(0.28)		(0.24)	
***E.** 4 covered cycles Number of cells: 1,443)*										
ATT	0.14***	0.17***	0.40**	0.31**	0.19***	0.17***	0.29***	0.19***	0.16***	0.12***
	(0.03)	(0.03)	(0.17)	(0.16)	(0.02)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)
Mean	1.32		1.90		1.45		1.44		1.31	
	(0.30)		(0.63)		(0.36)		(0.38)		(0.31)	
***F.** +5 covered cycles (Number of cells: 1,080)*										
ATT	0.55**	0.28*	0.90**	0.56**	0.43**	0.40**	0.59**	0.54**	0.47*	0.41**
	(0.19)	(0.17)	(0.35)	(0.34)	(0.17)	(0.18)	(0.27)	(0.23)	(0.25)	(0.18)
Mean	1.19		1.67		1.31		1.29		1.18	
	(0.25)		(0.54)		(0.31)		(0.31)		(0.26)	

Note: This table presents results from the GSC model specified in Equation (2). Study study sample includes all the births in the US from 1974-2014, aggregated into state-year cells. The control group for each model includes all the never mandated states. The included covariates in the model are mothers' age, education and mothers' and fathers' race and infant's sex, birth weight, five minutes APGAR score, the percent of women of childbearing age, the percent of college-educated women, the female labor force participation rate, the percent of employees working in big firms (employee > 500), the percent with private health insurance. and real per capita income. r denotes the estimated number of factors in the model. Bootstrapped standard errors estimated by 2,000 draws are presented in parentheses.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 4: Estimated effects of the number of covered cycles on the multiple birth rate from a Difference-in-Difference-in-Differences model

	All mothers				*+College mothers*				*Married mothers*				*White mothers*			
	All mandated		By coverage		All mandated		By coverage		All mandated		By coverage		All mandated		By coverage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1 to +5 cycles x Plus 35 x Post	0.16	0.28			0.06	-0.06			0.17	0.27			0.39	0.33		
	(0.64)	(0.47)			(0.69)	(0.54)			(0.70)	(0.51)			(0.66)	(0.49)		
1 cycle x Plus 35 x Post			-1.45***	-1.06**			-1.89***	-1.61***			-1.25**	-1.10*			-1.49***	-1.05**
			(0.32)	(0.41)			(0.22)	(0.20)			(0.49)	(0.59)			(0.27)	(0.40)
2 cycles x Plus 35 x Post			-1.38***	0.41			-1.40***	-0.64***			-1.60***	0.05			-1.24***	0.46
			(0.16)	(0.26)			(0.20)	(0.22)			(0.18)	(0.27)			(0.18)	(0.29)
3 cycles x Plus 35 x Post			0.87**	0.20			0.60	0.05			0.93***	0.36			1.07**	0.29
			(0.35)	(0.30)			(0.56)	(0.52)			(0.18)	(0.23)			(0.43)	(0.42)
4 cycles x Plus 35 x Post			1.42***	1.73***			1.48***	1.70***			1.38***	1.72***			1.77***	1.93***
			(0.20)	(0.54)			(0.19)	(0.16)			(0.19)	(0.39)			(0.18)	(0.45)
+5 cycles x Plus 35 x Post			2.61***	1.79***			2.76***	0.87**			3.20***	1.97***			2.76***	1.51***
			(0.17)	(0.21)			(0.20)	(0.34)			(0.18)	(0.21)			(0.19)	(0.20)
Constant	0.44***	47.82***	0.41***	49.18***	0.33***	24.19***	0.31***	24.84***	0.49***	36.19***	0.45***	37.64***	0.42***	37.74***	0.39***	37.91***
	(0.05)	(11.91)	(0.05)	(12.03)	(0.12)	(3.24)	(0.11)	(3.12)	(0.10)	(6.31)	(0.09)	(6.27)	(0.05)	(3.93)	(0.05)	(3.91)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of cells	56,848	49,755	56,848	49,755	51,393	51,393	513,93	51,393	52,236	49,497	52,236	49,497	56,417	49,402	56,417	49,402

Note: This table presents results from the DDD model specified in (3). Study sample includes all the births in the US from 1975-2014, within 15 years of the mandated coverage in each state. The data is aggregated by state-year-age. The control group for each model includes all the states which never mandated IVF coverage. All models include state, year and age fixed effects. Included covariates listed in notes for Table 3. Robust standard errors presented in parentheses are clustered in state level.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 5: Effects of the number of covered cycles on the number of cycles, embryos and multiple birth rate

(a) Women above 35 years old

	Log(number of cycles)				*Number of transferred embryos*				*Multiple birth rate (%)*			
	All mandated		By coverage		All mandated		By coverage		All mandated		By coverage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1 to +5 covered cycles	0.33**	1.24***			1.79***	0.59**			17.08***	8.93		
	(0.14)	(0.17)			(0.16)	(0.28)			(4.44)	(5.60)		
1 covered cycle			0.22	0.60***			1.48***	1.18***			7.89*	10.14**
			(0.14)	(0.15)			(0.20)	(0.24)			(4.52)	(5.13)
2 covered cycles			1.54***	1.41***			1.25***	1.53***			11.49***	9.38*
			(0.14)	(0.17)			(0.15)	(0.29)			(4.32)	(5.32)
3 covered cycles			0.33**	1.24***			1.79***	0.59**			17.08***	8.93
			(0.14)	(0.17)			(0.16)	(0.28)			(4.44)	(5.60)
4 covered cycles			2.56***	1.86***			1.02***	1.94***			9.91**	11.79**
			(0.13)	(0.16)			(0.12)	(0.33)			(4.25)	(5.84)
+5 covered cycles			2.87***	2.67***			1.46***	1.64***			11.54***	11.18**
			(0.13)	(0.15)			(0.14)	(0.25)			(4.30)	(5.05)
Constant	5.03***	4.26***	5.03***	4.26***	2.43***	3.45**	2.43***	3.45**	-0.68	10.86	-0.68	10.86
	(0.14)	(0.61)	(0.14)	(0.61)	(0.18)	(1.56)	(0.18)	(1.56)	(4.37)	(19.89)	(4.37)	(19.89)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of cells	574	574	574	574	574	574	574	574	574	574	574	574

(b) Women below 35 years old

	Log(number of cycles)				*Number of transferred embryos*				*Multiple birth rate (%)*			
	All mandated		By coverage		All mandated		By coverage		All mandated		By coverage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1 to +5 covered cycles	-0.20*	0.55***			-0.18***	-0.40***			-0.98	-2.63		
	(0.10)	(0.13)			(0.07)	(0.15)			(1.40)	(2.78)		
1 covered cycle			-0.85***	-0.50***			0.24**	0.18			3.01*	2.24
			(0.06)	(0.09)			(0.10)	(0.13)			(1.58)	(2.18)
2 covered cycles			0.78***	0.59***			-0.04	0.10			-0.04	2.18
			(0.07)	(0.09)			(0.07)	(0.12)			(1.15)	(2.18)
3 covered cycles			-0.20*	0.55***			-0.18***	-0.40***			-0.98	-2.63
			(0.10)	(0.13)			(0.07)	(0.15)			(1.40)	(2.78)
4 covered cycles			1.93***	1.52***			-0.18***	-0.14			0.58	2.05
			(0.05)	(0.10)			(0.06)	(0.26)			(1.04)	(2.11)
+5 covered cycles			2.14***	1.90***			-0.41***	-0.35***			-3.10***	-0.99
			(0.06)	(0.07)			(0.06)	(0.10)			(0.98)	(1.60)
Constant	5.32***	3.64***	5.32***	3.64***	3.68***	3.86***	3.68***	3.86***	8.72***	5.83	8.72***	5.83
	(0.07)	(0.47)	(0.07)	(0.47)	(0.12)	(0.49)	(0.12)	(0.49)	(1.08)	(11.98)	(1.08)	(11.98)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of cells	791	791	791	791	791	791	791	791	791	791	791	791

Note: This table presents effects of the number of covered of cycles on the log(number of cycles), the number of transferred embryos per cycle, and the multiple birth rate from the Fixed Effects model specified in (4). The study sample includes women who have received IVF treatment in a clinic in the US in 1995-2014 from SART's IVF clinic data. The data is collapsed into state-year cells. All estimates include year fixed effects. The included covariates include the CPS variables listed in the Notes for Table 3, as well as the number of clinics.Robust standard errors presented in parentheses.
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 6: Estimated effects of mandated IVF coverage on adoption

(a) Women above 35 years old

	All mandated		By coverage	
	(1)	(2)	(3)	(4)
1 to +5 covered cycles	0.27	0.57***		
	(0.23)	(0.11)		
1 covered cycle			-0.23	-0.17
			(0.23)	(0.12)
2 covered cycles			-0.08	-0.14**
			(0.21)	(0.06)
3 covered cycles			0.27	0.57***
			(0.23)	(0.11)
4 covered cycles			-0.46**	-0.09
			(0.22)	(0.12)
+5 covered cycles			-0.42*	-0.49***
			(0.22)	(0.06)
Constant	-2.49***	-5.50***	-2.49***	-5.50***
	(0.18)	(0.52)	(0.18)	(0.52)
Time fixed effects	Yes	Yes	Yes	Yes
Covars	No	Yes	No	Yes
Number of cells	9,437	9,437	9,437	9,437

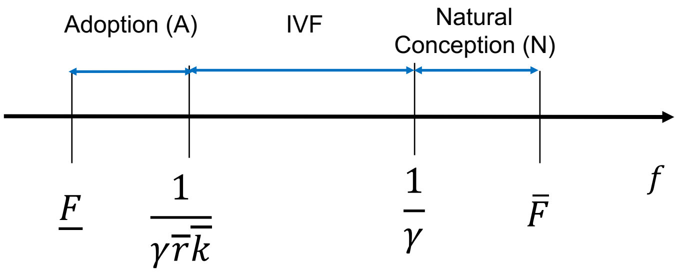
(b) Women below 35 years old

	All mandated		By coverage	
	(1)	(2)	(3)	(4)
1 to +5 covered cycles	0.96***	0.96***		
	(0.10)	(0.10)		
1 covered cycle			0.80***	1.09***
			(0.10)	(0.11)
2 covered cycles			0.58***	0.74***
			(0.10)	(0.08)
3 covered cycles			0.96***	1.05***
			(0.10)	(0.13)
4 covered cycles			0.05	0.69***
			(0.10)	(0.16)
+5 covered cycles			-0.03	-0.00
			(0.10)	(0.07)
Constant	-6.75***	-6.75***	-6.75***	-7.26***
	(0.09)	(0.09)	(0.09)	(0.59)
Time fixed effects	Yes	Yes	Yes	
Covars	No	No	Yes	
Number of cells	7,562	7,562	7,562	7,421

Note: This table presents the estimated effects of the number of covered cycles on adoption rates from the Fixed Effects model specified in Equation 4. The study sample includes all the 0-5 years old adopted children from 2000 to 2014 from the adoption data from the National Data Archive on Child Abuse and Neglect (NDACAN). The data is aggregated into state-year-mother age cells.The dependent variable is defined as the natural logarithm of the ratio of the total number of adopted children to the total number of births in each state-year-age cell. All estimated effects include year fixed effects. The included covariates from the CPS are listed in the Notes to Table 3. The number of IVF clinics in each state from SART's clinic level data are also included. Robust standard errors are presented in parentheses.
$*p < 0.10, **p < 0.05, ***p < 0.01$

Figures

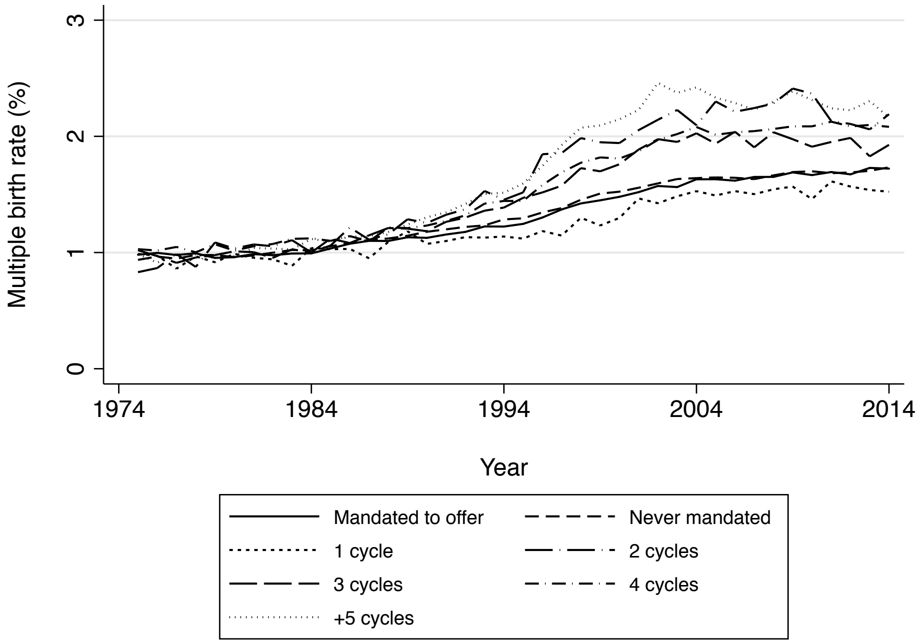
Figure 1: Patients' decision by their fertility



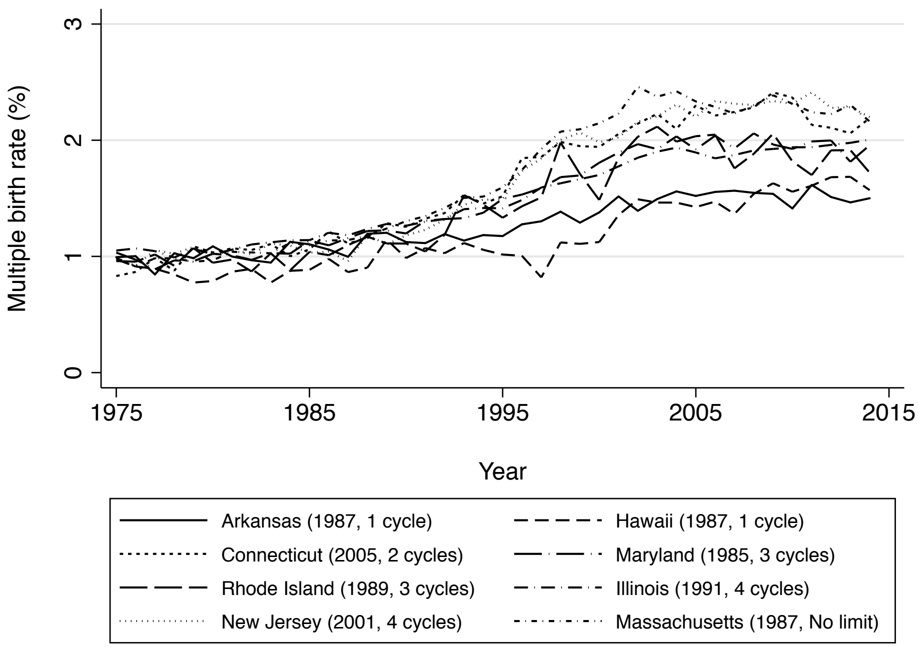
Note: This figure presents patients' choice for adopting an infant, IVF treatment and natural conception by their fertility (f) and the number of IVF cycles covered in their heath insurance plan ($\bar{r}$). $\bar{F}$ and $\underline{F}$ respectively denote the upper and lower limits of natural fertility. γ denotes the probability conceiving an infant naturally. $\widehat{k}$ denotes the maximum number of embryos that can be implanted.

Figure 2: Multiple birth rates

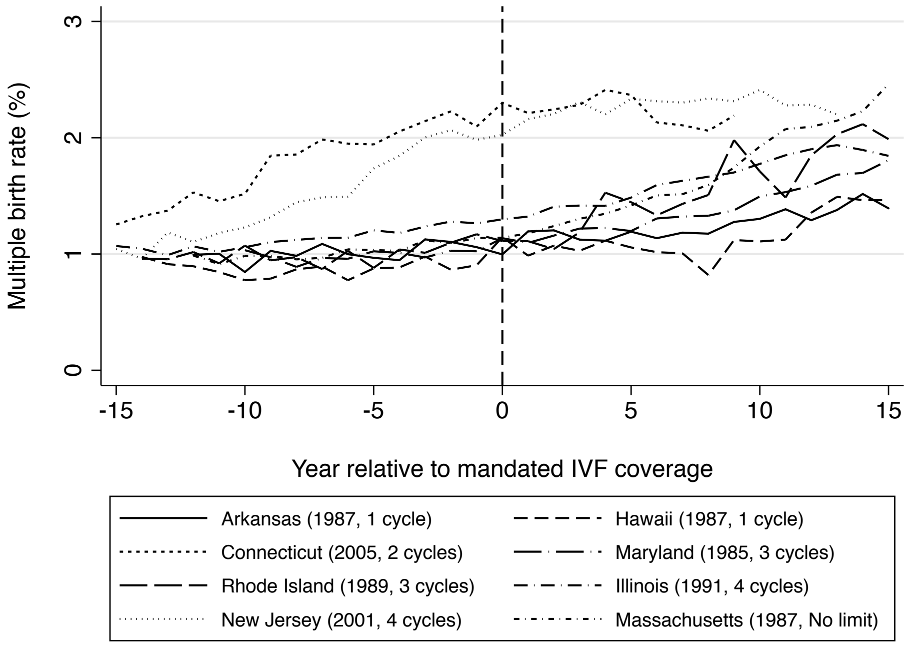
(a) By number of mandated covered cycles and year



(b) Mandated coverage states, by year



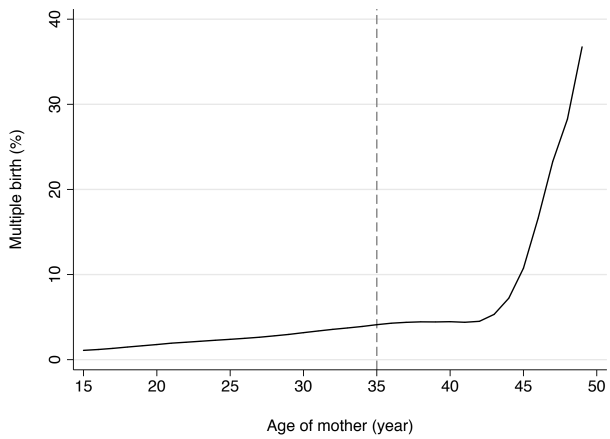
(c) Mandated coverage states, by year relative to mandate



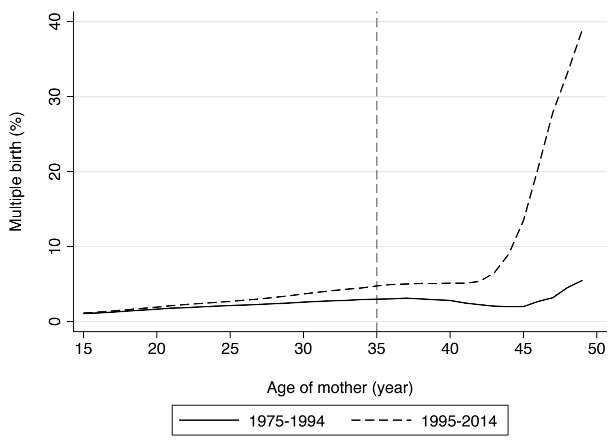
Note: This figure plots the trends in multiple birth rates in states with mandated insurance coverage for IVF treatment. The sample includes all the births from birth certificate data from the National Vital statistics from 1974-2014. Multiple births are defined as a birth which is not singleton, and our measure of multiple births gives the percentage of all births that were multiple.

Figure 3: Multiple births rate by mothers' age

(a) 1975-2014



(b) 1975-1994 and 1995-2014

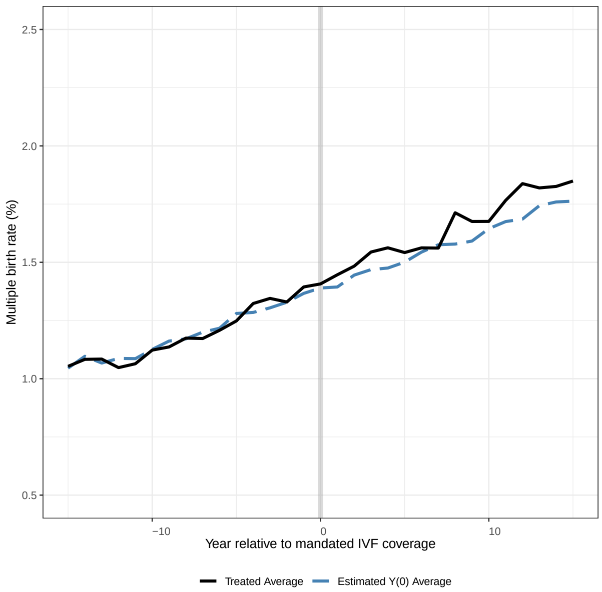


Note: Authors' calculations from the Detail Natality Data

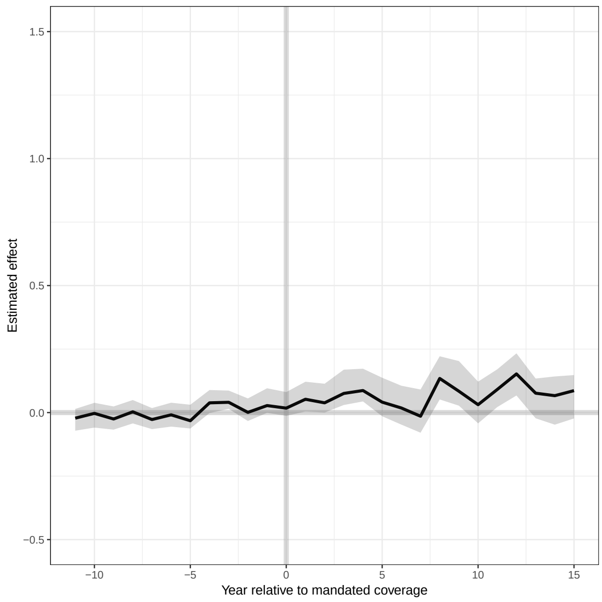
Figure 4: Treated average and estimated average for treated states and Average Treatment Effect on Treated (ATT) of the number of covered cycles on the multiple birth rate from General Synthetic Control model (all age mothers)

(a) All mandated states

(1) Treated average and estimated average for treated states

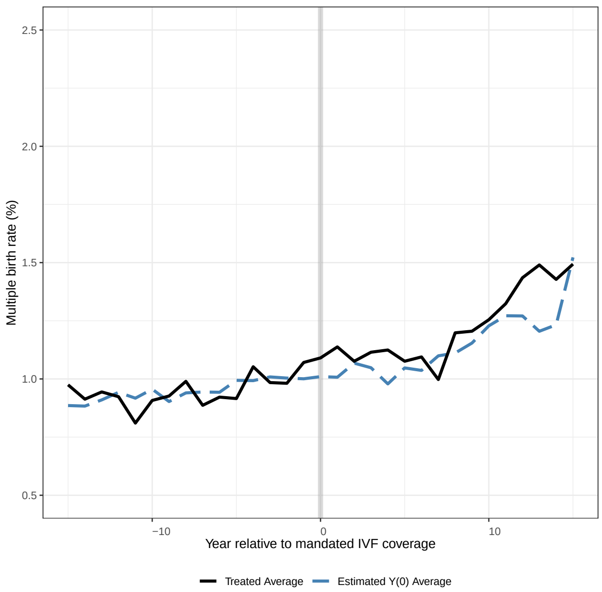


(2) Estimated Average Treatment effect on Treated (ATT)

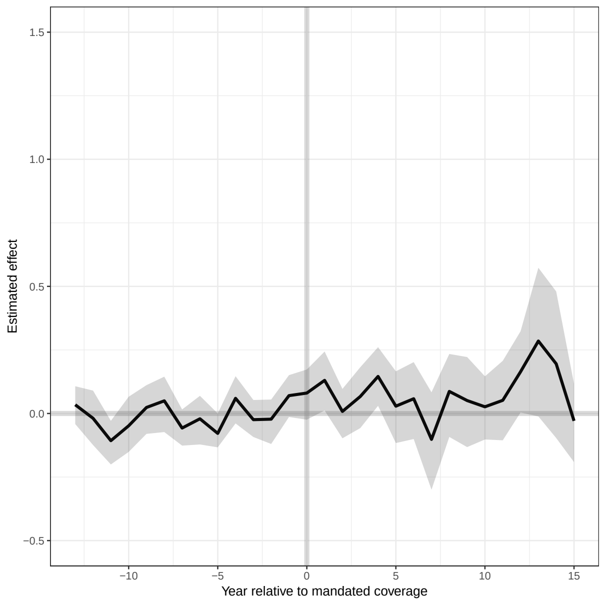


(b) States with one covered cycle

(1) Treated average and estimated average for treated states

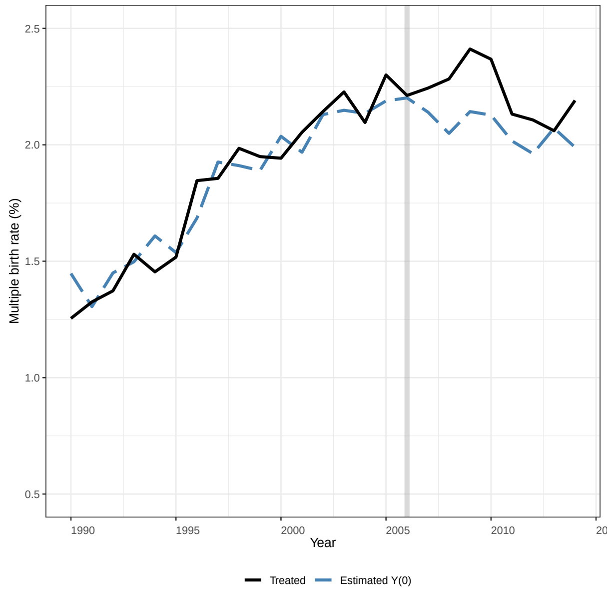


(2) Estimated Average Treatment effect on Treated (ATT)

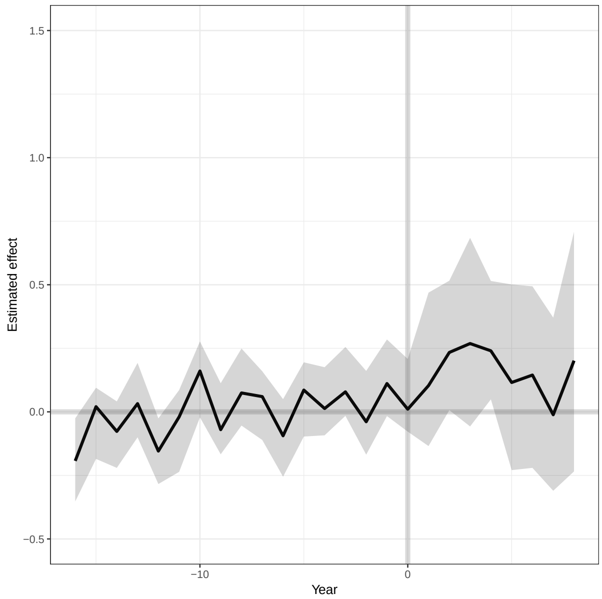


(c) States with two covered cycles

(1) Treated average and estimated average for treated states

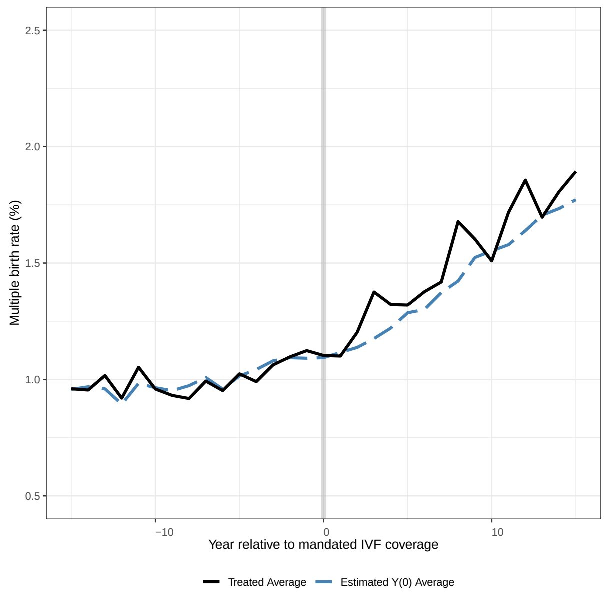


(2) Estimated Average Treatment effect on Treated (ATT)

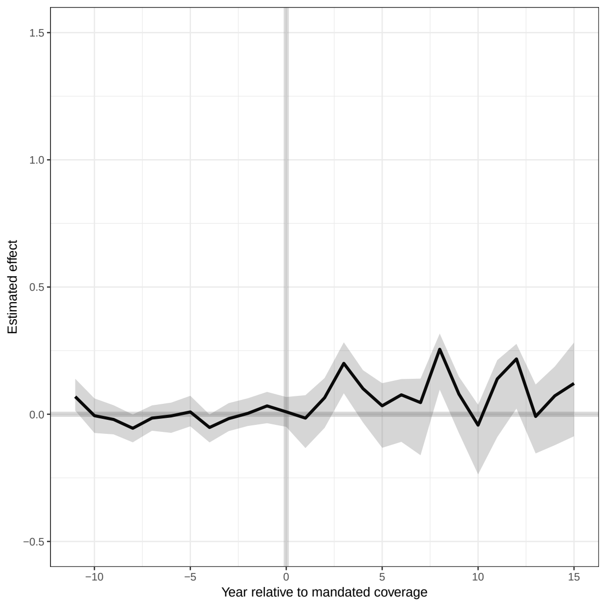


(d) States with three covered cycles

(1) Treated average and estimated average for treated states

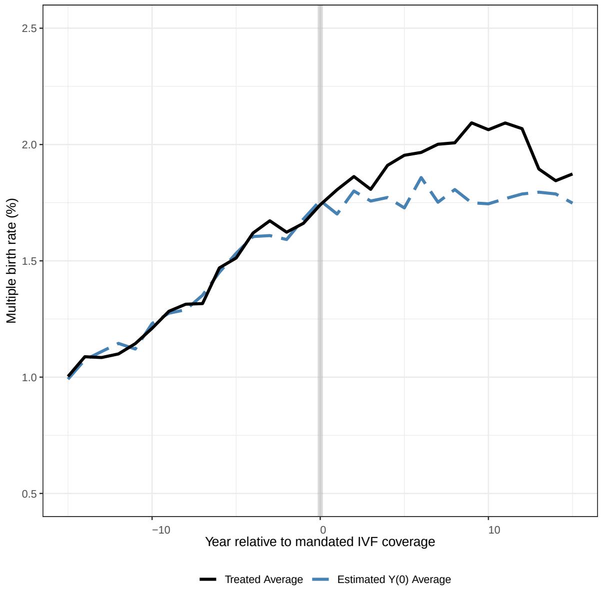


(2) Estimated Average Treatment effect on Treated (ATT)

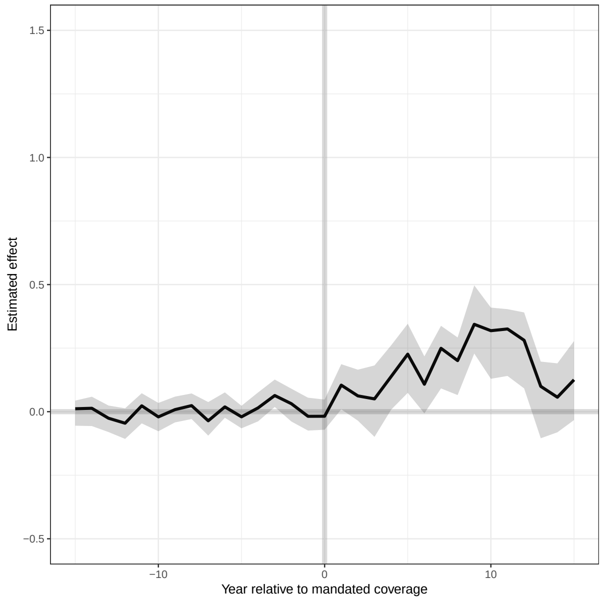


(e) States with four covered cycles

(1) Treated average and estimated average for treated states

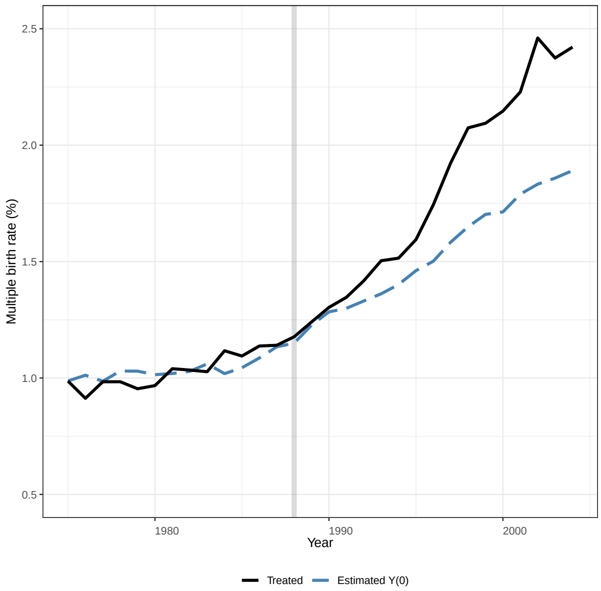


(2) Estimated Average Treatment effect on Treated (ATT)

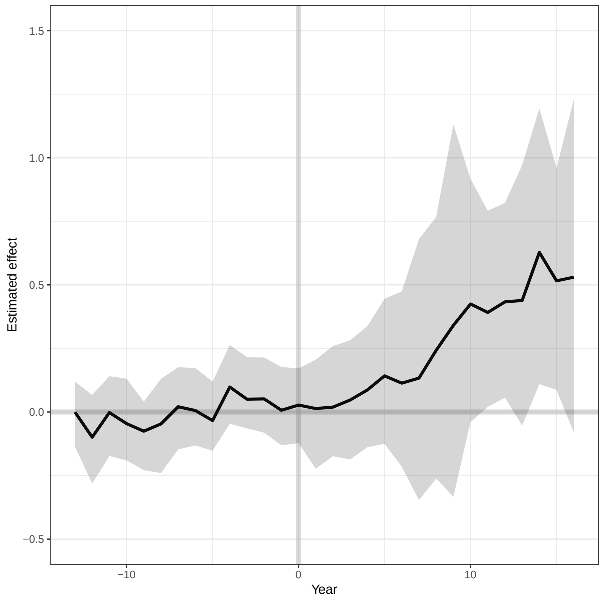


(f) States with more than five covered cycles

(1) Treated average and estimated average for treated states



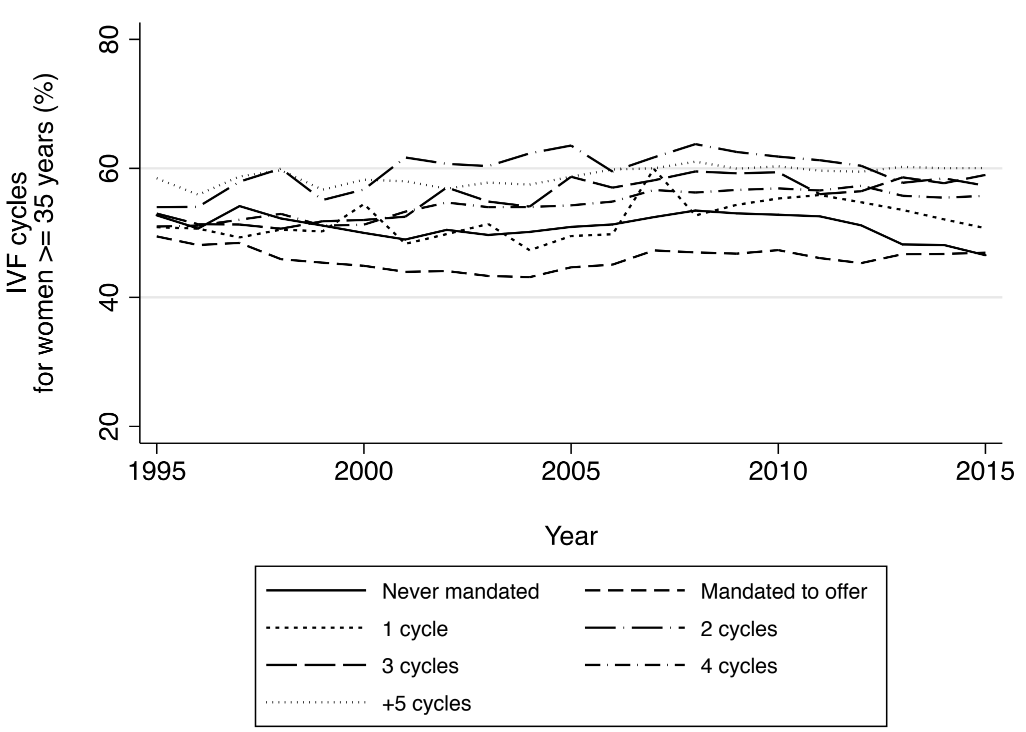
(2) Estimated Average Treatment effect on Treated (ATT)



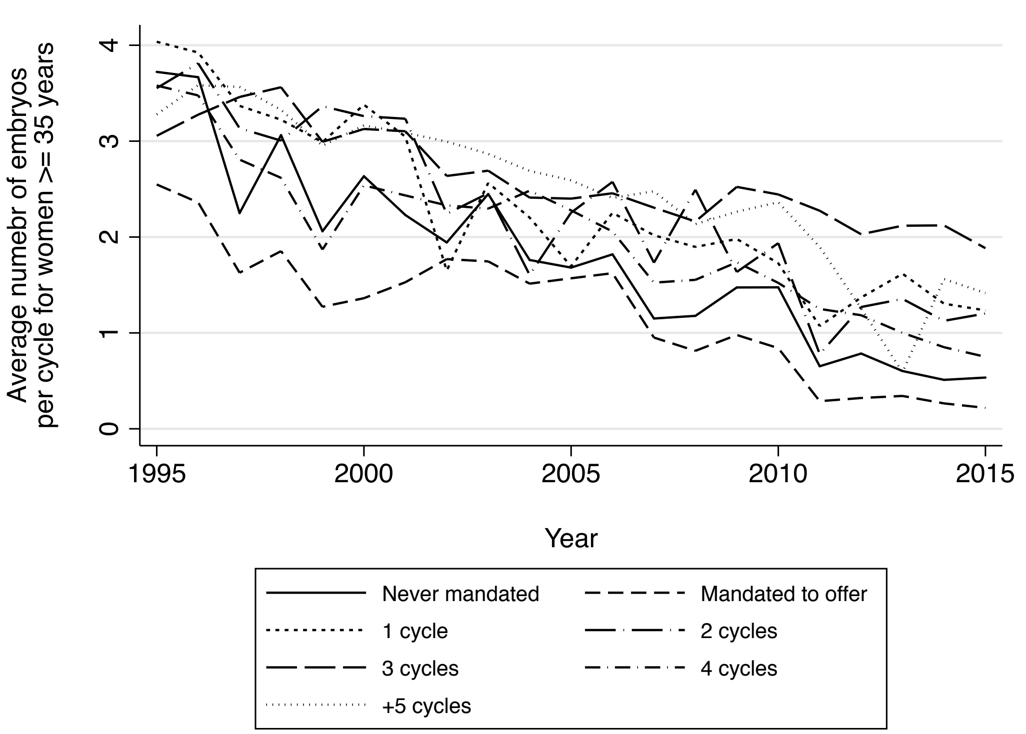
Note: This figure plots the estimated counter-factual outcome $Y(0)$ and the Average Treatment effect on Treatment (ATT) on multiple birth rate using the Generalized Synthetic Control model specified in Equation (2). The sample includes all the births in the US from 1975-2014 from the National Vital Statistics, aggregated by state-year. The treatment group includes states with mandated IVF coverage in their employer-provided health insurances (Arkansas (1987, 1 cycle), Massachusetts (1987, +5 cycles), Hawaii (1989, 1 cycle), Rhode Island (1989, 3 cycles), Illinois (1991, 4 cycles), Maryland (1985, 3 cycles), New Jersey (2001, 4 cycles) and Connecticut (2005, 2 cycles)) and, control group includes all the never mandated states. The included covariates in the model are listed in the Notes to Table 3The gray shade shows the %95 confidence intervals for the estimated ATT.

Figure 5: Mandated IVF coverage and cycles performed and number of transferred embryos per cycle

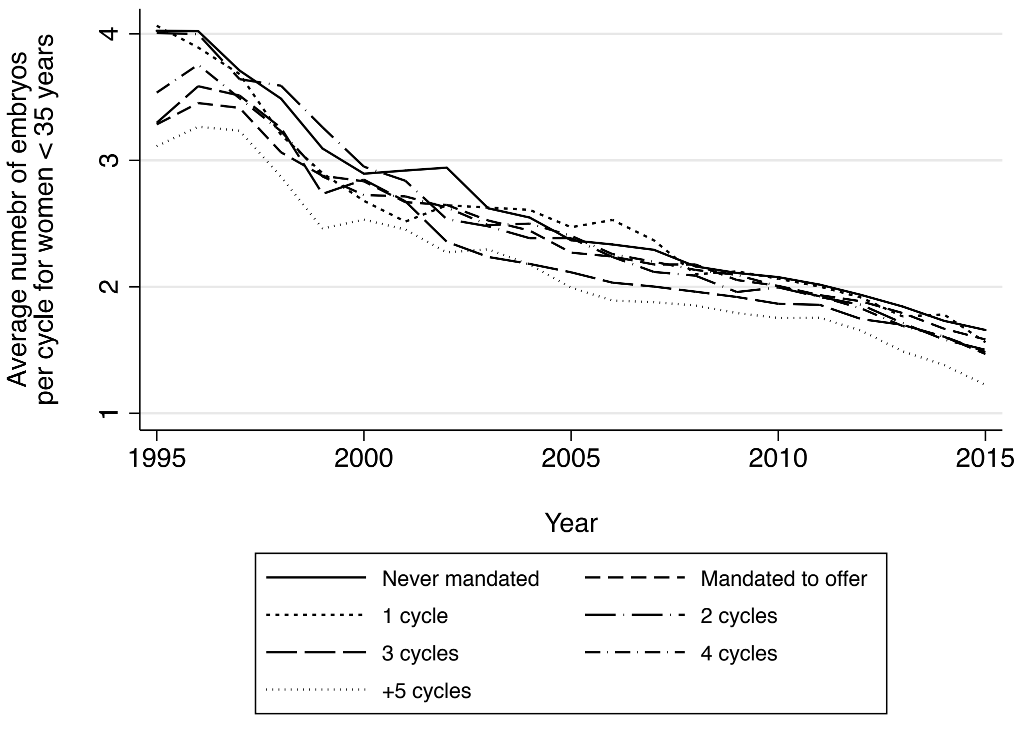
(a) IVF cycles performed for patients of 35 years and older



(b) Average number of implanted embryos for patients 35 years and older

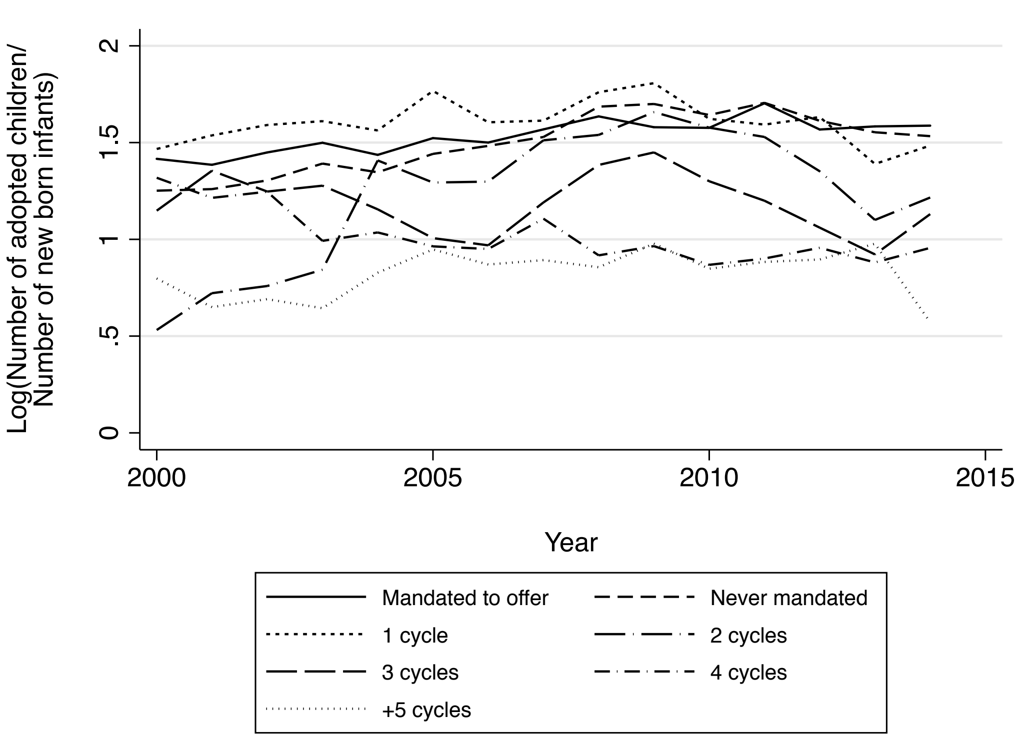


(c) Average number of implanted embryos for patients younger than 35 years



Note: This figure plots the trends in the portion of IVF cycles performed and the average number of transferred embryos. SART's clinic-level data from 1995-2015 used.

Figure 6: Number of adopted children to number of births by number of covered IVF cycles



Note: This figure plots the trends in Log(Number of adopted children/Number of new born infants) by the number of covered cycles. The study sample included 0-5 years old children adopted by women of 35 years and older from the adoption data of National Data Archive on Child Abuse and Neglect (NDACAN). The total number of births are from the birth certificate data from the Natality detail files.

Appendix

A Estimation procedure of a Generalized Synthetic Control model

Xu (2017) provides a procedure for estimating a Generalized Synthetic Control (GSC) model specified in Equation (2) as:

$$y_{it} = \delta_{it} D_{it} + X_{it}'\beta + \lambda_i' f_t + \epsilon_{it} \tag{A.1}$$

The procedure consists of three main steps. The first step includes estimating an interactive fixed effect model using the data only from the control group (i.e. setting $D_{it} = 0$ in Equation (A.1)). Assume that $F = [f_1, f_2, ..., f_T]$ and $\Lambda_{control} = [\lambda_1, \lambda_2, ..., \lambda_{control}]$ where $control$ denotes the number of states in control group and T denotes the time periods in the analysis. r is the number of factors (f_t and λ_i are r vectors). To identify β, F and $\Lambda_{control}$ however more constraints are required. Two constraints are imposed. First, all factors are normalized, $\frac{\widehat{F}'\widehat{F}}{|T|} = I_r$, where I_r denotes the identity matrix and $|T|$ is the total number of time periods in the analysis. Second, loadings are orthogonal to each other, $\widehat{\Lambda}_{control}'\widehat{\Lambda}_{control} =$ diagonal. To obtain the estimated $\widehat{\beta}$, $\widehat{F}$ and $\widehat{\Lambda}_{control}$ then:

$$(\widehat{\beta}, \widehat{F}, \widehat{\Lambda}_{control}) = \underset{\widehat{\beta}, \widehat{F}, \widehat{\Lambda}_{control}}{\arg\max} \sum_{i \in control} (Y_i - X_i\widehat{\beta} - \widehat{F}\widehat{\lambda}_i)'(Y_i - X_i\widehat{\beta} - \widehat{F}\widehat{\lambda}_i) \tag{A.2}$$

$$\text{s.t.} \quad \frac{\widehat{F}'\widehat{F}}{|T|} = I_r \text{ and } \widehat{\Lambda}_{control}'\widehat{\Lambda}_{control} = \text{diagonal}$$

The number of factors r is unknown and is estimated through a cross validation process that minimizes the prediction error of the model. The estimation process starts with a given r to obtain the corresponding $\widehat{\beta}$, $\widehat{F}$ and $\widehat{\Lambda}_{control}$. For each pre-treatment period $s \in \{1, 2, ..., T_0\}$, we hold back data of all treated states at time s. We then run an OLS regression using the rest of the pre-treatment data to obtain factor loadings for each treated unit i, $\widehat{\lambda}_{i,-s}$. We next predict the treated outcome at time s as $\widehat{y}_{is}(0) = X_{is}'\widehat{\beta} + \widehat{\lambda}_{i,-s}\widehat{f}_s$.[1]

We define the prediction error as $e_{is} = y_{is}(0) - \widehat{y}_{is}(0)$. The mean Square Prediction Error (MSPE) for given r is defined as:

$$MSPE(r) = \sum_{s=1}^{T_0} \sum_{i \in T} \frac{e_{is}^2}{T_0} \tag{A.3}$$

where T_0 denotes the number of pre-treatment periods. This process is repeated for different values of r (we try $r \in \{1, 2, ..., 5\}$). Then, r^* corresponding to the smallest prediction error is

[1]This is notation from potential outcome framework for casual inference where $y_{it}(0)$ and $y_{it}(1)$ are the potential outcome for state i at time t when respectively $D_{it} = 0$ and $D_{it} = 1$.

chosen.

The factor loadings for the treated states are estimated in the second step. This is done by minimizing the mean square error of the predicted treated outcome in pretreatment periods:

$$\widehat{\lambda}_i = \arg\max_{\widehat{\lambda}_i}(Y_i^0 - X_i^0\widehat{\beta} - \widehat{F}^0\widehat{\lambda}_i)'(Y_i^0 - X_i^0\widehat{\beta} - \widehat{F}^0\widehat{\lambda}_i) \tag{A.4}$$

where "0" superscripts denote the pre-treatment time periods and $\widehat{\beta}$ and $\widehat{F}^0$ are estimated from the first step.

The third step finally estimates the treated counter-factual based on $\widehat{\beta}$, $\widehat{F}$ and $\widehat{\lambda}_i$. That is:

$$\widehat{y}_{it}(0) = X_{it}'\widehat{\beta} + \widehat{\lambda}_i'\widehat{f}_i \quad \text{for } i \in Treated,\ t > T_0 \tag{A.5}$$

The estimated Average Treatment effect on Treated at time t, ATT_t then is:

$$\widehat{ATT}_t = \frac{1}{|Treated|}\sum_{i \in Treated}[y_{it}(1) - \widehat{y}_{it}(0)] \quad \text{for } t > T_0 \tag{A.6}$$

B Difference-in-Differences model

Table B.1: Estimated effects of mandated coverage of IVF on multiple birth rate from a Difference-in-Differences model

	All mothers		*+35 years mothers*		*+College mothers*		*Married mothers*		*White mothers*	
	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 to +5 cycles * Post	0.11***		0.21*		0.11***		0.15***		0.12***	
	(0.03)		(0.11)		(0.03)		(0.04)		(0.04)	
1 cycle * Post		-0.02		-0.31***		-0.07		-0.05		-0.05
		(0.03)		(0.11)		(0.04)		(0.04)		(0.03)
2 cycles * Post		0.17***		0.32***		0.09***		0.19***		0.16***
		(0.03)		(0.06)		(0.03)		(0.05)		(0.03)
3 cycles * Post		0.07		0.31***		0.14***		0.16**		0.10**
		(0.05)		(0.10)		(0.04)		(0.07)		(0.05)
4 cycles * Post		0.20**		0.35***		0.15***		0.26**		0.22**
		(0.08)		(0.12)		(0.04)		(0.10)		(0.10)
+5 cycles * Post		0.20***		0.65***		0.34***		0.31***		0.28***
		(0.05)		(0.10)		(0.05)		(0.07)		(0.03)
Constant	-2.48	-1.62	0.53	5.81	-0.35	1.63	0.05	1.62	-1.09	-1.02
	(2.35)	(2.60)	(7.78)	(7.71)	(2.18)	(2.08)	(3.53)	(3.90)	(1.47)	(1.20)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of cells	1,639	1,639	1,639	1,639	1,639	1,639	1,517	1,517	1,639	1,639

Note: This table presents the estimated average effects of mandated coverage of IVF in private health insurance plans on multiple birth rate from a Difference-in-Differences (DD) model. We estimate $MultiBirth_{it} = \alpha + \delta(Cover_{it} \times Post_t) + \beta X_i' + \lambda_i + \lambda_t + \epsilon_{it}$ where i denotes state and t denotes time. $MultiBirth_{it}$ denotes the multiple birth rate in state i at year t. $Cover_{it}$ denotes the number of covered cycles in mandated to cover states. It is set to zero for the never mandated states. $Post_{it}$ is another dummy switching on two years after the mandated coverage enacted. λ_i and λ_t are respectively state and time fixed effects. The vector X_i is a set of time-variant state characteristics to control for any observable differences that might confound the analysis. ϵ_{it} captures any remaining unobserved components that affect the multiple birth rate. The coefficient of interest is δ. Robust standard errors are presented in parentheses. $*p < 0.10, **p < 0.05, ***p < 0.01$

C Number of infants per thousand births

C.1 Tables

Table C.1: Estimated Average Treatment Effect on Treated (ATT) on number of instants per 1000 birth from Generalized Synthetic Control mode

Sample	*All mothers*		*+35 years mothers*		*+College mothers*		*Married mothers*		*White mothers*	
		Covars		Covars		Covars		Covars		Covars
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
***A.** All mandated states (Number of cells: 1,720)*										
ATT	1.53***	0.90***	2.87***	1.61***	1.25***	1.26***	2.48***	1.25***	1.90***	1.16***
	(0.09)	(0.10)	(0.36)	(0.51)	(0.14)	(0.19)	(0.15)	(0.17)	(0.11)	(0.15)
Mean	1,012.07		1,016.60		1,013.15		1,013.21		1,012.14	
	(3.77)		(6.98)		(4.59)		(5.12)		(4.19)	
***B.** 1 covered cycle (Number of cells: 1,110)*										
ATT	-1.25*	0.91***	-3.68***	-3.25*	-1.41*	0.26	-1.50***	-0.39	-1.06***	-0.88*
	(0.76)	(0.42)	(1.00)	(1.26)	(0.92)	(0.28)	(0.24)	(0.97)	(0.16)	(0.50)
Mean	1,012.20		1,017.24		1,013.52		1,013.23		1,012.11	
	(2.75)		(5.91)		(3.49)		(3.49)		(2.90)	
***C.** 2 covered cycles (Number of cells: 900)*										
ATT	2.89	2.09*	4.30	2.09	-1.65	1.08	4.01	2.28	1.14	0.66
	(1.50)	(1.29)	(2.57)	(2.62)	(2.46)	(1.95)	(2.56)	(0.27)	(1.23)	(1.56)
Mean	1,015.4		1,023.50		1,017.35		1,017.12		1,015.52	
	(2.51)		(5.39)		(2.99)		(3.27)		(2.58)	
***D.** 3 covered cycles (Number of cells: 1,036)*										
ATT	1.94***	0.68***	3.73**	3.82***	2.34***	1.36**	2.77***	1.38**	2.47***	0.62**
	(0.12)	(0.16)	(1.50)	(0.65)	(0.85)	(0.66)	(0.88)	(0.43)	(0.12)	(0.19)
Mean	1,011.89		1,016.61		1,013.28		1,012.81		1,011.77	
	(2.49)		(5.51)		(3.40)		(3.13)		(2.63)	
***E.** 4 covered cycles (Number of cells: 1,443)*										
ATT	1.93***	1.66***	4.76***	3.43***	2.09***	1.55***	3.86***	2.28***	2.30***	1.99***
	(0.26)	(0.20)	(0.71)	(0.65)	(0.13)	(0.26)	(0.29)	(0.26)	(0.32)	(0.35)
Mean	1,013.55		1,019.74		1,015.03		1,014.88		1,013.48	
	(3.23)		(6.74)		(3.93)		(4.12)		(3.38)	
***F.** +5 covered cycles (Number of cells: 1,080)*										
ATT	6.50**	2.92*	10.04**	6.35**	4.45**	4.15*	6.78**	0.51	4.91*	4.95*
	(2.32)	(2.12)	(3.50)	(3.84)	(1.94)	(2.21)	(3.31)	(3.04)	(2.79)	(2.38)
Mean	1,012.25		1,017.28		1,013.58		1,013.29		1,012.15	
	(2.74)		(5.93)		(3.93)		(3.48)		(2.90)	

Note: See notes for Table 3.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table C.2: Estimated effects of mandated coverage of IVF on number of infants per thousand births from a Difference-in-Difference-in-Differences model

	All mothers				*+College mothers*				*Married mothers*				*White mothers*			
	All mandated		By coverage		All mandated		By coverage		All mandated		By coverage		All mandated		By coverage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1 to +5 cyclesxPlus35xPost	0.32	1.46			-0.47	-1.89			0.35	1.34			2.82	1.95		
	(6.74)	(4.95)			(7.06)	(5.56)			(7.53)	(5.51)			(6.85)	(5.09)		
1 cyclexPlus35xPost			-16.89***	-12.76***			-21.54***	-18.70***			-15.15***	-13.62**			-17.49***	-13.09***
			(3.34)	(4.28)			(2.36)	(2.15)			(5.01)	(6.25)			(2.91)	(4.01)
2 cyclesxPlus35xPost			-16.08***	2.82			-14.14***	-6.28**			-18.52***	-1.20			-13.09***	4.73
			(1.66)	(2.77)			(2.11)	(2.35)			(1.93)	(2.70)			(2.00)	(3.10)
3 cyclesxPlus35xPost			7.78*	0.38			4.78	-1.32			7.71***	1.46			9.63*	0.89
			(4.26)	(3.69)			(5.97)	(5.49)			(2.19)	(2.94)			(5.00)	(5.00)
4 cyclesxPlus35xPost			14.03***	17.20***			14.70***	16.79***			14.25***	17.72***			17.73***	19.12***
			(1.79)	(5.18)			(2.50)	(1.59)			(2.08)	(4.26)			(1.79)	(4.38)
+5 cyclesxPlus35xPost			25.86***	16.78***			27.35***	6.65*			32.05***	18.33***			26.82***	12.80***
			(1.82)	(2.34)			(2.16)	(3.84)			(1.95)	(2.36)			(2.12)	(2.27)
Constant	1004.7***	1532.2***	1004.3***	1546.6***	1003.5***	1265.9***	1003.3***	1273.1***	1005.3***	1417.3***	1004.9***	1432.2***	1004.6***	1427.5***	1004.3***	1429.4***
	(0.56)	(132.54)	(0.52)	(133.81)	(1.18)	(37.26)	(1.16)	(36.10)	(1.05)	(72.91)	(0.98)	(72.57)	(0.56)	(45.67)	(0.51)	(45.48)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of cells	56,848	49,755	56,848	49,755	51,393	51,393	51,393	51,393	52,236	49,497	52,236	49,497	56,417	49,402	56,417	49,402

Note: See notes for Table 4.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table C.3: Estimated effects of mandated coverage of IVF on number of infants per thousand birth from a Difference-in-Differences model

	All mothers		*+35 years mothers*		*+College mothers*		*Married mothers*		*White mothers*	
	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage	All mandated	By coverage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 to +5 cycles * Post	1.16***		2.22*		1.20***		1.68***		1.33***	
	(0.32)		(1.21)		(0.38)		(0.40)		(0.43)	
1 cycle * Post		-0.15		-3.40***		-0.72*		-0.49		-0.47
		(0.28)		(1.19)		(0.41)		(0.33)		(0.31)
2 cycles * Post		1.79***		3.33***		0.93***		2.02***		1.67***
		(0.28)		(0.69)		(0.33)		(0.47)		(0.28)
3 cycles * Post		0.81		3.35***		1.60***		1.76**		1.16**
		(0.52)		(1.06)		(0.44)		(0.77)		(0.51)
4 cycles * Post		2.05**		3.62***		1.61***		2.74***		2.28**
		(0.76)		(1.03)		(0.32)		(0.90)		(0.96)
+5 cycles * Post		2.35***		7.34***		3.80***		3.49***		3.05***
		(0.49)		(1.06)		(0.61)		(0.75)		(0.35)
Constant	975.11***	985.78***	1014.68***	1074.34***	998.75***	1021.07***	1001.64***	1020.73***	989.55***	990.61***
	(24.66)	(27.24)	(81.95)	(80.30)	(24.13)	(22.70)	(37.63)	(41.13)	(15.85)	(13.11)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covars	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of cells	1,639	1,639	1,639	1,639	1,639	1,639	1,517	1,517	1,639	1,639

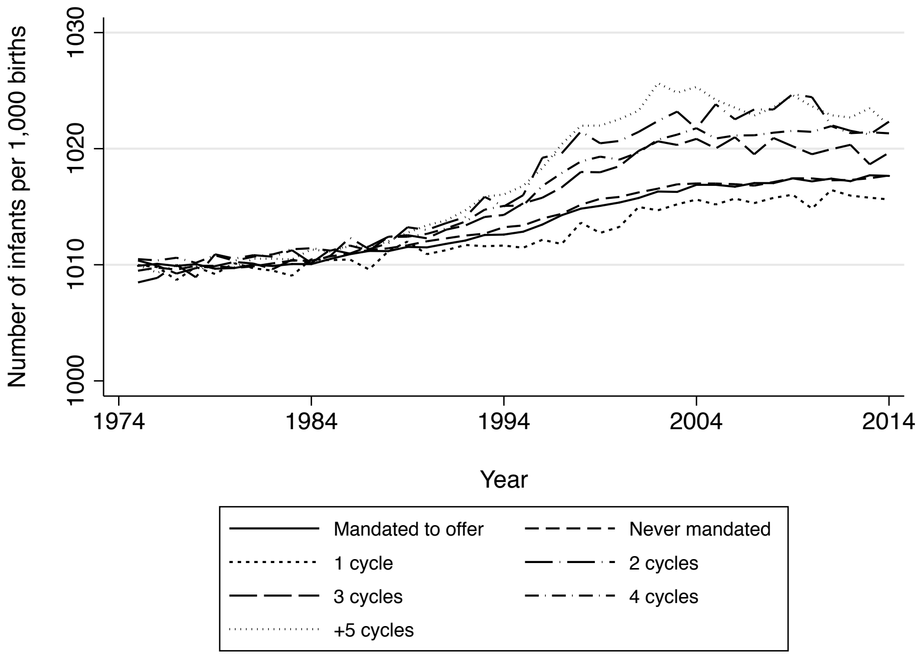
Note: See notes for Table B.1.

$*p < 0.10, **p < 0.05, ***p < 0.01$

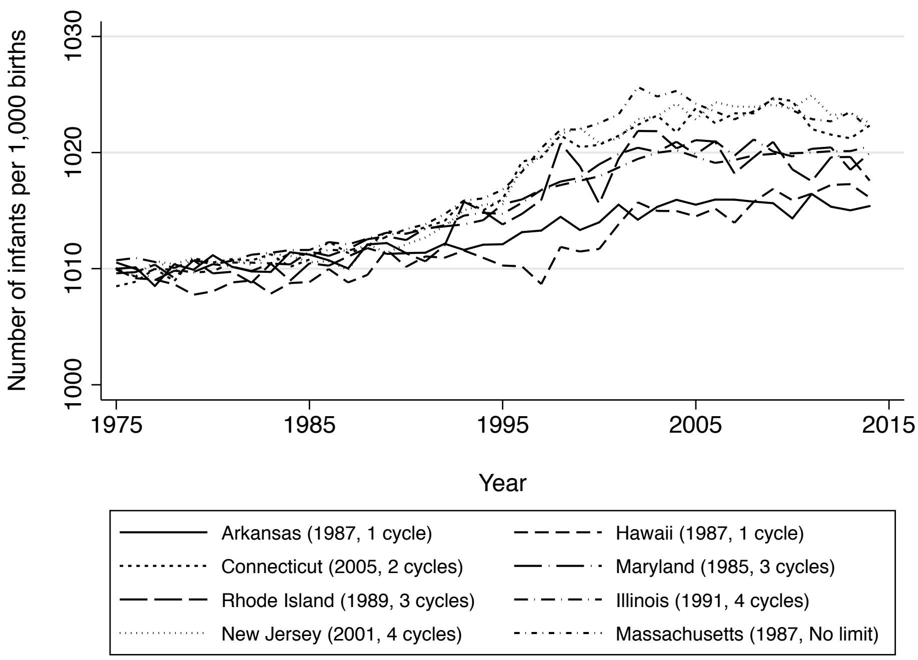
C.2 Figures

Figure C.1: Number of infants per thousand births

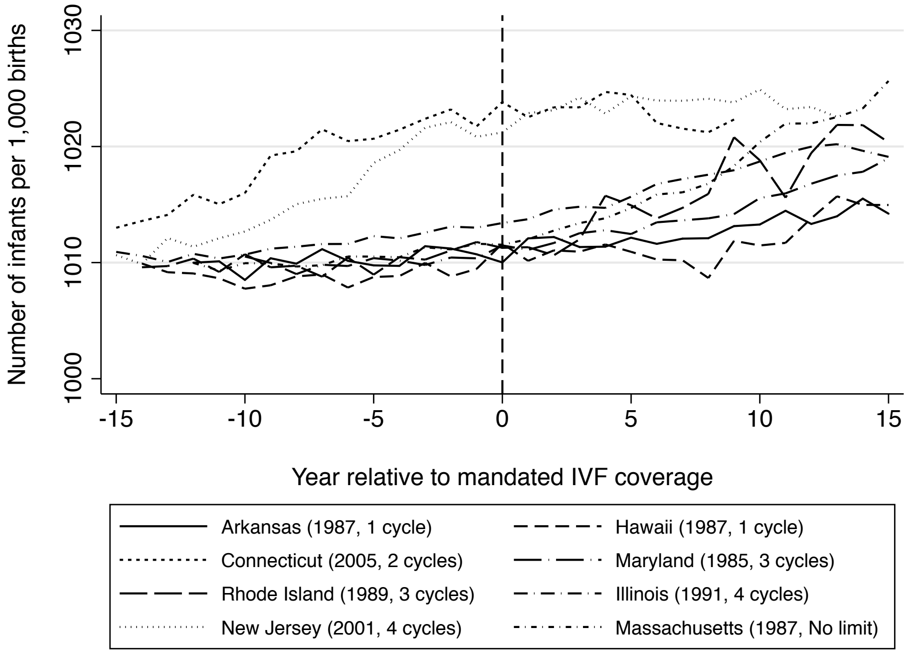
(a) Number of mandated covered cycles



(b) States with mandated cover over time



(c) States with mandated cover over year relative to mandate

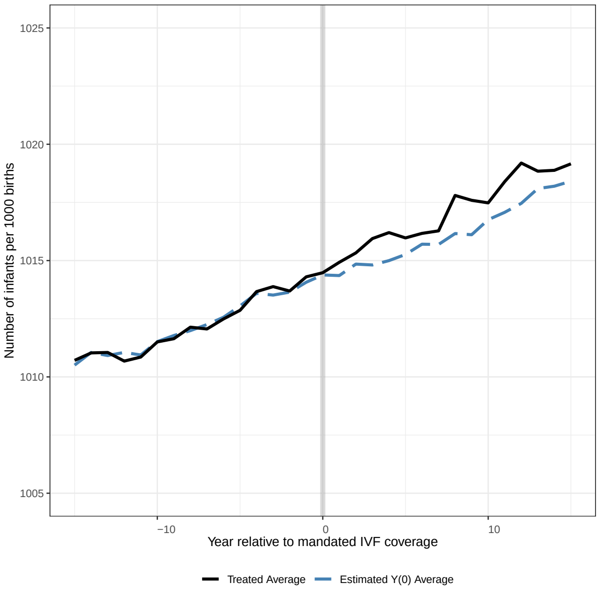


Note: This figure plots the trends in the number of infants per thousand birth in states with mandated insurance coverage for IVF treatment. The sample includes all the births from the National Vital statistics from 1974-2014. Panel (**??**) plots the trend in multiple birth rates over year by the number of cycles mandated to cover. Panel (b) and (c) plot the trend in multiple birth rates in the mandated states respectively over year and year relative to mandated coverage.

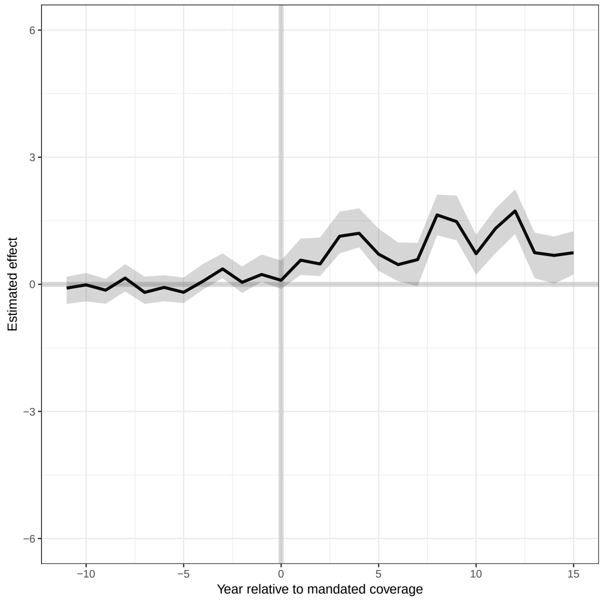
Figure C.2: Treated average and estimated average for treated states and Average Treatment Effect on Treated (ATT) of mandated coverage of IVF on number of infants per 1000 births from Synthetic Control model (all age mothers)

(a) All mandated states

(1) Treated average and estimated average for treated states

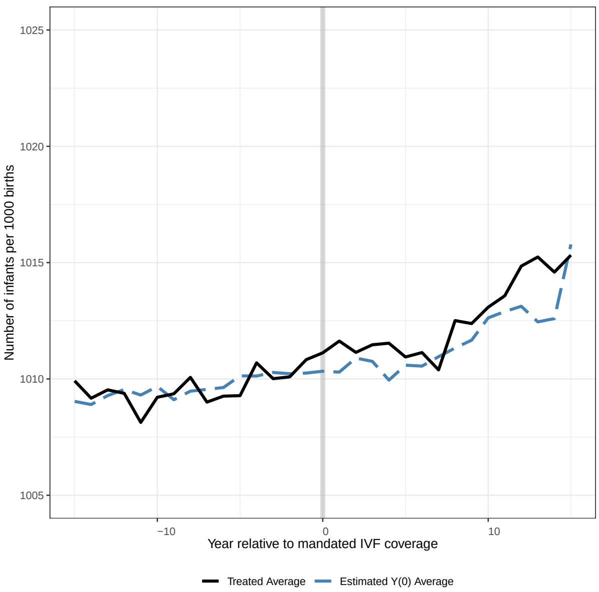


(2) Estimated Average Treatment effect on Treated (ATT)

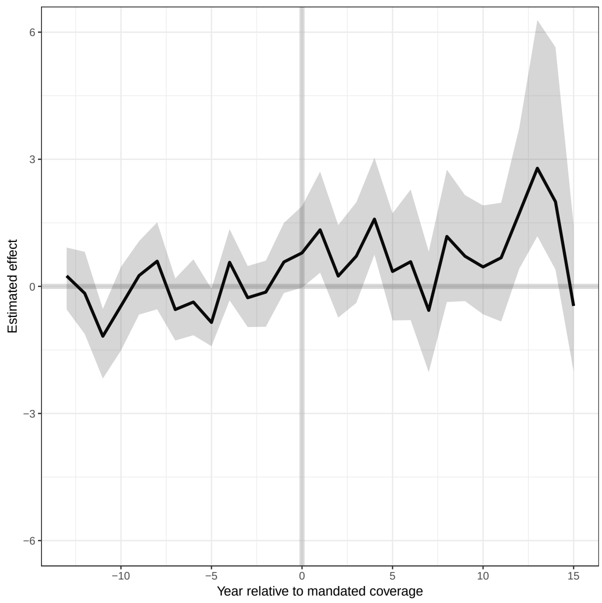


(b) States with one covered cycle

(1) Treated average and estimated average for treated states

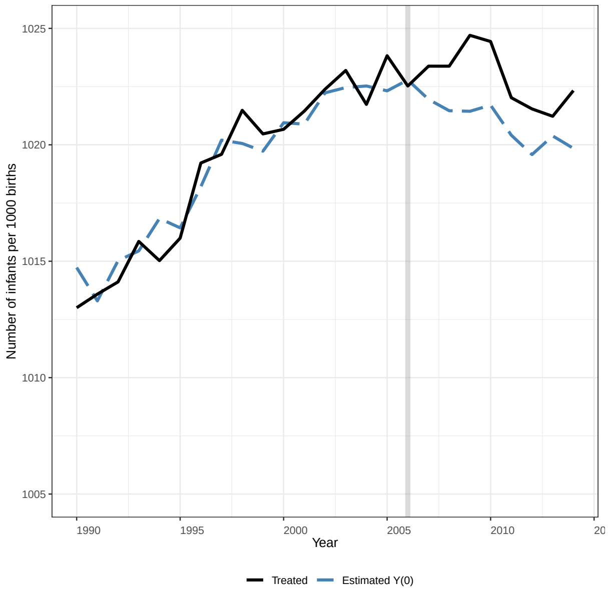


(2) Estimated Average Treatment effect on Treated (ATT)

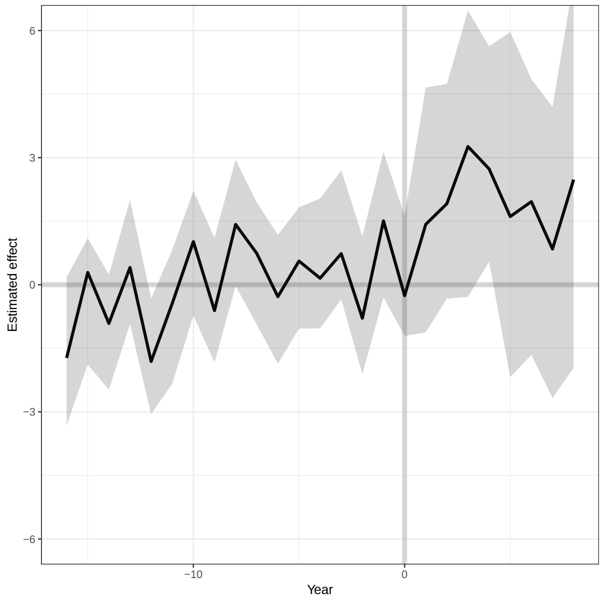


(c) States with two covered cycles

(1) Treated average and estimated average for treated states

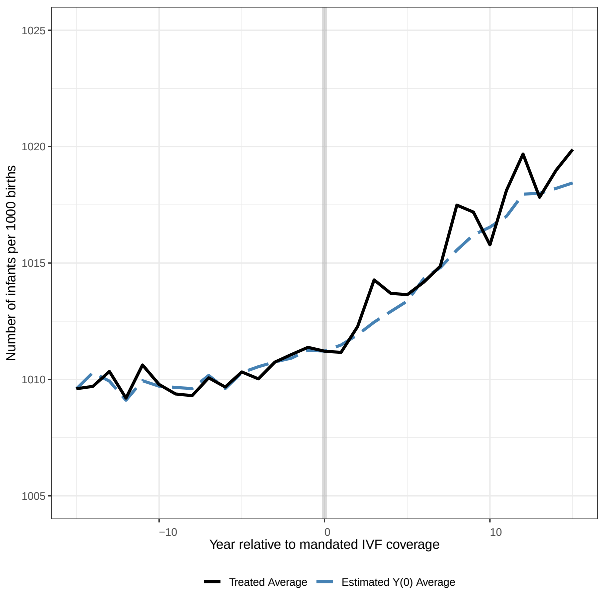


(2) Estimated Average Treatment effect on Treated (ATT)

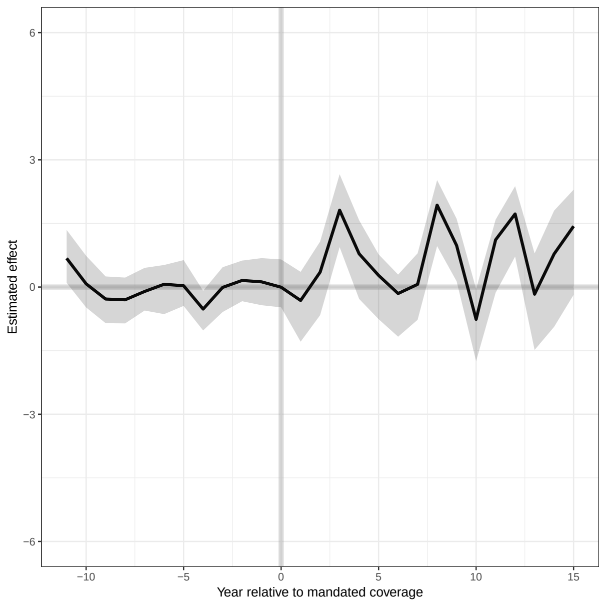


(d) States with three covered cycles

(1) Treated average and estimated average for treated states

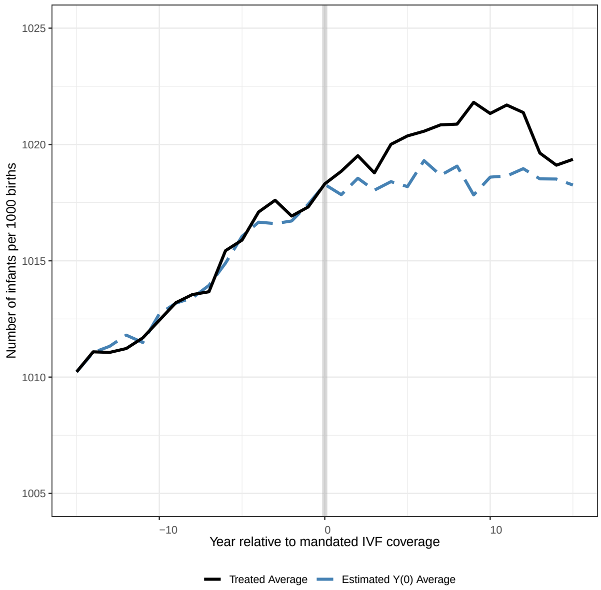


(2) Estimated Average Treatment effect on Treated (ATT)

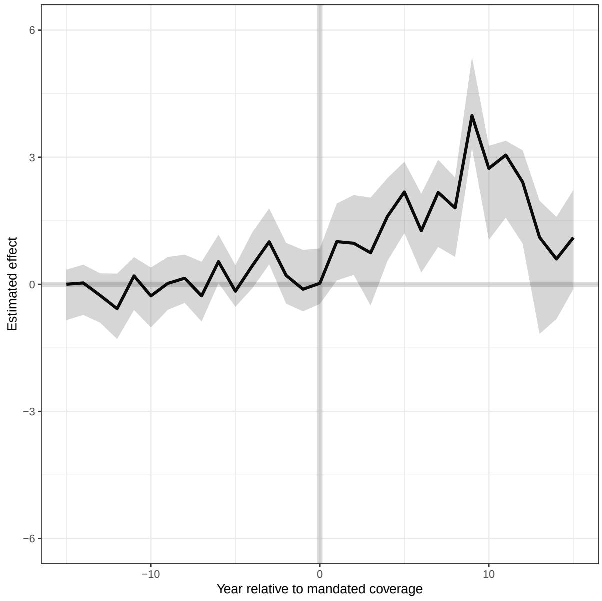


(e) States with four covered cycles

(1) Treated average and estimated average for treated states

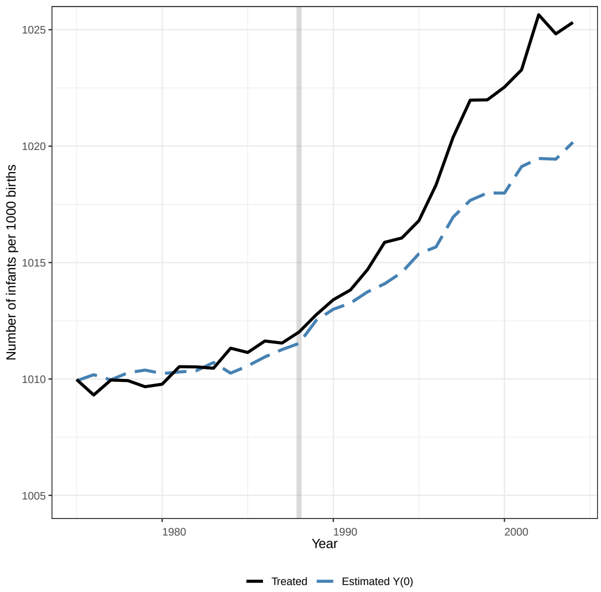


(2) Estimated Average Treatment effect on Treated (ATT)

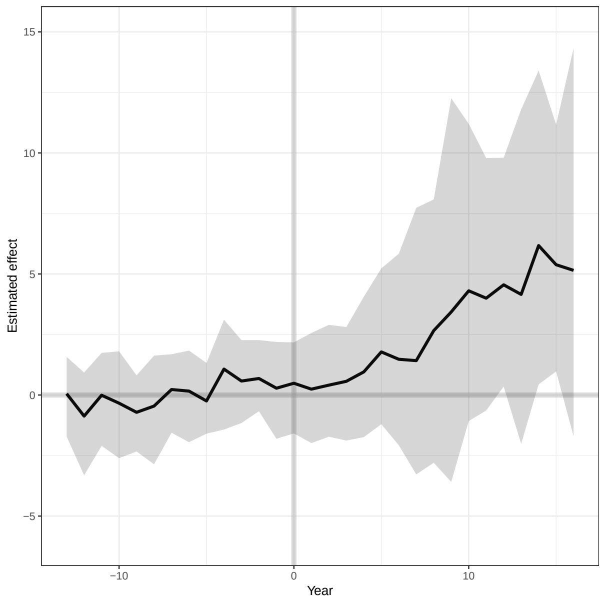


(f) States with more than five covered cycles

(1) Treated average and estimated average for treated states



(2) Estimated Average Treatment effect on Treated (ATT)



Note: This figure plots the estimated counter-factual outcome $Y(0)$ and the Average Treatment effect on Treatment (ATT) on number of infants per 1000 births using the Generalized Synthetic Control model specified in Equation (2). The sample includes all the births in the US from 1975-2014 from the National Vital Statistics, aggregated by state-year. The treatment group includes states with mandated IVF coverage in their employer provided health insurances (Arkansas (1987, 1 cycle), Massachusetts (1987, +5 cycles), Hawaii (1989, 1 cycle), Rhode Island (1989, 3 cycles), Illinois (1991, 4 cycles), Maryland (1985, 3 cycles), New Jersey (2001, 4 cycles) and Connecticut (2005, 2 cycles)) and, control group includes all the states who have never mandated covering IVF. The included covariates in the model are mothers' age, education and mothers' and fathers' race and infant's sex, birth weight, five minutes APGAR score. The portion of women in fertile age (16-49 year), portion of college educated women, women labor force participation, portion working in big firms (employee $>$ 500), portion with private health insurance and average real personal income are also included. The %95 confidence intervals for the estimated ATT are shown by the gray shade.