The Morning After: Prescription-Free Access to Emergency Contraceptive Pills*

Gregor Pfeifer Mirjam Reutter

October 15, 2020

Abstract

We analyze the introduction of prescription-free access to morning-after pills—emergency contraceptives aiming to prevent unintended pregnancy and subsequent abortion after unprotected sexual intercourse. Exploiting a staggered difference-in-differences setting for Europe combined with randomization inference, we find sharp increases in sales and manufacturers' revenues (100%). However, whilst not reducing abortions significantly, the policy triggers an unexpected increase in fertility of 4%, particularly among women aged 25–34. We elaborate on mechanisms by looking at within-country evidence from Germany, which suggests that fertility is driven by decreasing use of birth control pills in response to easier access to morning-after pills.

JEL Codes: I12; I18; C46; J13

Keywords: Emergency Contraception; Morning-After Pill; Unintended Side Effects; Fertility; Difference-in-Differences

*Pfeifer: University of Sydney, School of Economics, Social Sciences Building, NSW 2006, Australia; University of Hohenheim; CESifo; IZA. Reutter (corresponding author): European University Institute, Department of Economics, Villa La Fonte, Via delle Fontanelle 18, 50014 San Domenico di Fiesole (FI), Italy; mirjam.reutter@eui.eu; University of Hohenheim. The authors are grateful for valuable remarks from Daniel Avdic, Martha Bailey, Olvar Bergland, Hoyt Bleakley, W. David Bradford, Inna Cintina, Anna Chorniy, Davide Dragone, Steven Durlauf, Christian Dustmann, Martin Halla, Brad Humphreys, Michael Kvasnicka, Rafael Lalive, Attila Lindner, Melanie Lührmann, Dave Marcotte, Ioana Marinescu, Taryn Morrissey, Aderonke Osikominu, Steven Raphael, Imran Rasul, Jens Ruhose, Joseph Sabia, Uta Schönberg, Hannes Schwandt, David Slusky, Stephan Thomsen, Ben Vollaard, Frank Windmeijer, and Nicolas Ziebarth, as well as seminar and conference participants at University College London, the American-European Health Economics Study Group in Harvard and Vienna, the Barcelona GSE Summer Forum, the Annual Workshop on Economics of Risky Behaviors, the SDU Workshop on Applied Microeconomics, the Health Econometrics Workshop in Bergamo, the Essen Health and Labour Conference, SMYE, EEA, EALE, ESPE, WEAI, EuroCIM.

1 Introduction

Sometimes, well-intentioned policies are not effective in achieving the desired objective since humans do not always react as expected. As a consequence, an intervention might trigger unintended side effects potentially even harming individuals instead of benefiting them. Prominent examples are automobile safety regulations, HIV tests, the distribution of condoms at schools, or opioid antagonist medication (Peltzman, 1975; Philipson and Posner, 1995; Buckles and Hungerman, 2018; Doleac and Mukherjee, 2019). Nevertheless, policy makers' guidance is particularly important when it comes to matters of (future) life and death, or health in general. Here, we consider emergency contraception (EC), which women can draw on to prevent unintended pregnancy when a primary contraceptive method failed, no method was used, or sex was forced. The so-called morning-after pill is effective up to five days after unprotected intercourse, but works more effectively the sooner it is taken. Consequently, many countries have changed access to EC pills from prescription-only to over-the-counter (OTC), meaning that the drug can be obtained in pharmacies directly without having to consult a doctor first. The intent behind these policy reforms is to simplify access to the drug and thereby reduce the number of unintended pregnancies, which often lead to abortions. However, providing an easy way to prevent conception ex post could also decrease ex ante efforts in appropriately using contraceptives—if at all.

In this paper, we evaluate intended and unintended impacts of the switch to prescription-free access to morning-after pills. Precisely, we estimate causal effects on units sold, revenue figures, and specific health outcomes such as abortions, fertility, and sexually transmitted infections (STIs). In a first step, we identify our effects of interest by exploiting regional and temporal variations in the OTC introduction of EC pills across 28 European countries and 18 years, respectively. Throughout this difference-in-differences (DiD) approach with staggered treatment adoption, we account for the clustered data structure and the limited number of clusters (countries) by applying randomization inference (RI) to assess the significance of the effects. Moreover, we consider the concerns raised by the recent econometric literature regarding DiD designs with staggered treatment adoption (e.g., Athey and Imbens, 2018; Goodman-Bacon, 2018; de Chaisemartin and D'Haultfoeuille, 2019). In a second step, we zoom in on Germany, which only very recently switched from a prescription-only to an OTC regime, in order to elaborate on specific channels of our general findings. Particularly, we evaluate OTC effects on the usage of regular hormonal contraceptives and on individual sexual behavior.

In line with clear descriptive evidence, we find that prescription-free access to morning-after pills causes a sharp increase in the number of units sold as well as in revenues of 89% and 108%, respectively. Moreover, we cannot detect a stable and significant reduction in abortions when

controlling for cluster structures and country-specific linear time trends as in our preferred specification. Notably, however, we reveal a robust increase in birth rates and fertility of about 4%. By zooming in on age-group-specific fertility, we find that these effects are driven by the subgroup of women aged 25 to 34 and not by the suspected risk group, teenagers, as often hypothesized in the literature (Girma and Paton, 2011; Cintina and Johansen, 2015). When evaluating the effect of prescription-free access to EC pills on several STIs, we do not see any significant impact. This corroborates our findings on the relevant age group driving fertility in the sense that 25- to 34-year-old females supposedly are in stable relationships as opposed to having frequently changing sex partners. OTC access to EC pills might simply cause people to engage in having more, or more unprotected, sex by which unintended—but not unwanted—pregnancies emerge. This finding is underpinned by birth rate effects split by within and outside marriages: only the former shows a statistically significant increase as a response to the OTC introduction. For all these outcomes, we i) show that the more conservative RI p-values confirm the significance of our effects and ii) examine effect dynamics by conducting event studies. In so doing, we demonstrate both persistent impacts over several post-treatment years as well as no violation of the common trends assumption. Within-country evidence for Germany confirms the effects found for Europe. Importantly, it additionally shows a change in contraceptive behavior. First, individuals under the OTC regime report to act riskier with respect to how consistently they use contraceptives in general. Second, specific evidence on sales of the birth control pill suggests that its use significantly declines with OTC access to the morning-after pill, pointing to a substitution from highly effective to less effective contraceptive methods. Taken together, these findings can explain the unexpected, positive fertility effects.

Although clinical trials have proven the effectiveness of EC pills, medical studies are inconclusive regarding public health benefits in terms of reduced unintended pregnancy rates in response to increased access to EC pills. Further, most part of this medical literature does not consider prescription requirements and is restricted to specific regions or sub-populations, whereas evidence is missing for the respective majority of the population (Glasier and Baird, 1998; Glasier et al., 2004; Raymond et al., 2004; Raine et al., 2005; Raymond et al., 2007; Cleland et al., 2014). Now, the economic literature has barely analyzed effects of advanced EC provision on its usage or the effect of OTC access on sales, revenues, or any other comparable outcome measure.[1] Most studies only cover the U.S. (or even single states) and primarily focus on the effects of greater access to EC pills on abortions, births, or fertility in general, without first assessing whether modified availability actually matters, and if so, to what extent (Girma and Paton, 2006, 2011; Zuppann, 2011; Durrance, 2013; Koohi, 2013; Gross et al., 2014; Cintina and Johansen, 2015; Mulligan, 2016; Cintina, 2017). Usually, this research does

[1] An exception is Gross et al. (2014), who descriptively show that a national policy change in the U.S. increased OTC sales figures.

not find any significant impact on abortions and birth rates. Exceptionally, Cintina and Johansen (2015) exhibit a moderate decrease in abortions. However, this effect is significant only for a very small and young age cohort. In a later study, Cintina (2017) examines the 1998 case of Washington and states similar results for a wider age range. However, this finding is at odds with what Durrance (2013) reports for Washington using different data and identification. So far, thus, this strand of the literature remains inconclusive. Yet another hypothesis within the literature is that increased access to EC pills may lead to behavioral adaptions, where most of this research exclusively focuses on riskier sexual behavior measured by STI rates (e.g., Girma and Paton, 2011; Zuppann, 2011; Durrance, 2013; Mulligan, 2016; Atkins and Bradford, 2015a,b). Hence, these studies abstract from other potential side effects such as an increase in unintended pregnancies, potentially resulting in rising fertility, driven by behavioral changes with respect to sexual activity or contraceptive use. Lastly, Bentancor and Clarke (2017) find significant reductions in fertility and illegal abortions, especially pronounced for teenagers, while studying the mere availability of EC pills in Chile irrespective of any OTC context.[2]

We make several contributions to the existing literature. To begin with, we conduct a Europe-wide analysis of OTC accessibility to EC pills. To the best of our knowledge, there is no research analyzing the effects of prescription-free access to morning-after pills on a multinational level. Such evidence is particularly missing for Europe, where 70% of all abortions from developed countries occurred in 2008, and where EC pills can offer an important remedy (Sedgh et al., 2012). In a necessary first step, we check whether simplified access leads to more frequent use of such drugs. Using registered pharmaceutical data, we causally evaluate impacts on units sold and manufacturers' revenue, aspects the literature has been silent about so far. We then not only examine whether OTC access leads to the desired decline in unintended pregnancies, by looking at abortions, but also investigate other direct and indirect health outcomes to uncover potential side effects. This also means that we do not just focus on teenagers, but consider all women of childbearing age. In so doing, we are first to document a stable increase in fertility due to prescription-free access to the morning-after pill. We further show that this rise is driven by women aged 25–34, who are in rather stable relationships. To complete the picture, we elaborate on underlying channels of the unexpected fertility effect by focusing on within-country evidence from Germany. We contribute with new evidence on contraceptive behavior by exploiting rich pharmaceutical as well as survey data on both conventional hormonal contraceptives and emergency contraceptives. We are able to demonstrate that OTC access to the morning-after pill triggers a substitution between regular contraceptive pills and emergency contraceptive pills, explaining the observed rise in fertility.

[2] Related literature on Chile looks at contraceptive behavior and women's health outcomes (Nuevo-Chiquero and Pino, 2019; Clarke and Salinas, 2020).

We can also show that this substitution channel holds true for other European countries, too. Eventually, on the methodological side, we make use of randomization inference within our DiD framework. RI revises the conventional thought experiment of repeated sampling from an underlying population to a given sample and repeated permutations of, for example, the treatment variable. This implies that there emerges no sampling-based uncertainty but rather design-based uncertainty, which perfectly fits our setting as we have full population data (Abadie et al., 2020).

The remainder of the paper proceeds as follows: In Section 2, we provide background information, introduce the data, and show descriptive evidence. In Section 3, we explain our across-country identification strategy and briefly introduce randomization inference. In Section 4, we present and discuss direct effects, age-group-specific impacts, potential side effects, as well as effect dynamics via event studies. In Section 5, we zoom in on Germany (and other European countries) to elaborate on potential underlying channels by providing both descriptive and causal within-country evidence. We conclude in Section 6.

2 Background and First Evidence

Institutional Details

To prevent unintended pregnancies after unprotected sex, women can choose between different types of emergency contraceptive methods. Most popular is the EC pill, also known as "Plan B" or the "morning-after pill".[3] EC pills are less effective than regular contraceptive methods, and the intake of such drugs is often accompanied by side effects like delayed or early menstruation, headache, nausea, dizziness, or abdominal pain. Hence, morning-after pills should only be used in case of an actual emergency, e.g., when a primary contraceptive fails,[4] and not as a regular method of birth control. Moreover, self-medication might be difficult in general, as many women are badly informed about their menstrual cycle, when and how to use EC, and how regular contraception can be ensured following EC medication (ESHRE, 2015). Consequently, accessibility to the morning-after pill was initially set to prescription-only, including the consultation of a physician.

Essentially, there exist two different types of morning-after pills, containing either lev-

[3] Note that Plan B is the name of one of the most common *brands* of EC pills in the US.

[4] The birth control pill is the most popular contraceptive in European countries (e.g., Eeckhaut et al., 2014 report a share of more than 60% for Germany and Spinelli et al. (2000) show that the pill is ranked first across several European countries), however, it is prone to application errors. Contrarily, long-acting reversible contraceptives (LARC), such as implants or (copper) intrauterine devices, can eliminate application errors, however, are not very popular (11% in Germany according to Eeckhaut et al., 2014 and 14% across several European countries as stated by Spinelli et al., 2000). An exception might be (very) young women in the US, who use LARC somewhat more frequently (Eeckhaut et al., 2014 and, i.a., Kelly et al., 2020).

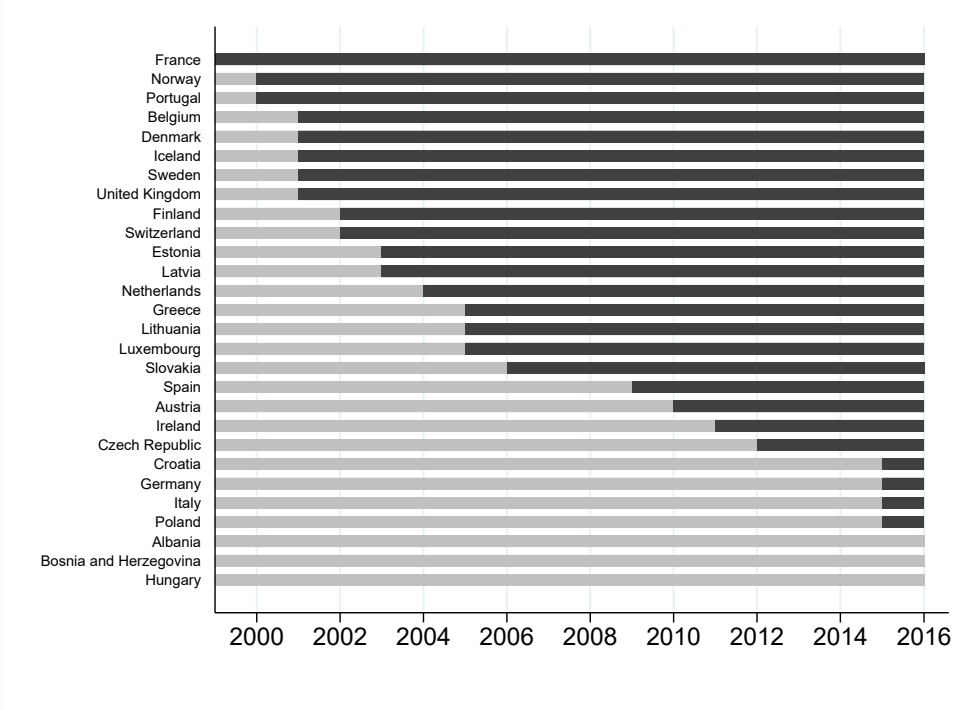


Figure 1: OTC Introduction of EC Pills in European Countries over Time

Note: Timing of the OTC introduction of EC pills in European countries from 1999 to 2016. Light gray bars indicate country-year combinations where the drug is not (yet) available without a prescription. Dark gray bars indicate country-year combinations with OTC access.

onorgestrel or ulipristal acetate, which can be effective up to 72 or 120 hours, respectively. Thus, pregnancies can be prevented up to five days after unprotected sexual intercourse. However, EC pills primarily prevent fertilization by delaying or disrupting ovulation.[5] This means that a pregnancy cannot be prevented if ovulation has already taken place and, consequently, treatment delay is the major factor impeding the drug's effectiveness.[6] More precisely, the pill is effective in about 95% of cases if taken within the first 24 hours, in approx. 85% during the following 24 hours, and only in about 58% afterwards (NHS, 2018). Quick accessibility is, therefore, the most important argument in favor of an OTC regime concerning morning-after pills. Nevertheless, soft factors also play a role. For instance, women may choose not to see a physician because of potential stigma. A meta-analysis of medical papers on EC pill user characteristics across several European countries reveals that the morning-after pill is not only used by teenagers, as is often suspected, but that the average user is in its mid-twenties. Further, it shows that in most countries more than 60% of such women are first-time users.[7]

Over the last 15 years, almost all European countries followed the advice of the European

[5] However, a debate exist whether EC might offer secondary protection of reducing the likelihood a fertilized egg will successfully implant on the uterine wall. See, e.g., U.S. Food & Drug Administration (2020).

[6] This also means that EC pills are not to be confused with so-called "abortion pills", i.e., medication abortion via a combination of mifepristone and misoprostol.

[7] The "Data and Institutional Appendix" contains more detailed country-by-country information on users, OTC implementation dates, approximate costs of the drug, and relevant references.

Commission and introduced EC pills as OTC products. Figure 1 provides a graphical overview of the introduction dates by country.[8] The first European nation providing prescription-free access to EC pills was France in 1999. Norway and Portugal followed suit in 2000, and then Belgium, Denmark, Great Britain, Iceland, and Sweden in 2001. Most recently, Germany, Italy, and Poland switched to OTC access in 2015. Overall, Figure 1 clearly illustrates the regional and temporal variation in the OTC introduction of EC pills. Thus, changes in the legal framework across European countries over the last 17 years constitute an ideal setting for a DiD analysis.

Conceptual Considerations

In many cases, policy interventions do not only reveal, if at all, the desired effects after implementation, but also unintended side effects. This might happen as individuals do not respond completely rationally, as issues of moral hazard emerge, or as behavioral responses in general are ignored. To cover as many important determinants as possible within an empirical investigation regarding the impacts of a switch in the prescription status of EC drugs, one should first think of potential ongoing mechanisms. More precisely, in our context, we consider how women could respond to easier access to morning-after pills.[9]

To begin with, simplifying access to EC pills lowers the burden of obtaining the drug and should have the intended effect that women can take EC medication more quickly, as well as increase the number of women who use the drug. This would lead to fewer unintended and unwanted pregnancies, whereas the latter ("unwanted") should also show up in a reduced number of abortions. Note, however, that EC pills are not as effective as conventional birth control methods in preventing pregnancy. If women respond to easier OTC access with a change in their contraceptive behavior, for example, by no longer using birth control pills, this may also have an opposing effect: an increase in pregnancies, which may then show up as an increase in abortions or, if the pregnancy is unplanned but not unwanted, in a rise in fertility rates.[10]

Another way to think about this is that OTC access reduces the costs of preventing a pregnancy, which may consequently increase risky behavior, that is, unprotected sexual activity or any type of sexual activity. Put differently, moral hazard can appear since women may consider the simplified availability of EC pills as insurance against unintended pregnancy

[8] Information on such introduction dates comes from various sources and is the basis of our treatment indicator (see, e.g., ECEC, 2019; pro familia, 2019; Italia and Brand, 2016). The "Data and Institutional Appendix" contains more details on the treatment, as well as on all dependent and independent variables.

[9] A formal model is discussed in Gross et al. (2014) and similar conceptual considerations are made in Girma and Paton (2011), Durrance (2013), Atkins and Bradford (2015b), and Cintina and Johansen (2015).

[10] An alternative classification would be to differentiate between mistimed and unwanted pregnancies, which then could be considered together as unintended pregnancies, see D'Angelo et al. (2004).

and, thus, engage in riskier sexual activity. Such behavior is well known in economics and is often called the "Peltzman effect". In his study, Peltzman (1975) shows that automobile safety regulations, which should improve traffic safety, actually cause people to drive with less care and to increase risk-taking, leading to an opposing effect.[11] Doleac and Mukherjee (2019) discuss similar counter-intuitive effects in the context of prescription drugs. They find that broadened access to naloxone, a drug that can reverse an opioid overdose if administered quickly, encourages risky behavior with respect to opioid abuse. Philipson and Posner (1995) analyze the relationship between HIV tests and the incidence of AIDS, finding that those with negative tests engage in riskier sexual behaviors and, thus, increase the actual chance of becoming infected. Analogously, Buckles and Hungerman (2018) study the effect of access to condoms at schools and find an increase in teen fertility rates.[12]

In our setting, risky or unprotected sexual activity comprises two different types of risk. First, the risk of getting pregnant, which can be reduced by EC pills. Second, the risk of becoming infected with an STI, which cannot be tackled by EC medication. The latter risk is rather an issue of multiple or changing sexual partners, and should not be a strong factor for women in stable relationships.

Taken together, because many opposing effects may occur, the net effects of OTC access to morning-after pills are a priori unclear and need to be empirically investigated.[13] Thus, we aim at providing a comprehensive picture regarding the effects of the OTC switch to uncover not only the intended results, but also potential unintended side effects.

Data and Descriptive Evidence

We use data from various official and commercial data-bases for our further analysis. To be precise, we obtained data from IQVIA, an information service provider in healthcare, and international institutions such as the World Health Organization, the World Bank, and Eurostat (IQVIA, 2016; WHO, 2018; World Bank, 2018; Eurostat, 2018). From the commercial provider, we received quarterly data on units sold and manufacturers' revenues for European countries from 2005 to the third quarter of 2016. IQVIA provides information from wholesalers and covers both the pharmacy as well as the hospital market. If one would examine the pharmacy market only, an increase in units sold could merely reflect a shift regarding the

[11] Note that Cohen and Einav (2003), using different data and identification, do not find strong support for this kind of effect when re-evaluating mandatory seat belt laws.

[12] For more examples, from various fields within economics, and more general discussions on the effectiveness of regulations and/or incentives see, e.g., Bharadwaj et al. (2020); Cameron et al. (2020); Gneezy and Rustichini (2000); Fehr and Falk (2002); Bowles (2016).

[13] Bear in mind that the mere possibility of obtaining the morning-after pill as an OTC product might cause such changes in women's behavior.

Table 1: Outcome Variables: Summary Statistics

	Mean	SD	Min	Max	N
Sales Figures					
Units Sold (per 1,000 women)	7.0029	3.8458	0.07	20.90	1,353
Manufacturers' Revenue (in € per 1,000 women)	58.7022	35.0475	0.69	204.31	1,353
Direct Health Outcomes					
Abortions (per 1,000 women)	4.58	2.99	0.0	19.5	459
Abortions (per births)	0.22	0.16	0.0	1.2	444
Fertility (births per women)	1.57	0.25	1.1	2.2	504
Births (per 1,000 people)	10.84	1.73	7.8	17.3	504
Birthrate Within Marriages	13.29	3.03	7.4	22.2	454
Birthrate Outside Marriages	7.76	3.99	0.7	20.5	454
Indirect Health Outcomes					
Syphilis (cases per 1,000 people)	0.50	0.76	0.0	6.4	342
Gonorrhea (cases per 1,000 people)	0.86	1.05	0.0	8.2	340
Chlamydia (cases per 1,000 people)	12.98	17.86	0.0	84.1	249
Herpes (cases per 1,000 people)	0.83	1.20	0.0	4.9	107
HIV (cases per 1,000 people)	0.71	1.01	0.0	10.6	345

Note: Means, standard deviations, minimum and maximum values, and the number of observations, N, for all potential outcome variables. Minimum and maximum values are country by year or quarter averages. We observe quarterly data for sales figures and annual data for health outcomes. The "Data and Institutional Appendix" contains more details on all dependent and independent variables.

venue of access from hospitals to pharmacies, and not an increase in use per se.[14] From the latter institutions, we use annual data on health outcomes, as well as data for our control variables, covering 28 European countries from 1999 to 2016. Thus, for most of the outcome variables we have a balanced panel of at most 504 observations from 28 countries over 18 years.

Table 1 provides summary statistics and an overview of the outcome variables. The set of potential outcomes can be categorized into sales figures, as well as direct and indirect health figures. Recall that our data is on country-quarter or country-year level. For instance, a minimum value of 1.1 for fertility corresponds to the smallest average value of births per women over all country-year combinations. Table 9 in the appendix shows analogous descriptives for our control variables, that is, GDP per capita, unemployment rate, male and female youth rate (share of 15- to 19-year-olds), female rate, population density, life expectancy at birth, and a dummy indicating whether abortions are legal for a respective country-year combination.

To determine whether the switch to OTC availability of the morning-after pill actually had an impact, we first report descriptive evidence for several countries in our sample. The evidence indicates clear jumps in sales figures at the time of the respective OTC introduction. Figure 13 in the appendix shows the number of sold packages for all countries with switches in the prescription status of EC pills between 2005 and 2016, namely Slovakia, Spain, Austria,

[14] Indeed, for the U.S., Gross et al. (2014) find a shift in the venue of provision from hospital emergency departments to pharmacies, which is accompanied by a decrease in reports of sexual assault.

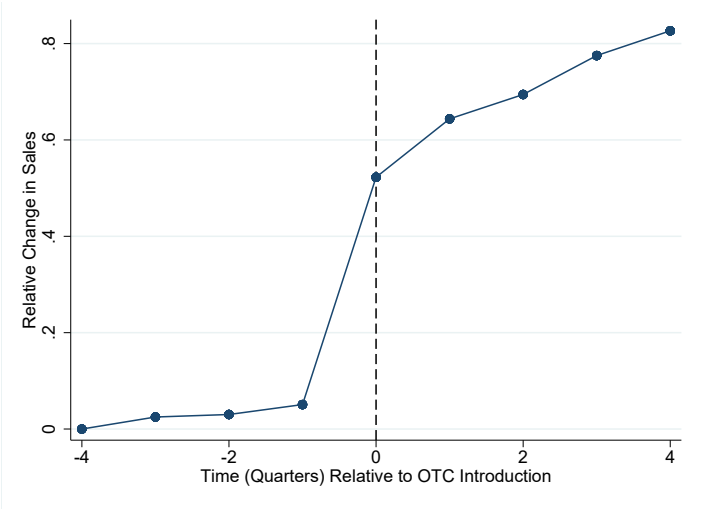


Figure 2: Sales of EC Pills in Europe

Note: Quarterly sales data from 2005 to 2016. Mean changes in quarterly sales of EC pills relative to the fourth quarter prior to the switch, over time relative to the OTC introduction. The dashed vertical line at zero indicates the start of prescription-free access. The figure comprises ten countries for the time span -1 to 4, nine countries for -2, and eight countries for -4 to -3.

Ireland, the Czech Republic, Germany, Italy, and Poland. Most recently, Germany, Italy, and Poland introduced EC pills as OTC products at the beginning of 2015. The sales figures for these three countries exhibit a sharp increase at that precise date. In Ireland, EC pills have been freely available since February 2011, as indicated by an immediate and substantial rise in sales. The same holds for the Czech Republic some months later. Regarding Spain, a first increase in sales figures appears in 2009, followed by an even larger jump in 2010. This jump is due to the timing of the OTC introduction, which happened relatively late in the year, in September 2009.[15]

Figure 2 condenses all country-specific sales data from Figure 13 in the appendix, for which we observe at least four quarters before and after the respective regime switch into a single graph. More precisely, we zoom in on a four-quarter time window around the switch to OTC access. To make countries comparable, we scale units sold and plot mean changes in quarterly sales relative to the fourth quarter prior to the OTC switch. Thus, the line starts from a level of zero at time -4. While quarters -4 until -1 show a quite constant level of approximately zero, sales sharply increase by about 50% immediately at the OTC introduction of EC pills. During the following quarters, this effect continues to rise until it reaches more than 80%.

[15] Data from Google Trends discloses that the demand for news concerning the search term "morning-after pill" increases significantly around the switch to OTC access with a peak exactly during the introduction week. This indicates that knowledge and awareness regarding this topic spread rather fast among the population.

3 Method

Difference-in-Differences with Staggered Treatment Adoption

To evaluate the causal effect of the policy change on our outcomes of interest, we apply a difference-in-differences (DiD) approach that exploits regional and temporal variations in the introduction dates of OTC access to EC pills across Europe. We estimate the following model:

$$y_{ct} = \alpha + \beta \text{OTC}_{ct} + \gamma_c + \delta_t + \text{X}'_{ct}\lambda + \epsilon_{ct}, \tag{1}$$

where y_{ct} reflects the respective outcome variable (e.g., sales, abortions, or births), OTC_{ct} is a dummy variable indicating whether EC pills are available OTC for a certain country-time combination, γ_c and δ_t are country and time fixed effects, respectively, and X_{ct} controls for economic, health, and population conditions of the countries over time.[16] ϵ_{ct} is the error term. The effect of interest is captured by β. Given the staggered adoption of treatment, this overall effect can be seen as a weighted average of all possible two-groups-two-periods (conventional 2×2) DiD estimates and should only be causally interpreted when treatment effects are homogeneous across countries as well as time (Abraham and Sun, 2018; Goodman-Bacon, 2018). We will consider this specific concern in more detail at the end of Section 4. Generally, however, when estimating causal effects using a DiD approach, two fundamental challenges must be addressed. First, the causal effect of the policy change can be identified only under the common trends assumption. This means that absent the intervention, treatment and control group would evolve in the same way. This assumption can never be tested directly, but there are several ways to deal with common trends and examine their plausibility. To relax the identifying assumption, we include country-specific linear time trends (CST) in our richest specification. In so doing, we allow each country to develop differently over time (Angrist and Pischke, 2009). Because we do not want to absorb a potential treatment effect by forcing one single CST across the whole time span, we allow for different trends before and after the OTC introduction, respectively. Furthermore, we have multiple pre- and post-treatment periods in our data and can implement a causality test in the spirit of Granger (1969). The intuition behind such a test is that if effects appear prior to the OTC introduction rather than vice versa, then this would raise doubts regarding the identification strategy. Therefore, we augment Equation (1) with several leads (anticipatory effects) and also lags (post-treatment effects). In other words, we conduct event studies, which allow us to generally explore the

[16] As mentioned above, these are GDP per capita, unemployment rate, male and female youth rate (share of 15- to 19-year-olds), female rate, population density, life expectancy at birth, and a dummy indicating whether abortions are legal for a respective country-year combination.

dynamics of the OTC impact:

$$y_{ct} = \alpha + \sum_{j=-\underline{J}}^{\overline{J}} \beta_j \text{OTC}_{ct}^{j} + \gamma_c + \delta_t + \text{X}_{ct}'\lambda + \epsilon_{ct}. \tag{2}$$

OTC_{ct}^{j} is a binary variable, which indicates that the respective country-time observation is $j = -\underline{J}, ..., \overline{J}$ periods away from the event—in our case the introduction of OTC access. More precisely, we include indicator variables for the points in time before (i.e., leads for $j < 0$) and after (i.e., lags for $j \geq 0$) EC pills were accessible OTC. Point $j = 0$ indicates the time in which a country introduces prescription-free access to EC pills, and we exclude the indicator for the preceding period (i.e., relative time $j = -1$), which then serves as the reference point. Note that Equation (2) reveals the dynamics of the impacts by estimating the effects for each pre- and post-intervention date separately, whereas the results obtained by Equation (1) capture the average effects of the OTC introduction over the entire post-intervention period as a whole. As graphical examples for our sales figures and direct health outcomes, Figures 3, 4, and 6 in Section 4 will show that none of the coefficients on the pre-intervention indicators turns significant, which suggests no violation of the common trends assumption.

(Randomization) Inference in DiD Approaches

The second challenge concerns the correct calculation of standard errors. Many DiD applications have to deal with clustered or serial correlated data, where conventional inference methods lead to standard errors that are, in most cases, too small (Bertrand et al., 2004). A common remedy for such situations is using cluster-robust standard errors, which, however, only lead to asymptotically valid inference. Hence, the problem still persists in finite samples (Cameron and Miller, 2015). As in our study the number of clusters (countries) is rather small (maximum 28), we apply randomization inference (RI) that originated in Fisher (1935) to obtain valid p-values.[17] Because this inferential method relies on non-parametric tests, no assumptions about the distribution of the error terms must be made, and the distribution of the test statistic may be unknown. Thus, RI is especially useful in situations with complex or even unknown structures of the error terms. It revises the conventional thought experiment of repeated sampling from an underlying population to a given sample and repeated permutations of, for instance, the treatment variable. This means that uncertainty is design-based and

[17] Early discussions of RI can be found in Edgington (1995), Kennedy and Cade (1996), and Manly (2006). More recently, Barrios et al. (2012) provide a detailed theoretical and empirical explanation of why researchers should care about the data structure beyond state-level clustering. The application of RI is not restricted only to DiD approaches (Erikson et al., 2010; Pfeifer et al., 2018), but can also be applied within randomized experiments (Young, 2018), the regression discontinuity design (Cattaneo et al., 2015) or, more generally, the potential outcome framework (Ho and Imai, 2006).

not sampling-based, which perfectly fits our setting with full population data (Abadie et al., 2020).

The general procedure can be summarized in four steps. First, the test statistic is computed for the original data set, i.e., the original DiD regression as shown in Equation (1) is run and the corresponding t-value of the estimated effect of interest ($\hat{\beta}$) is stored. Second, the data (in our case, the treatment indicator) is permuted, the regression is run again, and the resulting test statistic is saved. Third, the second step is repeated, for example, $m = 10,000$ times, as in our study. Last, the original test statistic is compared with the distribution of permutation-based test statistics generated throughout the third step. The corresponding RI p-value is determined by the share of the generated randomization distribution, which is greater than or equal to the observed test statistic of the original data, in absolute values for a two-sided test.[18] Thus, we create the reference distribution for testing with the data at hand and do not have to rely on the conventional t-distribution. Since for clustered data, the randomization distribution mostly features fatter tails than the t-distribution, we evaluate the effects of interest more conservatively.

Note that the permutation procedure of our analysis shuffles whole sequences of treatment statuses on a country-by-country basis. This is essential because completely random permutations of the treatment variable could lead to absurd chronologies of the OTC indicator within countries. Specifically, with completely random shuffles, various switches from prescription-only access to OTC (and vice versa) could occur within the considered period. This would be unrealistic because we know from the institutional background that there only appeared one switch per country, namely from prescription-only to OTC. To generate realistic permutations, our RI process acts as if country labels are reassigned randomly, so that, for example, Germany is exposed to Spain's OTC introduction scheme, and so forth.

4 Estimation Results

Effects on Sales

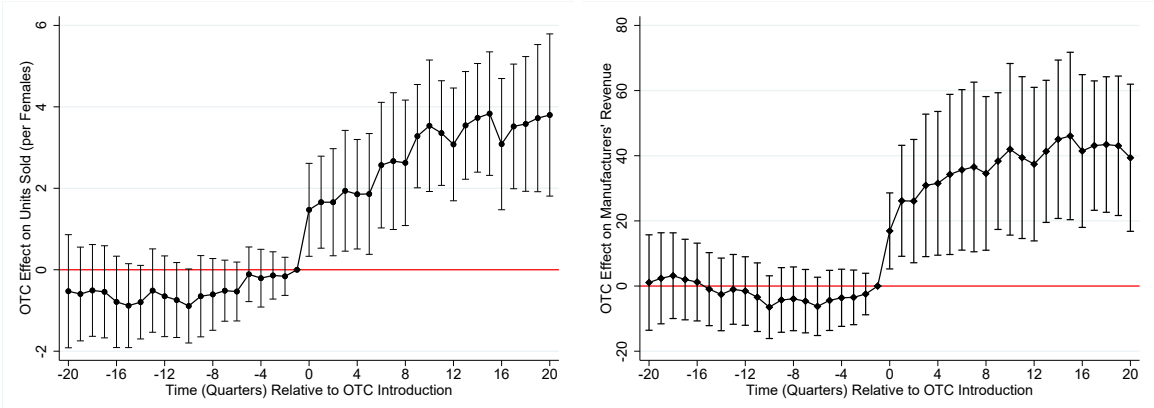
Tables 2 and 3 successively present several specifications across Panels A to D. We start with a raw DiD (Panel A), include control variables (Panel B), use cluster-robust standard errors (Panel C), and additionally include country-specific linear time trends (separately for the periods before and after the OTC introduction), as well as report RI p-values in the richest specification (Panel D).

[18] In order to rely on a pivotal statistic, our RI procedure is based on cluster-robust t-statistics and not on the coefficient of interest, as proposed by Conley and Taber (2011). For more details see Kennedy and Cade (1996) or MacKinnon and Webb (2018).

Table 2: OTC Effects on Units Sold and Revenues

	(1) Units Sold	(2) Manufacturers' Revenue
Panel A: Without Controls		
OTC	3.0451***	28.2459***
	(0.2337)	(2.2486)
Panel B: With Controls		
OTC	2.7667***	27.0053***
	(0.2173)	(2.3583)
Panel C: Clustered		
OTC	2.7667***	27.0053***
	(0.7433)	(8.3292)
Panel D: Country-Specific Trends (CST)		
OTC	2.6839***	29.9693***
	(0.8881)	(10.5252)
RI p-value	[0.0473]	[0.0456]
%-Change	88.51	108.03
$Mean_0$	3.0324	27.7414
N	1,111	1,111
R^2	0.928	0.911

Note: OTC effects on quarterly sales figures; sold units per 1,000 females in (1) and manufactures' revenue in euro (accounted for exchange rate fluctuations) per 1,000 females in (2). $Mean_0$ shows the level in not (yet) affected countries and %-Change the respective relative effect. Standard errors in parenthesis and as of Panel C clustered on country level. The specification for the results presented in Panel D includes separate country-specific linear time trends for the periods before and after the OTC introduction, respectively. Level of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.



(a) Units Sold

(b) Manufacturers' Revenue

Figure 3: OTC Effects on Units Sold and Revenues over Time

Note: Event studies for the outcome variables units sold and manufacturers' revenue per 1,000 females. Leads and lags of the OTC indicator are included in the estimation equation (richest specification with country-specific linear time trends). Resulting coefficients with 95% confidence intervals. For these two outcomes, time stands for quarters.

The estimation results reported in Table 2 show that OTC accessibility of the morning-after pill leads to a significant increase in units sold and manufacturers' revenues, respectively. The effects reported in Panels A and B are very similar, indicating that adding observable characteristics simply increases precision of the estimated treatment effects. This also suggests that there might not be huge differences with respect to unobservables either. The cluster-robust standard errors in Panel C are much larger than the conventional ones in Panel B. For both outcomes, the standard error increases by more than 300%, which points to the existence of a strong cluster-structure in the data. In Panel D, we include country-specific linear time trends, separately for the pre- and the post-intervention period, to relax the common trends assumption. This reduces the OTC effects and their significance levels only slightly. The effects do not vanish and remain statistically significant, which demonstrates the robustness of our results. Even when evaluated more conservatively with RI, see p-values in brackets, the impacts are significant on a 5% level.[19] Quantitatively, Panel D shows that prescription-free availability increases the number of sold packages each quarter by 2.68 per 1,000 female inhabitants and quarterly revenues by €29.97 per 1,000 woman, which can be translated into relative increases of about 89% and 108%, respectively. This underpins the descriptive evidence from Section 2, showing that the availability of EC pills without a prescription leads to more frequent uses, and also shows that this increases revenues by a substantial magnitude. For Europe, where about 274 million women live, a simple back-of-the-envelope calculation shows that a rise in revenue of €0.12 per woman per year can be translated into an annual increase in manufacturers' revenues of more than €32 million.

As discussed in Section 3, the key identifying assumption in DiD approaches is the common trends assumption. We can assess its plausibility and examine effect dynamics via event studies, showing the development of the OTC effects over time. For this purpose, we plot coefficients of the leads and lags as well as corresponding 95% confidence intervals over time relative to the period preceding the OTC introduction, recall Equation (2). Figure 3 shows the results for sales and revenues, respectively. No significant effect appears before OTC implementation, indicating the validity of the common trends assumption. More specifically, all pre-intervention coefficients are very close to zero. In contrast, all coefficients in the post-intervention period are considerably above zero and statistically significant at a 5% level. Moreover, the positive effect after treatment shows a slightly increasing development over time, which is in line with our descriptive evidence.

[19] More details on such RI results, especially corresponding graphical depictions and their interpretation, are provided in the Randomization Inference Appendix. There, we consider all major outcomes examined in this paper.

Effects on Direct Health Outcomes

Table 3 shows impacts of the OTC introduction on direct health outcomes. For birth-related outcome variables, reported in Columns (3) and (4), we estimate effects of a lagged OTC indicator (OTC_L), because it takes nine months from the time of unprotected sexual intercourse until delivery. Columns (1) and (2) report effects on abortions, using as outcomes "abortion rate" (abortions per $1,000$ females) and "abortion ratio" (abortions per births), respectively.

Panels A to C of Column (1) show a decrease in abortion rates due to OTC availability of EC drugs, which is, however, not always statistically significantly different from zero. This is particularly true for Panel C, where we use cluster robust standard errors. Panels A to C of Column (2) report similar results for the abortion ratio. While negative impacts seem a bit stronger here, accounting for the clustered data structure in Panel C shrinks the statistical significance level once again. Moreover, as soon as we include country-specific linear time trends in Panel D, the absolute effect magnitude regarding both abortion measures turns out to be much smaller (-1.2% and -2.4%), approaching zero. This specification is our preferred one as it relaxes the common trends assumption, which is particularly challenging in across-country DiD settings. However, no matter at which panel we look, the respective effect magnitudes are substantially smaller than what one might have expected to reveal: Moreau et al. (2005) discuss that about 40 to 60 percent of (unintended) pregnancies leading to abortions could have been avoided by the use of EC. Taken together, though, the results of Columns (1) and (2) of Table 3 indicate that we are not able to detect a robust reduction in abortions, i.e. an overall negative effect at the population level, due to OTC access to morning-after pills.[20] Having in mind, however, that we showed a clear and strong increase in demand for EC pills in response to the policy, it is indeed informative that we do not find a significant impact on abortions. This might be explained by two opposing effects on abortions canceling each other out, recall the *Conceptual Considerations* section. Analogous to the event studies on sales, dynamic effects for the abortion rate and the abortion ratio are depicted in Figure 4. All of the estimated coefficients for the effect prior to the OTC introduction are insignificant and lie around zero, corroborating the plausibility of the common trends assumption once again. For all of the years throughout the post-intervention period, the OTC effects on abortions also remain close to zero and are statistically insignificant.

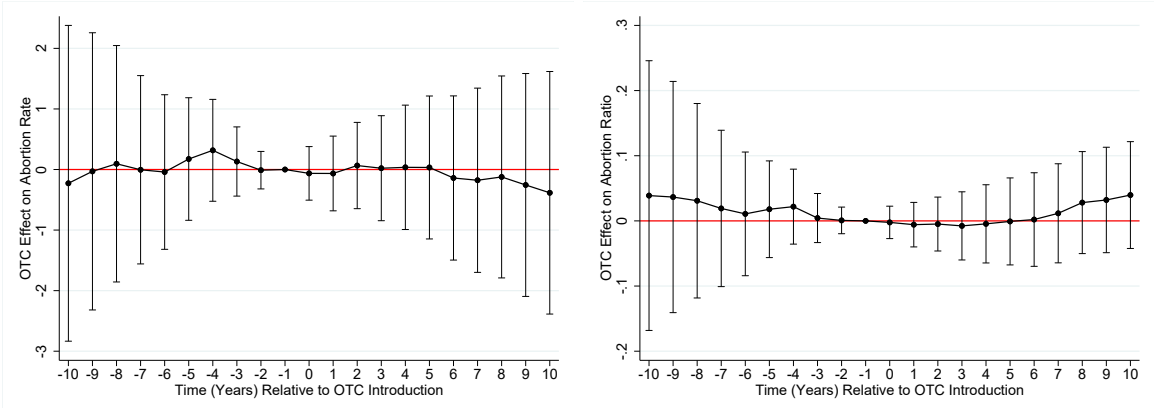
Columns (3) and (4) of Table 3 report positive and highly significant effects of the lagged OTC introduction on the crude birth rate (births per $1,000$ people) and fertility, which are very persistent throughout all panels. When country-specific trends are included, as in Panel D,

[20] Similarly, Table 10 in the appendix reports OTC effects on abortion rates for six age groups from under 20 to 35 or older. The sign of the estimated coefficients switches across the groups and none of the effects is significantly different from zero.

Table 3: OTC Effects on Direct Health Outcomes

	(1) Abortion Rate	(2) Abortion Ratio	(3) Birth Rate	(4) Fertility
Panel A: Without Controls				
OTC(_L)	-0.1639	-0.0310**	0.3145***	0.0732***
	(0.1980)	(0.0126)	(0.1161)	(0.0143)
Panel B: With Controls				
OTC(_L)	-0.4948***	-0.0439***	0.3720***	0.0781***
	(0.1593)	(0.0100)	(0.0965)	(0.0129)
Panel C: Clustered				
OTC(_L)	-0.4948	-0.0439*	0.3720**	0.0781***
	(0.2978)	(0.0222)	(0.1755)	(0.0192)
Panel D: With CST				
OTC(_L)	-0.0467	-0.0052	0.3769**	0.0603***
	(0.2591)	(0.0126)	(0.1432)	(0.0179)
RI p-value	[0.8849]	[0.7609]	[0.0285]	[0.0055]
%-Change	-1.15	-2.40	3.60	4.13
$Mean_0$	4.0481	0.2165	10.4590	1.4589
N (for Panel D)	459	444	504	504
R^2 (for Panel D)	0.987	0.989	0.962	0.968

Note: Lagged OTC (OTC_L) and OTC effects on abortions per 1,000 females in (1), abortions per births in (2), births per 1,000 inhabitants in (3), and fertility in (4). $Mean_0$ shows the level in not (yet) affected countries and %-Change the respective relative effect. Standard errors in parenthesis and as of Panel C clustered on country level. RI p-values in brackets. Fertility is the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year. Level of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.



(a) Abortion Rate

(b) Abortion Ratio

Figure 4: OTC Effects on Abortion Rate and Abortion Ratio over Time

Note: Event studies for the outcome variables abortion rate and abortion ratio. Leads and lags of the OTC indicator are included in the estimation equation (richest specification with country-specific linear time trends). Resulting coefficients with 95% confidence intervals. For these two outcomes, time stands for years.

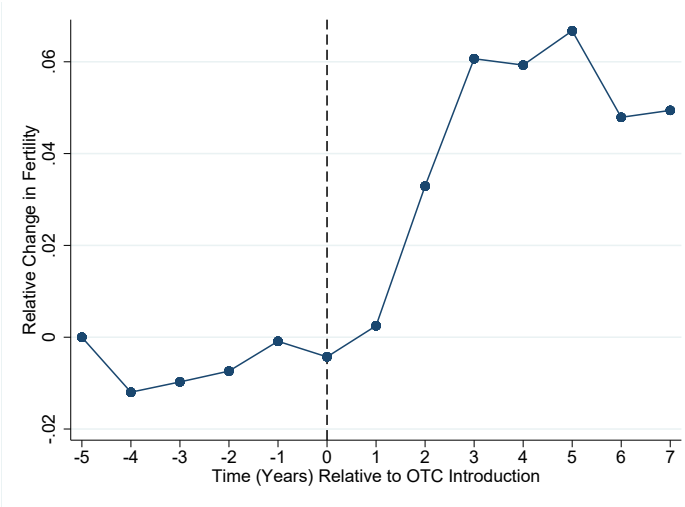


Figure 5: Fertility in Europe Relative to OTC Access

Note: Mean changes in annual fertility over time relative to the introduction of OTC access to EC pills, relative to the fifth year prior to the switch. The dashed vertical line at zero indicates the start of the prescription-free access. The figure comprises twelve countries for the time span −5 to 3, eight countries for 4 to 6, and seven countries for 7.

OTC access increases the birth rate by 0.38, which is a substantial and significant relative increase of 3.6%. In line with that, the fertility rate increases by 0.06, which can be translated into a relative rise of 4.1%. This unexpected, positive effect on fertility is also evident from using our raw data without conducting any estimation. Analogous to Figure 2 in Section 2, Figure 5 shows a descriptive version of an event study. Here, fertility is depicted over time (years) relative to the OTC introduction, where the fifth year prior to treatment is fixed to zero in order to track percentage changes. Already descriptively, one can see a clear increase in fertility after EC pills are accessible without prescription, whereas the development is rather flat in the years before. The rise does not directly start at zero, which shows the naturally induced lagged effect on birth-related outcomes. The average relative change in fertility one to seven years after the OTC introduction is 4.0%, which is in line with the magnitudes of the causal estimates reported in Table 3.

To understand better whether this effect is reasonable and potentially explainable by the mere failure rate of the emergency pill, we provide some back-of-the-envelope calculations. To start with, we can think about bounds of the fertility effect depending on the difference with respect to effectiveness between a regular method of contraception, providing almost 100% protection against pregnancy (when used correctly), and the emergency contraceptive pill. On the low end, we can assume a 5 percentage points difference if women take the EC pill within the first 24 hours. The risk of getting pregnant after unprotected sexual intercourse is approximately 10% if a women is within the three to five peak days of her menstrual cycle ending with ovulation (Wilcox et al., 2001), which yields a potential lower bound of 0.05%

increase in fertility. On the high end, we could assume a 20 percentage points difference with respect to effectiveness if we take the entire five days into account in which the EC pill could prevent a pregnancy. Additionally, if we assume a risk of getting pregnant of 20% given the exact day within the menstrual cycle offering the highest chance to conceive (Wilcox et al., 2001), this results in a potential plus of 4%. Taken together, our OTC-induced fertility finding of about 4% is at the upper bound of what could be explainable by the mere failure rate of the morning-after pill. Hence, it seems likely that only a part of our result is driven by the lower effectiveness of EC pills, and that people also change their sexual and contraceptive behavior. Alternatively, we could set our estimates in a dose-response relation to comprehend how many units of morning-after pills sold, due to OTC availability, trigger an additional birth. The (quarterly) effect on EC sales per 1,000 women was 2.8, that is, approximately 11.2 additional units per year. The (annual) effect on births per 1,000 people was 0.37, multiplied by two—to roughly arrive at births per 1,000 women—results in 0.74. Relating these figures shows that there are $0.74/11.2 = 0.066$ additional births per EC pill sold. In other words, there is an additional birth for every 15 units of morning-after pills sold, or a 6% failure rate leading to births. This exhibits a reasonable figure with regard to the effectiveness of the emergency contraceptive drug, which lies between 95% and 58% depending on the promptness of intake (NHS, 2018).

To investigate whether the unexpected fertility effects are driven by a certain age group of the female population and to get a better sense of what channels might underlie our previous findings, we focus on age-specific fertility in a next step. Table 4 reports lagged OTC effects of our richest specification on fertility for six brackets from 15 to 49 years, as well as the sum of these age-group-specific fertility rates in the last column. Corresponding coefficients are all positive, suggesting that the OTC introduction actually causes a positive net effect and does not merely induce a fertility shift between age groups. The strongest and most significant increases appear for the brackets 25 to 29 as well as 30 to 34.[21] When evaluated by RI, the effects for these intermediate groups remain statistically significant at a 10% and 5% level, respectively. The positive effect on total fertility, the (manually computed) sum of all age-group-specific rates, is also significant and comparable in magnitude to the fertility effect reported in Table 3.[22] Event studies for the OTC effect on overall fertility as well as on fertility in the age group 30 to 34 are reported in Subfigures (a) and (b) of Figure 6, respectively. As before, no significant effects appear in the pre-intervention period. The effects grow stronger during the first few post-introduction years, leading to significant positive impacts after time

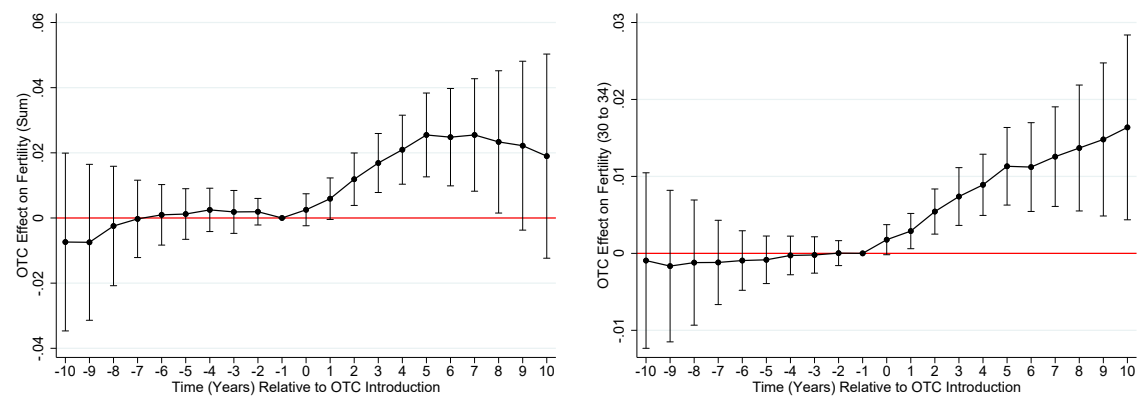
[21] For a graphical depiction, see Figure 14 in the appendix, which plots the OTC effects over the corresponding age groups including 95% confidence intervals.

[22] Note that data on overall fertility (Column (4) of Table 3) and fertility by age groups (Table 4) come from two different sources, which explains the slightly different sample sizes and overall effects. See the Data and Institutional Appendix for more details.

Table 4: OTC Effects on Fertility by Age Groups

	(1) under 20	(2) 20–24	(3) 25–29	(4) 30–34	(5) 35–39	(6) 40 or older	(7) Sum
OTC_L	0.0003	0.0018	0.0026*	0.0025**	0.0000	0.0002	0.0063*
	(0.0004)	(0.0014)	(0.0013)	(0.0011)	(0.0007)	(0.0002)	(0.0035)
RI p-value	[0.4269]	[0.2449]	[0.0636]	[0.0317]	[0.9566]	[0.2852]	[0.0797]
%-Change	2.11	3.26	2.85	3.01	0.00	2.67	2.18
$Mean_0$	0.0142	0.0552	0.0912	0.0831	0.0382	0.0075	0.2890
N	440	443	443	443	443	443	440
R^2	0.986	0.974	0.972	0.989	0.993	0.988	0.979

Note: Lagged OTC effects on fertility in different age groups. Column (7) reports estimates for the sum of all age-group-specific rates. All specifications include state and year fixed effects, as well as GDP per capita, unemployment rate, male and female youth rate, share of females in the total population, population density, life expectancy, an indicator for the legalization of abortions, and country-specific linear time trends. $Mean_0$ shows the level of the respective outcome variables in not (yet) affected countries and %-Change the respective relative effect. Standard errors, clustered on country level, in parenthesis. RI p-values in brackets. Significance levels: $^*p < 0.10$,$^{**}p < 0.05$,$^{***}p < 0.01$.



(a) Fertility (Sum)

(b) Fertility (age group 30 to 34)

Figure 6: OTC Effects on Fertility over Time

Note: Event studies for the outcome variables fertility as the sum of all age-group-specific fertility and fertility of age group 30–34. Leads and lags of the OTC indicator are included in the estimation equation (richest specification with country-specific linear time trends). Resulting coefficients with 95% confidence intervals. For these two outcomes, time stands for years.

0, which is the year of the OTC introduction. This also illustrates the naturally induced, lagged effect on fertility. For overall, summed fertility in Subfigure (a), the effect seems to fade out a bit after eight years.[23] For the subgroup of women aged 30 to 34 in Subfigure (b), however, the positive effect on fertility increases steadily and remains statistically significant even up to ten years after the OTC introduction.

Taken together, the results of Tables 3, 4, and 10, as well as Figures 4 and 6 suggest that our fertility effects are mainly driven by the subgroup of women aged 25 to 34 while there are no (age-specific) impacts on abortions. This is in contrast to related literature from the UK, the U.S., and Chile, which often focuses on teenagers or young adults (Girma and Paton, 2011; Atkins and Bradford, 2015b) or finds stronger effects for young women (Cintina and Johansen, 2015; Cintina, 2017; Bentancor and Clarke, 2017).[24] For our Europe-wide analysis, however, it seems as though the effects are not driven by this young and supposed risk group, but rather by women aged 25 to 34, who are most likely in a stable relationship. As described in the *Conceptual Considerations* section above, a positive effect on fertility could occur if women respond to OTC access substantially stronger with changes in their sexual and/or contraceptive behavior than the drug is effective. For instance, evidence from Germany suggests that there indeed is a decline in the use of the birth control pill coinciding with the OTC introduction, which points to a change in women's general contraceptive behavior.[25] This could explain the stable, unexpected increase in births and fertility of about 4%.

To elaborate on the conjecture that the effects are driven by women aged 25 to 34 in rather stable relationships, we distinguish OTC effects on birth rates (births per $1,000$ females) by marital status. Corresponding results, reported in Table 5, show that OTC access leads to a significant increase in birth rates within marriages. Contrarily, no significant effect (albeit being positive as well) appears for birth rates outside of marriages. These results give us reason to believe that OTC access indeed triggers fertility to rise for the specific sub-group of women in stable relations, in other words, "older" people in long-term relationships such as marriages.[26] Moreover, Figure 16 in the appendix shows representative evidence on Germany,

[23] Figure 15 in the appendix shows a descriptive version of an event study. There, fertility (sum) is depicted over time (years) relative to OTC introduction, where the fifth year prior to treatment is fixed to zero in order to track percentage changes. Already descriptively, one can see a clear increase in fertility after EC pills are accessible without prescription, whereas the development is rather flat in the years before. The mean relative change in fertility for the years after the OTC introduction is 4.1%, which is similar to the causal effects on the respective fertility measure reported in Table 3 and Figure 5.

[24] An exception is the study of Gross et al. (2014), which finds a similar increase in births (2.2%) for the intermediate age group of women aged 18–30. However, they argue that this result might be misleading due to an increasing pre-intervention trend in their treatment group.

[25] More details are provided in Section 5.

[26] When looking at birth order, we find positive, albeit insignificant effects for the first, the second, as well as the third child. Consequently, we conclude that the increase in births is equal regarding the birth order and is thus not driven by the extensive margin or additional children.

Table 5: OTC Effects on Birthrates Within and Outside Marriages

	(1) Birthrate Within Marriages	(2) Birthrate Outside Marriages
OTC_L	0.3033**	0.1580
	(0.1369)	(0.1364)
RI p-value	[0.0396]	[0.2688]
%-Change	2.13	2.64
$Mean_0$	14.2640	5.9947
N	454	454
R^2	0.985	0.994

Note: Lagged OTC effects on birth rates (births per 1,000 females) within and outside marriages, respectively. All specifications include state and year fixed effects, as well as GDP per capita, unemployment rate, male and female youth rate, share of females in the total population, population density, life expectancy, an indicator for the legalization of abortions, and country-specific linear time trends. $Mean_0$ shows the level of the respective outcome variables in not (yet) affected countries and %-Change the respective relative effect. Standard errors, clustered on country level, in parenthesis. Significance levels: $^*p < 0.10$,$^{**}p < 0.05$,$^{***}p < 0.01$.

revealing that the majority of individuals (72%) are in a stable relationship at age 25–29. For age groups 30 and above, this share even increases to more than 85%. Further, about one quarter of individuals aged 25–29 are already married. For the next age group, 30–34, this share more than doubles to slightly below 60%.

Overall, we find a substantial increase in sales caused by OTC access to EC drugs. Hence, one could assume that there was an under-use of the morning-after pill when a prescription was mandatory. This might indicate that the old regime involves too much temporal and/or psychological burden for women, who have to see a doctor first in order to obtain the needed medication. However, we also detect increasing birth and fertility figures, while seeing no reductions in abortions, which is in contrast to the aim of the policy reform. A potential explanation for these effects is that people might change their contraceptive behavior due to simplified access to EC drugs and engage in more and/or more risky sexual activities. Furthermore, one has to consider that the morning-after pill does not provide an absolute protection against pregnancy and is less effective than conventional contraceptives. In the end, this might result in several unplanned—but still not unwanted—children.

Effects on Indirect Health Outcomes

As discussed throughout the *Conceptual Considerations* section above and described with respect to the related literature, simplified access to EC pills may trigger moral hazards in the form of more or riskier sexual behavior (Girma and Paton, 2006; Durrance, 2013; Atkins and Bradford, 2015a,b; Mulligan, 2016). Recall that unprotected intercourse comprises two different types of risks: the risk of getting pregnant and the risk of becoming infected with

Table 6: OTC Effects on Indirect Health Outcomes

	(1) Syphilis	(2) Gonorrhea	(3) Chlamydia	(4) Herpes	(5) HIV	(6) Sum (1)–(4)
OTC	0.1072	0.1628	-1.4121	0.1194	-0.2280	0.8415
	(0.1591)	(0.1244)	(2.0819)	(0.1427)	(0.2289)	(1.6092)
RI p-value	[0.5258]	[0.2128]	[0.5722]	[0.4978]	[0.3745]	[0.6116]
%-Change	21.03	23.60	-24.23	24.37	-47.79	7.89
$Mean_0$	0.5098	0.6897	5.8289	0.4899	0.4771	10.6644
N	342	340	249	107	345	504
R^2	0.884	0.918	0.934	0.955	0.814	0.707

Note: OTC effects on STI rates (cases per 1,000 people). All specifications include state and year fixed effects, as well as controls and country-specific linear time trends. $Mean_0$ shows the level of the respective outcome variables in not (yet) affected countries and %-Change the respective relative effect. Standard errors, clustered on country level, in parenthesis. Significance levels: $^*p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$.

an STI. The former is reflected in the unexpected rise of fertility as already evaluated. It is unclear whether this unintended effect constitutes a truly bad scenario since it is driven by women aged 25 to 34 in rather stable relationships and not by teenagers. However, it seems indisputable that policy makers wish to prevent the latter risk (i.e., infections) in any case for the entire population.

We therefore analyze the effect of OTC access to morning-after pills on risky sexual activity, proxied by several STIs: syphilis, gonorrhea, chlamydia, herpes, and HIV. Corresponding results are reported in Table 6, but should be taken with some caution due to several missing values and difficult data reporting. While percentage impacts seem to be substantial, the OTC effect is statistically insignificant for all of the STI outcomes when including controls and accounting for the clustered data structure.[27] In Column (6), we sum up the STI rates from Columns (1)–(4), which all feature a short incubation period of a few days or weeks. In this regression, we replace missing values with the respective variable's mean and additionally include a missing indicator. Nevertheless, the estimated OTC effect remains statistically insignificant. Similar results occur when missing values are kept, replaced by zero, or the outcome herpes—where most of the missing values appear—is omitted.

Altogether, we find no significant increases in STI rates, which might—at first sight—contradict the hypothesis that easier EC access leads to riskier sexual behavior. An explanation might be that cases of STIs are simply less frequently detected after the OTC introduction. Since women no longer have to visit a doctor to obtain an EC pill, they might skip medical consultations or STI tests. However, as it is the case for syphilis, some undetected cases of disease do not even necessarily result in spreading: people often take antibiotics for any kind of sickness, which then also effectively treat syphilis. Eventually, we saw from the age-group-

[27] We can also not reject the one-sided null hypothesis that these effects are greater than zero.

specific fertility effects, reported in Table 4, that women aged between 25 and 34 react most strongly to the policy reform. The majority of these women in our intermediate age group are most probably in a stable relationship. Moreover, Table 5 showed that the OTC effect is more pronounced for married individuals. For individuals without multiple sex partners, the risk of catching an STI should be negligible. Consequently, due to unprotected intercourse, this subgroup of women faces the risk of getting pregnant, but not the risk of becoming infected with an STI—reflected in positive effects on fertility and insignificant effects on STIs.

Robustness and Heterogeneity

Table 7 reports several robustness checks for the outcomes units sold and fertility and compares them with our baseline specification given by Equation (1), which is provided in Column (1). In the following three columns, we relax the parallel trends assumption by adding linear time trends in different ways. In Column (2), we include country-specific linear time trends for the pre- and the post-intervention period separately, as already done in Panels D of Tables 2 and 3. In Column (3), we include a single country-specific linear time trend over the entire observation period. In Column (4), we replace such trends by group specific pre-trends, where the groups are defined by the timing of the prescription-free availability of EC pills. Eventually, in Column (5), we disaggregate the time fixed effects and include region-by-time effects. For this purpose, we divide Europe into five geographical regions (north, west, mid, east, and southeast). In Column (6), we use the female population of a respective country at a respective year as weights. Since our observations represent averages on country-time level, we account for the underlying amount of single observations with the number of elements that gave rise to these averages. Column (7) excludes countries where abortions were or are still illegal (i.e., Portugal, Spain, Switzerland, Poland, and Ireland), since these countries might constitute a special sub-group.[28] Overall, Table 7 shows that the effects of OTC access stay positive, highly statistically significant, as well as close to our baseline effects in Column (1) and to the effects of our preferred specification in Column (2). However, note that in Panel A of Column (3) the effect on units sold is with 70% quite a bit smaller than both the baseline effect, where we did not include time trends at all, and the effect from our augmented model, where we include country-specific linear time trends separately by pre- and post periods. As shown descriptively in Figures 2, 9, and 13, OTC access does not only shift the number of sold EC pill packages to a higher level, but there is also an increasing trend in sales during

[28] In Switzerland abortions were illegal until 2002, in Portugal until 2007, in Spain until 2010, in Ireland until 2019, and in Poland abortions are still illegal. Recall that we include an indicator for the legal status of abortions in the basic set of our control variables anyway. Overall, however, our main findings, i.e., the effects on sales and fertility figures, do not depend on conditioning on covariates, but already appear in the raw DiD; see Tables 2 and 3.

Table 7: OTC Effects on Main Outcomes across Different Specifications – Robustness Checks

	(1) Baseline without Trends	(2) Pre-&Post Country Trends	(3) Country-Specific Trends	(4) Group-Specific Pre-Trends	(5) Region-by-Time Fixed Effects	(6) Weighted by Female Population	(7) No "Illegal-Abortion" Countries
Panel A: Units Sold							
OTC	2.7667***	2.6839***	2.1051***	2.3743***	2.7786***	2.6804***	1.8424**
	(0.7433)	(0.8881)	(0.5756)	(0.6954)	(0.9821)	(0.6340)	(0.8375)
%-Change	91.24	88.51	69.42	78.30	91.63	95.47	76.23
$Mean_0$	3.03	3.03	3.03	3.03	3.03	2.81	2.42
N	1,111	1,111	1,111	1,111	1,111	1,111	923
R^2	0.862	0.928	0.929	0.871	0.891	0.840	0.862
Panel B: Fertility							
OTC_L	0.0781***	0.0603***	0.0605***	0.0709***	0.0670***	0.0722***	0.0800***
	(0.0192)	(0.0179)	(0.0176)	(0.0176)	(0.0220)	(0.0195)	(0.0218)
%-Change	5.29	4.08	4.10	4.81	4.54	5.13	5.45
$Mean_0$	1.48	1.48	1.48	1.48	1.48	1.41	1.47
N	504	504	504	504	504	504	414
R^2	0.922	0.968	0.960	0.936	0.938	0.964	0.915

Note: OTC effects on units sold per 1,000 females in Panel A, and lagged OTC (OTC_L) effects on fertility in Panel B. $Mean_0$ shows the level in not (yet) affected countries, and %-Change shows the effect relative to the outcome level in not (yet) affected countries. Column (1) is the baseline specification as expressed in Equation (1) without any time trends. Column (2) includes country-specific linear time trends for the pre- and the post-intervention period separately, as in Panels D of our main Tables. Column (3) includes a single linear time trend for each country. Column (4) includes timing-group specific pre-trends. Column (5) includes region-by-time fixed effects. Column (6) weights by female population. Column (7) excludes countries where abortions were or are still illegal. Standard errors in parenthesis, clustered on country level. Level of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the post-intervention period. Hence, by including only one single linear time trend for each country, the overall slope is steeper than the slope in the pre-period in case of separate trends, which might absorb parts of the OTC effect. Moreover, in Column (7), the effect on units sold becomes a bit weaker, which means that the effect of OTC access on sales is even more pronounced in countries where abortions are still illegal or have been restricted in the past. This seems plausible because in these countries the morning-after pill is (was) the only alternative to prevent unintended pregnancies after unprotected intercourse. Analogously, the effect on fertility is slightly stronger, which points towards a more consequent prevention of pregnancies in countries where abortions are or were no option.

As already mentioned in Section 3, a DiD approach with staggered treatment adoption is an extension of the classical DiD setting, where only two groups (control and treatment) and two periods (before and after) exist. In the extension with multiple groups and periods, the general estimator is a weighted average of all possible 2×2 DiD estimates (Goodman-Bacon, 2018).[29] Figure 7 reports the results of two examinations we perform in order to investigate the time-varying nature of the treatment variable and its components. For units sold, Subfigure (a) plots each 2×2 DiD estimate against their weights, calculated according to

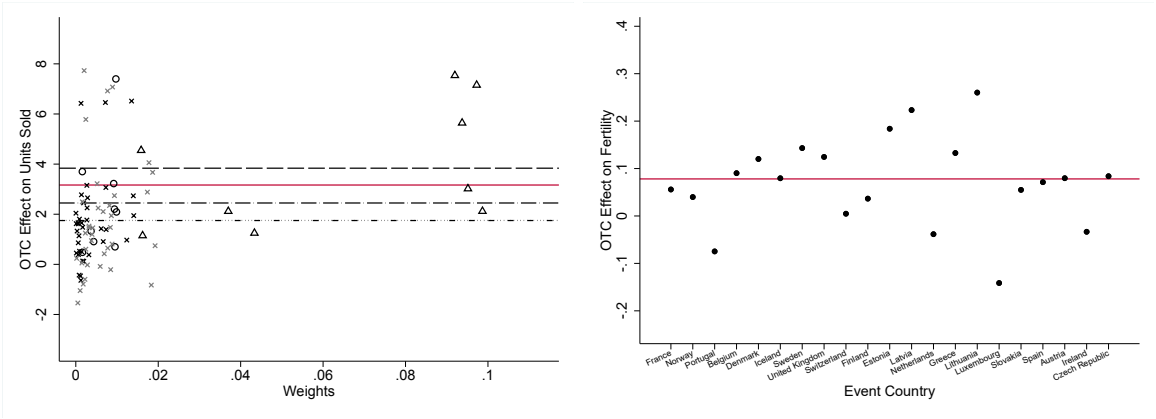
[29] For more details on DiD with staggered treatment adoption see, for example, Abraham and Sun (2018); Athey and Imbens (2018); Borusyak and Jaravel (2017); Callaway and Sant'Anna (2018).

the DiD decomposition theorem proposed by Goodman-Bacon (2018). The different symbols (circles, triangles, and x's) of the single 2×2 effects indicate the type of countries that are used as control and treatment group. Not only always- and never-treated countries can serve as control group, but also countries with a switch in the treatment variable (timing group). In such cases, the period before or after the treatment introduction is omitted. The open circles are estimates where one timing group acts as treatment group and the never treated country as control group. The open triangles are estimates where one timing group acts as treatment group and the pre-2005 OTC countries—the always-treated, so to speak—as control group. The x's are timing-only estimates, where an early treated country acts as treatment group and a later treated country as control group (black x's), or vice versa (gray x's). The DiD estimate from the two-way fixed effects regression, given by Equation (1) and indicated by the red horizontal line, equals the average of the y-axis values weighted by their x-axis values. The dashed lines indicate the average DiD effects of the timing-only (dots and short dash), the untreated (long dash), and the pre-2005 OTC (long dash dot) comparisons. The average DiD estimates of the respective groups are considerably above zero and lie closely around the overall effect. The averages of the two timing-groups (early treated vs. late control and early control vs. late treated) are very similar, thus, the short dashed and the dotted lines overlay. All in all, Subfigure (a) shows that almost all 2×2 estimates are positive and most of them are substantially larger than zero, which indicates the robustness of our DiD setting with respect to its components or underlying groups.

Next, to examine the heterogeneity of our effects we conduct a country-by-country analysis in the style of Cengiz et al. (2019). Subfigure (b) shows OTC effects on fertility for each country that introduced OTC access separately. For this purpose, we conduct separate regressions for each country by keeping an event-window of ten years ($t = -5, ..., 4$ with the treatment indicator switching on at $t = 0$), and countries without any change in the treatment variable within this time frame as clean control units. The red horizontal line indicates the fertility effect from our preferred specification. The countries on the x-axis are ordered chronologically with respect to the OTC introduction of EC pills. It becomes visible that most of the estimates with a single country as treated group are very close to the overall OTC effect on fertility, which indicates a homogeneous treatment effect across the different units of our DiD setting.[30]

To assess the robustness of our results even further, we eventually consider the estimator proposed by de Chaisemartin and D'Haultfoeuille (2019). In their paper, they show that the occurrence of heterogeneous treatment effects might result in misleading or invalid estimates of the commonly employed two-way fixed effects estimator. This problem can arise when already-treated units serve as control group and negative weights are assigned to their effect

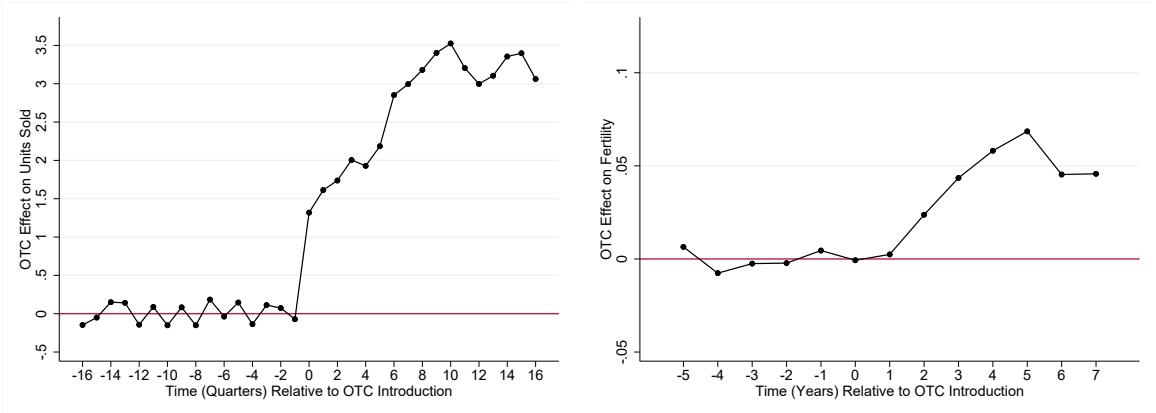
[30] One negative outlier, for example, appears for Luxembourg, which is one of the smallest countries in our data set.



(a) 2x2 DiDs for Units Sold (b) Country-by-Country DiDs for Fertility

Figure 7: 2x2 and Country-by-Country DiD Estimates for Units Sold and Fertility

Note: Subfigure (a) plots each 2 × 2 DiD estimate against their weights calculated according to the DiD decomposition theorem proposed by Goodman-Bacon (2018) for units sold. The open circles are estimates where one timing group acts as treatment group and the never treated country as control group. The open triangles are estimates where one timing group acts as treatment group and the pre-2005 OTC countries as control group. The x's are timing-only estimates, where the early treated group acts as treatment group and the later treated group as control group (black x's) and vice versa (gray x's), respectively. The DiD estimate from a two-way fixed effects regression, indicated by the red horizontal line, equals the average of the y-axis values weighted by their x-axis values. The dashed lines indicate the average DiD effects of the timing-only (dots and short dash), the untreated (long dash), and the pre-2005 OTC (long dash dot) comparisons. Subfigure (b) shows OTC effects on fertility for each country separately within a 10-year window and pure controls. The red horizontal line indicates the baseline effect on fertility. This exercise is based on the study of Cengiz et al. (2019).



(a) Effect on Units Sold (b) Effect on Fertility

Figure 8: OTC Effects on Units Sold and Fertility

Note: The figures show OTC effects obtained by using the estimator proposed by de Chaisemartin and D'Haultfoeuille (2019), that is valid even if the treatment effect is heterogeneous over time or across groups, on units sold and fertility in Subfigures (a) and (b), respectively. In Subfigure (a), time stands for quarters; in Subfigure (b), time stands for years.

contribution in the calculation of the overall average treatment effect. As a consequence, de Chaisemartin and D'Haultfoeuille (2019) introduce a new estimator, which is valid even if the treatment effect is heterogeneous over time or across groups. Figure 8 shows corresponding effects of OTC access to the morning-after pill on units sold in Subfigure (a) and on fertility in Subfigure (b). These results are in line with what we have reported before by using the two-way fixed effects estimator and our event study approach, emphasizing their robustness.

5 Exploring Channels by Zooming in on Germany

EC Pill Sales and Contraceptive Behavior

In a next step, we provide evidence for potential mechanisms driving the aforementioned results. We focus on a single country, Germany, which introduced OTC access only very recently and for which we have additional monthly data on the morning-after pill, as well as on other hormonal contraceptives, births, and individual survey data regarding contraceptive behavior. Data on sales figures comes from the commercial information service provider IQVIA, and official data on health outcomes are available from the German Federal Statistical Office (IQVIA, 2018; Destatis, 2018). In order to study potential adjustment behaviors, we rely on a survey called pairfam ("Panel Analysis of Intimate Relationships and Family Dynamics"), a longitudinal study on German couples (Brüderl et al., 2018), as well as the German Socio-Economic Panel (SOEP), a representative annual survey of $11,000$ households covering $20,000$ individuals (Wagner et al., 2007).

Germany became subject to the policy change when access to EC pills switched from prescription-only to OTC in the middle of March 2015. Figure 9 illustrates the number of packages sold per month from January 2010 to December 2018. In the prescription-only regime, the number of packages sold was slightly increasing from $30,000$ to around $40,000$. After the OTC introduction, there appears an immediate and sharp increase to approximately $60,000$ packages, a plus of about 50%. Moreover, the upward sales trend has a steeper slope over the available post-intervention period than during the months before and even reaches a level of about $80,000$ packages per month in December 2018. This descriptive evidence not only shows that the policy change has an instant, strong, and positive impact on sales figures of EC pills in Germany, but also that our within-country data is totally in line with what we found for Europe as a whole.[31]

[31] Recall that this is data from wholesalers. For Germany, we can also rely on monthly data from a pharmacy panel conducted by Insight Health, see Figure 17 in the appendix. There, we see similar numbers and the same immediate increase in the number of EC pills in March 2015, the month when prescription-free access was introduced. This gives us reason to believe that our preferred wholesales data is a reliable proxy for actual sales to *end users*, and does not merely reflect anticipation in the form of stockpiling. Furthermore, we again

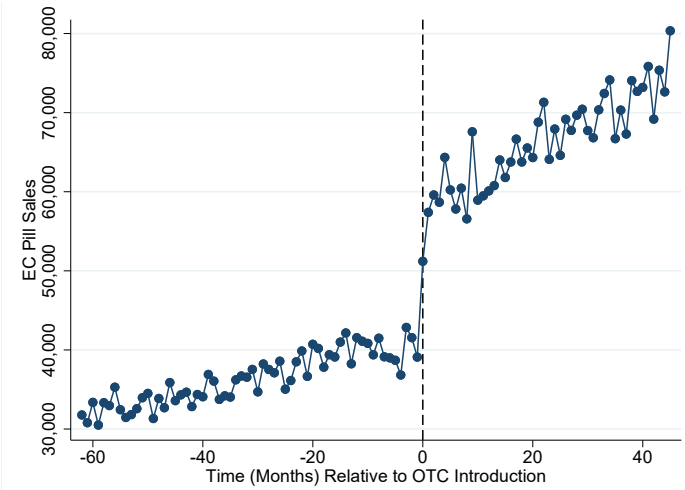


Figure 9: Monthly Sales of EC Pills in Germany

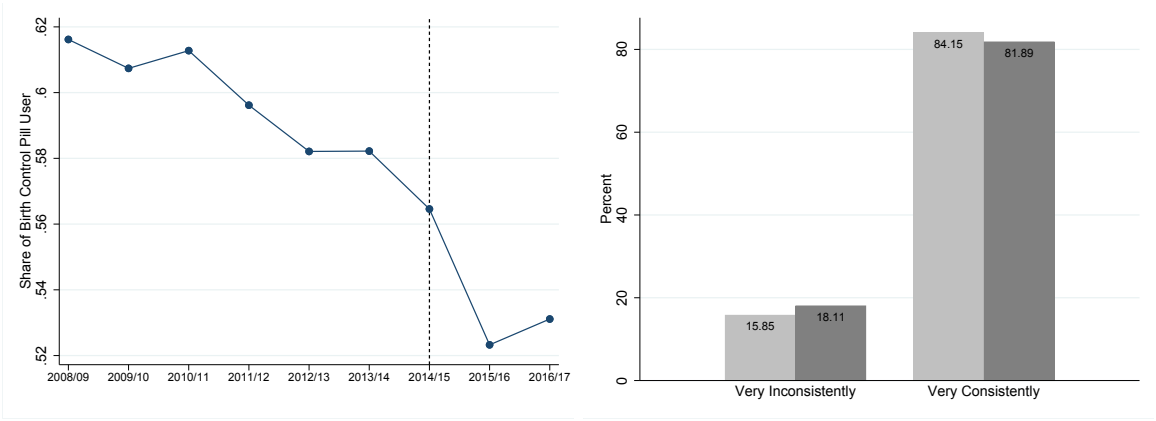
Note: Monthly sales of packages of EC pills from January 2010 to December 2018. The dashed vertical line indicates March 2015, the month in which EC pills became available OTC in Germany.

In order to provide evidence that might corroborate our hypothesis on behavioral responses, we refer to survey data from the German Family Panel pairfam, aimed at researching partnership and family dynamics. Figure 10 yields two merely descriptive depictions, which still deliver interesting insights on how people report about their contraceptive behavior in connection to OTC availability of the morning-after pill. Subfigure (a) shows an overall decreasing trend in the share of individuals stating to use the birth control pill as a method of contraception over the last six years. This negative development sharply intensifies at exactly the time EC pills became accessible OTC. Further, Subfigure (b) shows how consistently or inconsistently respondents use a regular method of contraception, broken down by people having access to EC pills with or without prescription, respectively.[32] Although differences between the two groups do not seem to be huge, it can be seen that people with OTC access (dark grey) report to use regular contraceptives more inconsistently and less consistently, respectively, as compared with people needing to see a doctor first and get a prescription in order to access EC pills (light grey). Actually, these differences turn out to be statistically significant at a 5% level.[33] Taken together, this snapshot of survey data indicates that the decline in use of the birth control pill is amplified by OTC access to the morning-after pill. Moreover, at the same time, individuals might engage in riskier behavior with respect to how consistently they use

observe a persistently higher level of sales under the OTC regime, which also goes against stockpiling.

[32] Because over all nine waves of the pairfam dataset individuals might differ with respect to age, relationship-length and -status, etc., we restrict the sample to waves 7 (2014/15) and 8 (2015/16), hence, closely before and after the OTC introduction.

[33] In addition, the relationship status of those who indicated that they have used emergency contraception is slightly more often a stable relationship (53%) than single (47%).



(a) Birth Control Pill User over Time

(b) Consistent Use of Contraception

Figure 10: Contraceptive Behavior in Germany

Note: Subfigure (a) shows the share of individuals, who use the birth control pill as method of contraception. Subfigure (b) shows how consistently respondents use their method of contraception. Only waves 7 (2014/15) and 8 (2015/16) are used to counter selection concerns. Light and dark grey indicate prescription-only and OTC access to EC pills, respectively.

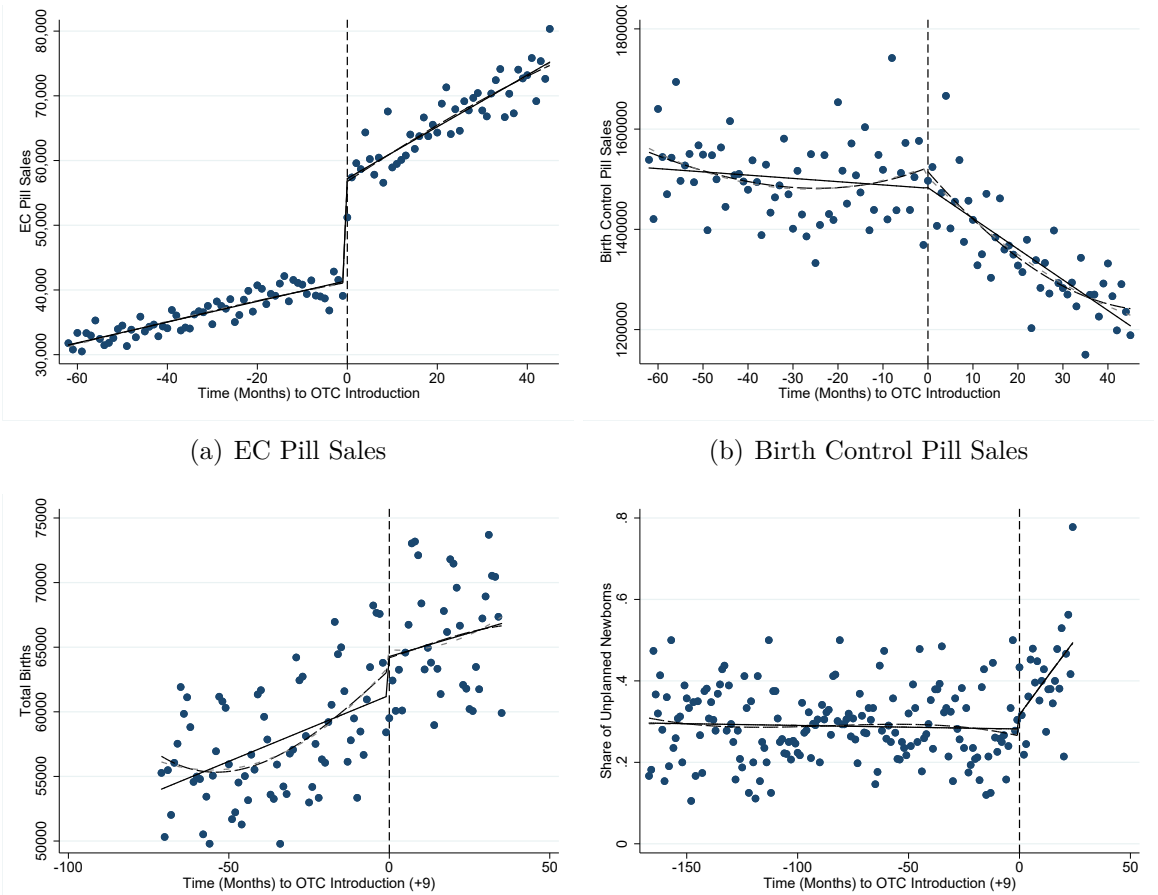
a regular contraceptive method, potentially explaining the rise in fertility figures.

When Plan B Becomes Plan A

By focusing on Germany, the only variation in OTC access is over time, because prescription-free availability was introduced nationwide at the same time for all regions and women of all ages. Besides providing descriptive evidence or plotting outcomes over time in an event study style, we can rely on a regression discontinuity in time (RDiT) approach whenever we have high frequent data and observe enough data points around the cutoff (see, e.g., Auffhammer and Kellogg, 2011; Anderson, 2014). RDiT is a special case of the classical regression discontinuity design (RDD), where time is the so-called running or forcing variable. Thus, one has to account for this special feature by applying time series techniques as discussed by Hausman and Rapson (2018). According to Imbens and Lemieux (2008), one estimates the following model when adopting an RDiT approach:

$$y_t = \alpha + \beta \text{OTC}_t + \gamma_1 \text{time}_t + \gamma_2 \text{time}_t \cdot \text{OTC}_t + \epsilon_t, \tag{3}$$

where y_t reflects the respective outcome variable (sales of EC pills and other hormonal contraceptives, births, or unplanned newborns) for Germany as a whole at time t. OTC_t is a dummy variable indicating whether EC pills are available OTC. A flexible function of time, which is normalized to zero for the month where access switched to OTC, is defined as $\gamma_1 \text{time}_t + \gamma_2 \text{time}_t \cdot \text{OTC}_t$ and should absorb everything that changes outcome y_t smoothly around the cutoff. ϵ_t is the error term. Thus, β is the coefficient of interest, the immediate



(a) EC Pill Sales

(b) Birth Control Pill Sales

(c) Births

(d) Unplanned Newborns

Figure 11: EC Pill Sales, Pill Sales, Births, and Unplanned Newborns over Time

Note: Raw data for EC pill sales and other hormonal contraceptive sales (subfigure caption just states "Pill" for the sake of brevity and because this category is mostly comprised of the pill), as well as number of births and share of unplanned newborns over time relative to the OTC introduction of EC pills, indicated by the vertical, dashed line. For birth outcomes in Panels (c) and (d), "time 0" is lagged by nine months. The black, solid lines indicate the fitted values of a simple, linear RDiT specification without any controls. The black, long-dashed lines show fitted values when squared time trends are included, and the gray, short-dashed lines when cubic time trends are included.

OTC effect, for which we obtain an unbiased estimate under the RD assumption that ϵ_t does not change discontinuously at the policy introduction (Anderson, 2014). γ_1 is a general, linear time trend for the entire observation period, and γ_2 indicates a potential change in the time trend for the post-intervention period.

As a starting point, we plot raw data for sales of EC pills and other hormonal contraceptives, as well as the number of births and the share of unplanned newborns over time relative to the OTC introduction. This is shown in the four subfigures of Figure 11. The vertical, dashed lines indicate the policy change, where for the birth outcomes, "time 0" is lagged by nine months. First, we try to fit the data with a basic, linear RDiT specification without any controls, as described by Equation (3). The fitted values are depicted by black, solid lines. Second, we additionally include time in a quadratic as well as a cubic form to account for

potential non-linear developments of our outcome variables over time. This is indicated by the black and gray dashed lines, respectively. At first sight, a clear jump as well as a positive turn of the slope become visible for EC pill sales shown in Subfigure (a). For the sales of regular hormonal contraceptives, mostly consisting of the birth control pill and shown in Subfigure (b), it seems that there is no immediate drop. However, the slope becomes much more negative after the cutoff indicating a reduction in the use of the regular pill once the emergency pill becomes available OTC—in line with Subfigure (a) of Figure 10.[34] Subfigure (c) shows a jump in the overall upward-trending number of births, and Subfigure (d) suggests an increasing trend in the share of unplanned newborns.[35]

Overall, however, our outcomes seem to exhibit strong seasonal patterns. Consequently, and thirdly, we control for seasonality and augment Equation (3) by including month fixed effects. Further, to estimate proper OTC effects given the time series structure of our data, we examine (partial) autocorrelations for each outcome variable separately. We include up to four lags of the dependent variable or add a 12th lag if the respective series shows a visible seasonal pattern to accommodate the dynamic structure of each time series. This is done until the residuals appear to be white noise and residual correlograms as well as Portmanteaus tests do not indicate any significant autocorrelations anymore. Alternatively, we provide smoothed versions of the four graphs shown in Figure 11 by using annual aggregates and linear pre- and post-treatment fits, which is depicted in Figure 18 in the appendix.

Results of our preferred specification are shown in Table 8. The two rows show the immediate effect of the OTC introduction (OTC(_L)) and the potential impact on the time trend throughout the post-intervention period (Time·OTC(_L)).[36] Consistent with the results we found using the DiD approach for Europe, we detect a highly significant and strong increase in sales of EC pills for Germany with a jump of about $18,000$ packages or 50% in relative terms. Analogously, we find a highly significant increase of about 3.6% in births nine months after the OTC introduction.[37] As already mentioned above, an explanation for such a positive effect on births might be a change in contraceptive behavior. Column (2) reports respective results for sales of all hormonal contraceptives other than EC pills, which mostly consists of the birth control pill. We find a significant, direct decrease in pill sales of 2.5% and a strong,

[34] Note that the birth control pill is usually soled in packages containing three or six blister packs (with single pills) for one month each, and one should actually talk to the gynecologist before stopping the intake. Thus, although women might decide to finish regular hormonal contraception immediately at the time of OTC introduction of EC pills, it might need some months until this is reflected in the sales figures.

[35] The SOEP contains a special questionnaire on mothers and their newborns. There, it is asked whether the pregnancy was rather unplanned or planned. For more details, see the Data and Institutional Appendix.

[36] Note that the policy change occurred exactly in the middle of March, which raises the question whether the observation for entire March should be considered as treated or not. Thus, we omit observations for March 2015.

[37] Eventually, as in the European case, we also cannot find any significant effect on abortions. Corresponding results are not reported in the paper and are available upon request.

Table 8: OTC Effects on EC Pill Sales, Pill Sales, Births, and Unplanned Newborns

	(1) Sales EC Pill	(2) Sales Pill	(3) Births	(4) Unplanned
OTC(_L)	18,102.5522***	-37,949.9088*	2,089.9675***	0.0493
	(2,090.6216)	(19,657.4211)	(613.6377)	(0.0490)
%-Change	49.73	-2.53	3.63	6.06
Time·OTC(_L)	254.7649	-10,879.0972**	-49.7832	0.0103***
	(191.9074)	(4,910.4079)	(98.6661)	(0.0038)
$Mean_0$	36,399.77	1,502,662.00	57,594.89	0.2892
Time, Time^2, Time^3	X	X	X	X
AR(4)	X	X	X	X
12th Lag	X	X	X	X
N	95	95	94	179
R^2	0.992	0.939	0.978	0.294

Note: OTC effects on sales of EC pills and other hormonal contraception (column head just states "Pill" for the sake of brevity and because this category is mostly comprised of birth control pills), number of births, and share of unplanned newborns. All specifications include month fixed effects. For birth outcomes in Columns (3) and (4), the OTC indicator is lagged by nine months, OTC_L. Significance levels: $^*p < 0.10$,$^{**}p < 0.05$,$^{***}p < 0.01$.

statistically significant decrease in the time trend for the post-intervention period—an additional drop of approximately 11,000 packages per month. This underpins the hypothesis that, as a reaction to OTC access of EC pills, women might change their contraceptive behavior by cutting the daily intake of hormones, while having in mind that the morning-after pill is now easily accessible. The combination of a reduced intake of birth control pills, a less effective morning-after pill, and potentially under-informed, more risky behaving people, might trigger an increase in unplanned, but not unwanted, children. To elaborate on this conjecture, we finally have a look at survey data in Column (4), where mothers indicated whether the pregnancy of a respective newborn was rather planned or not. Indeed, we find a strongly increasing trend in the share of unplanned newborns starting right after nine months of OTC access to the morning-after pill. A simple before-after comparison shows that the share of unplanned newborns increases significantly from 29% to 40%.

Taken together, these findings point to a strong substitution effect between emergency contraceptive pills and regular contraceptives. To get a more precise feeling of how much of our overall fertility finding could indeed be driven by this substitution channel, we conduct a simple back-of-the-envelope calculation. If we assume a difference in effectiveness between the birth control pill and the morning-after pill of 5 percentage points (within the first 24 hours), and a positive sales effect around the German cutoff of 20,000 units, this would lead to 1,000 additional children born—if we assume that one emergency pill sale was intended to prevent one birth. These additional 1,000 children scaled by the baseline number of about

60,000 before the cutoff would mean a plus of 1.7%, which is about half the magnitude of the OTC-driven fertility effect we find for Germany. This would mean that there is some room for other behavioral responses besides the substitution effect, for example, an increase in (risky) sexual activity. However, it could easily be that not all women react within the first 24 hours, which makes the difference in effectiveness compared with the birth control pill quite a bit larger. This, in turn, might lead to a point where the entire fertility effect is driven by substitution, for example, if the difference in effectiveness would be approximately 10 percentage points on average.

Other Countries, Same Channel

To exemplify that the proposed channel is not merely due to specific characteristics of a certain country, Germany in this case, we present further evidence on other European countries. We start with the Czech Republic, a country that introduced EC pills as OTC product in the fourth quarter of 2011. Importantly, we have annual sales data of the regular birth control pill from the Czech Republic's State Institute for Drug Control (Kafkadesk, 2020). What is more, we already know that the Czech Republic also shows a strong first stage response, i.e., a distinct jump in sales of morning-after pills of approximately 45% immediately after their OTC availability. As is the case for Germany or Europe as a whole, this development continues to further increase over time, see Subfigure (e) of Figure 13 in the appendix. Eventually, the Czech Republic is an interesting case to look at since it delivers a country-specific fertility response completely in line with our causal estimate for overall Europe, recall Subfigure (b) of Figure 7.

Figure 12 shows annual sales data on the regular birth control pill in the Czech Republic from 2005 until 2017, the period mirroring the time frame of Figure 13 in the appendix. While the annual frequency does not allow for a causal analysis as conducted for Germany where we were able to use monthly data, the mere descriptive evidence appears to be quite clear already. Pre-period pill sales are relatively stable with around 3.4 million throughout the six-year window where the morning-after pill was still only accessible with a prescription. Shortly after the introduction of OTC access, however, we can see a distinct and ongoing decline in demand of the regular pill, reaching 2.1 million in 2017. This development seems even more pronounced as what we have observed for Germany.

Eventually, analogous evidence on further European countries demonstrates the stability of this substitution pattern from regular to emergency contraceptives. Looking at Spain, for example, where OTC access to EC pills was introduced in the third quarter of 2009, Carrasco-Garrido et al. (2016) show a significant decrease of almost 30% in the consumption of oral contraceptives from 2006 to 2012. For Switzerland, which switched to OTC availability in the

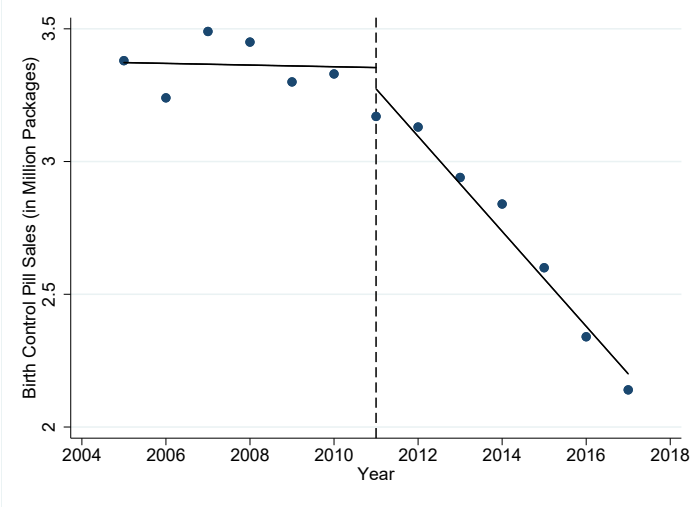


Figure 12: Birth Control Pill Sales over Time in the Czech Republic

Note: Annual hormonal contraceptive sales in million packages ("Birth Control Pill" for the sake of brevity and because this category is mostly comprised of birth control pills). Linear fits are provided for the pre- and post-periods, respectively. The OTC introduction of EC pills in 2011 is indicated by the vertical, dashed line.

fourth quarter of 2002, Späth et al. (2017) demonstrate that the share of women using the regular birth control pill is 30% for the pre-period from 1992 to 2002. This share shrinks to a noticeable lower level of 18% in 2007, reflecting a relative decrease of 40%. While this country-specific evidence might not be perfectly comparable with each other concerning time frames and other domestic features, all available information points to the same channel discussed above: a substitution from a highly effective (the birth control pill) to a less effective (the EC pill) contraceptive method, which in turn can explain the positive fertility finding in response to OTC availability of the morning-after pill.

6 Conclusion

We analyzed intended and unintended impacts of over-the-counter (OTC) access to emergency contraceptive pills by examining sales, revenues, and health outcomes. Exploiting the timing of OTC introductions across European countries and years, we identified these effects via a difference-in-differences strategy with staggered treatment adoption. We evaluated corresponding estimates with randomization inference to account for the clustered data structure and to present conservative results. By zooming in on Germany and applying a regression discontinuity approach, we elaborated on potential underlying mechanisms.

In a nutshell, we find a significant and substantial increase in units sold and manufacturers' revenues, no effects on abortions, no effects on STIs, but a stable increase in births and fertility. The latter effects are driven by women aged 25 to 34, and not by teenagers, as often discussed

in the literature regarding single countries or specific settings. Put differently, while we find no evidence that the introduction of EC pills' OTC availability causes the number of unintended pregnancies to decline, the clear and significant increase in sales figures points to an under-use of EC pills in the prescription-only regime. Further, the robust increase in births and fertility in combination with insignificant effects on STIs points to more unprotected sexual activity of individuals in rather stable relationships. This is corroborated by evidence that the fertility effect rather stems from within marriage relations as opposed to outside marriage relations. Moreover, our within-country study shows that OTC access to the morning-after pill triggers a declining use of conventional hormonal contraceptives (e.g., birth control pills), which indicates a substitution between regular contraceptives and emergency contraceptives. Taken together, while we present new causal evidence on sales and revenues, our findings with respect to health outcomes are at odds with the existing literature. Such research often focuses on the U.S., other single countries, or even sub-groups or sub-regions within a given country, and mostly finds no effect on abortions, no effect on fertility, but an increase in STI rates due to better access to EC pills (Durrance, 2013; Girma and Paton, 2011).

In the end, whether liberal OTC access to EC pills is the superior regime lies in the eye of the beholder or depends on the respective policy maker's objective. OTC access clearly increases awareness, purchases, and use of the morning-after pill, thereby boosting profits for the pharmacy sector. For Europe, where about 274 million women live, a simple back-of-the-envelope calculation shows that a rise in revenue of €0.12 per woman per year can be translated into an annual increase in manufacturers' revenues of more than €32 million. However, the focus of policy makers is predominantly on reducing unintended pregnancies. While this might have occurred on an individual level, this is not reflected in our overall abortion figures. A potential explanation is behavioral responses. Unintended side effects in the form of more (unprotected) intercourse and inconsistent use of contraception might offset the effectiveness of EC pills and even lead to an increase in births and fertility. Whether an unintended rise in fertility is actually unwelcome remains debatable since this effect is not driven by teenagers, but by women in the middle of childbearing age and in rather stable relationships. Moreover, it seems as if women substitute regular hormonal contraceptives (the pill) with the morning-after pill or the mere possibility to use a plan B. However, as the name suggests, EC pills should only be taken in case of an actual emergency, and not as steady means of contraception. If policy makers arrive at the conclusion that women use morning-after pills in an unreasonable way—potentially triggering unintended and undesirable side effects—they might want to re-consider a regime warranting proper medical examination and consultation before EC pills can be used. The main downside of this, however, is the timing issue when having the urgent need for emergency medication. Taking the current situation

with an OTC regime and our corresponding evidence as given, it seems at least important to promote large-scale information campaigns on benefits, risks, and proper use of the morning-after pill.

References

Abadie, A., Athey, S., Imbens, G. W., and Wooldridge, J. M. (2020). Sampling-based versus design-based uncertainty in regression analysis. *Econometrica*, 88(1):265–296.

Abraham, S. and Sun, L. (2018). Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects. Available at SSRN: https://ssrn.com/abstract=3158747 or http://dx.doi.org/10.2139/ssrn.3158747.

Anderson, M. L. (2014). Subways, Strikes, and Slowdowns: The Impacts of Public Transit on Traffic Congestion. *American Economic Review*, 104(9):2763–96.

Angrist, J. D. and Pischke, J.-S. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton university press.

Athey, S. and Imbens, G. W. (2018). Design-Based Analysis in Difference-in-Differences Settings with Staggered Adoption. NBER Working Paper 24963, National Bureau of Economic Research.

Atkins, D. N. and Bradford, W. D. (2015a). Association between Increased Emergency Contraception Availability and Risky Sexual Practices. *Health Services Research*, 50(3):809–829.

Atkins, D. N. and Bradford, W. D. (2015b). The Effect of Changes in State and Federal Policy For Nonprescription Access to Emergency Contraception On Youth Contraceptive Use: A Difference-In-Difference Analysis Across New England States. *Contemporary Economic Policy*, 33(3):405–417.

Auffhammer, M. and Kellogg, R. (2011). Clearing the Air? The Effects of Gasoline Content Regulation on Air Quality. *American Economic Review*, 101(6):2687–2722.

Barrios, T., Diamond, R., Imbens, G. W., and Kolesár, M. (2012). Clustering, Spatial Correlations, and Randomization Inference. *Journal of the American Statistical Association*, 107(498):578–591.

Bentancor, A. and Clarke, D. (2017). Assessing Plan B: The Effect of the Morning After Pill on Children and Women. *The Economic Journal*, 127(607):2525–2552.

Bertrand, M., Duflo, E., and Mullainathan, S. (2004). How Much Should We Trust Differences-in-Differences Estimates? *The Quarterly Journal of Economics*, 119(1):249–275.

Bharadwaj, P., Lakdawala, L. K., and Li, N. (2020). Perverse Consequences of Well Intentioned Regulation: Evidence from India's Child Labor Ban. *Journal of the European Economic Association*, 18(3):1158–1195.

Borusyak, K. and Jaravel, X. (2017). Revisiting Event Study Designs. *Available at SSRN 2826228*.

Bowles, S. (2016). *The Moral Economy: Why Good Incentives Are No Substitute for Good Citizens*. Yale University Press.

Brüderl, J., Drobnic, S., Hank, K., Huinink, J., Nauck, B., Neyer, F. J., Walper, S., Alt, P., Borschel, E., Bozoyan, C., Buhr, P., Finn, C., Garrett, M., Greischel, H., Hajek, K., Herzig, M., Huyer-May, B., Lenke, R., Müller, B., Peter, T., Schmiedeberg, C., Schütze, P., Schumann, N., Thönnissen, C., Wetzel, M., and Wilhelm, B. (2018). The German Family Panel (pairfam). GESIS Data Archive, Cologne. ZA5678 Data file Version 9.1.0, doi: 10.4232/pairfam.5678.9.1.0.

Buckles, K. S. and Hungerman, D. M. (2018). The Incidental Fertility Effects of School Condom Distribution Programs. *Journal of Policy Analysis and Management*, 37(3):464–492.

Callaway, B. and Sant'Anna, P. H. (2018). Difference-in-Differences with Multiple Time Periods and an Application on the Minimum Wage and Employment. *arXiv preprint arXiv:1803.09015*.

Cameron, A. C., Gelbach, J. B., and Miller, D. L. (2008). Bootstrap-based Improvements for Inference with Clustered Errors. *The Review of Economics and Statistics*, 90(3):414–427.

Cameron, A. C. and Miller, D. L. (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, 50(2):317–372.

Cameron, L., Seager, J., and Shah, M. (2020). Crimes Against Morality: Unintended Consequences of Criminalizing Sex Work. NBER Working Paper 27846, National Bureau of Economic Research.

Carrasco-Garrido, P., de Andrés, A. L., Hernández-Barrera, V., Jiménez-Trujillo, I., Esteban-Peña, M., Pérez-Farinós, N., and Jiménez-García, R. (2016). Trends in the Use of Oral Contraceptives Among Adolescents and Young Women in Spain. *Reproductive Health*, 13(1):122.

Cattaneo, M. D., Frandsen, B. R., and Titiunik, R. (2015). Randomization Inference in the Regression Discontinuity Design: An application to Party Advantages in the US Senate. *Journal of Causal Inference*, 3(1):1–24.

Cengiz, D., Dube, A., Lindner, A., and Zipperer, B. (2019). The Effect of Minimum Wages on Low Wage Jobs. *The Quarterly Journal of Economics*, (forthcoming).

Cintina, I. (2017). Behind-the-Counter, but Over-the-Border? The Assessment of the Geographical Spillover Effects of Emergency Contraception on Abortions. *Health Economics*, 26(10):1249–1263.

Cintina, I. and Johansen, M. S. (2015). The effect of Plan B on Teen Abortions: Evidence from the 2006 FDA Ruling. *Contemporary Economic Policy*, 33(3):418–433.

Clarke, D. and Salinas, V. (2020). Access to The Emergency Contraceptive Pill Improves Women's Health: Evidence from Chile. IZA Discussion Paper No. 13134, Institute for the Study of Labor (IZA).

Cleland, K. C., Raymond, E. G., and Trussell, J. (2014). Emergency contraception: a last chance to prevent unintended pregnancy. *Contemporary Readings in Law and Social Justice*, 6(2):7–38.

Cohen, A. and Einav, L. (2003). The Effects of Mandatory Seat Belt Laws on Driving Behavior and Traffic Fatalities. *Review of Economics and Statistics*, 85(4):828–843.

Conley, T. G. and Taber, C. R. (2011). Inference with "Difference in Differences" with a Small Number of Policy Changes. *The Review of Economics and Statistics*, 93(1):113–125.

D'Angelo, D. V., Gilbert, B. C., Rochat, R. W., Santelli, J. S., and Herold, J. M. (2004). Differences between mistimed and unwanted pregnancies among women who have live births. *Perspectives on Sexual and Reproductive Health*, 36(5):192–197.

de Chaisemartin, C. and D'Haultfoeuille, X. (2019). Two-way Fixed Effects Estimators with Heterogeneous Treatment Effects. NBER Working Paper 25904, National Bureau of Economic Research.

Doleac, J. L. and Mukherjee, A. (March 31, 2019). The Moral Hazard of Lifesaving Innovations: Naloxone Access, Opioid Abuse, and Crime. Available at SSRN: https://ssrn.com/abstract=3135264 or http://dx.doi.org/10.2139/ssrn.3135264 .

Durrance, C. P. (2013). The Effects of Increased Access to Emergency Contraception on Sexually Transmitted Disease and Abortion Rates. *Economic Inquiry*, 51(3):1682–1695.

Edgington, E. S. (1995). *Randomization Tests*. New York: Marcel Dekker.

Eeckhaut, M. C., Sweeney, M. M., and Gipson, J. D. (2014). Who Is Using Long-Acting Reversible Contraceptive Methods? Findings from Nine Low-Fertility Countries. *Perspectives on Sexual and Reproductive Health*, 46(3):149–155.

Erikson, R. S., Pinto, P. M., and Rader, K. T. (2010). Randomization Tests and Multi-Level Data in US State Politics. *State Politics & Policy Quarterly*, 10(2):180–198.

ESHRE Capri Workshop Group (2015). Emergency Contraception. Widely Available and Effective but Disappointing as a Public Health Intervention: a Review. *Human Reproduction*, 30(4):751–760.

European Consortium for Emergency Contraception (ECEC) (2019). Emergency Contraception in Europe, Country-by-Country Information. Retrieved from `http://www.ec-ec.org/emergency-contraception-in-europe/country-by-country-information-2/`.

Eurostat (2018). Population (Demography, Migration and Projections), Data, Database. Retrieved from `https://ec.europa.eu/eurostat/web/population-demography-migration-projections/data/database`.

Fehr, E. and Falk, A. (2002). Psychological Foundations of Incentives. *European Economic Review*, 46(4-5):687–724.

Fisher, R. A. (1935). The Design of Experiments. *Oliver and Boyd, Edinburgh*.

Girma, S. and Paton, D. (2006). Matching Estimates of the Impact of Over-The-Counter Emergency Birth Control on Teenage Pregnancy. *Health Economics*, 15(9):1021–1032.

Girma, S. and Paton, D. (2011). The Impact of Emergency Birth Control on Teen Pregnancy and STIs. *Journal of Health Economics*, 30(2):373–380.

Glasier, A. and Baird, D. (1998). The Effects of Self-Administering Emergency Contraception. *New England Journal of Medicine*, 339(1):1–4.

Glasier, A., Fairhurst, K., Wyke, S., Ziebland, S., Seaman, P., Walker, J., and Lakha, F. (2004). Advanced Provision of Emergency Contraception does not Reduce Abortion Rates. *Contraception*, 69(5):361–366.

Gneezy, U. and Rustichini, A. (2000). A Fine is a Price. *The Journal of Legal Studies*, 29(1):1–17.

Goodman-Bacon, A. (2018). Difference-in-Differences with Variation in Treatment Timing. NBER Working Paper 25018, National Bureau of Economic Research.

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, 37(3):424–438.

Gross, T., Lafortune, J., and Low, C. (2014). What happens the Morning After? The Costs and Benefits of Expanding Access to Emergency Contraception. *Journal of Policy Analysis and Management*, 33(1):70–93.

Hausman, C. and Rapson, D. S. (2018). Regression Discontinuity in Time: Considerations for Empirical Applications. *Annual Review of Resource Economics*, 10(1):533–552.

Ho, D. E. and Imai, K. (2006). Randomization Inference with Natural Experiments: An Analysis of Ballot Effects in the 2003 California Recall Election. *Journal of the American Statistical Association*, 101(475):888–900.

Imbens, G. W. and Lemieux, T. (2008). Regression Discontinuity Designs: A Guide to Practice. *Journal of Econometrics*, 142(2):615–635.

IQVIA Commercial GmbH & Co. OHG (2018). IMS PharmaScope: National Sonderstudie für die Universität Hohenheim. Hormonelle Kontrazeptiva.

IQVIA MIDAS (2016). MIDAS Quantum, Data Elements, Measures & Statistics. IQVIA AG — Dorfplatz 4, 6330 Cham, Switzerland.

Italia, S. and Brand, H. (2016). Status of Emergency Contraceptives in Europe One Year After the European Medicines Agency's Recommendation to Switch Ulipristal Acetate to Non-Prescription Status. *Public Health Genomics*, 19(4):203–210.

Kafkadesk (2020). Use of birth control pills in the Czech Republic drops to all-time low. Retrieved from https://kafkadesk.org/2020/05/09/use-of-birth-control-pills-in-the-czech-republic-drops-to-all-time-low/.

Kelly, A. M., Lindo, J., and Packham, A. (2020). The Power of the IUD: Effects of Expanding Access to Contraception Through Title X Clinics. *Journal of Public Economics*, forthcoming.

Kennedy, P. E. and Cade, B. S. (1996). Randomization Tests for Multiple Regression. *Communications in Statistics-Simulation and Computation*, 25(4):923–936.

Koohi, S. (2013). The Power of Plan B: The Impact of Emergency Contraception on Fertility and Child Characteristics. Unpublished Working Paper, Brown University.

MacKinnon, J. G. and Webb, M. D. (2017). Wild Bootstrap Inference for Wildly Different Cluster Sizes. *Journal of Applied Econometrics*, 32(2):233–254.

MacKinnon, J. G. and Webb, M. D. (2018). Randomization Inference for Difference-in-Differences with Few Treated Clusters. (2110-2018-4491):39.

Manly, B. F. J. (2006). *Randomization, Bootstrap and Monte Carlo Methods in Biology*, volume 70 of *Chapman & Hall / CRC Texts in Statistical Science*. Chapman & Hall (CRC Press).

Moreau, C., Bouyer, J., Goulard, H., and Bajos, N. (2005). The Remaining Barriers to the Use of Emergency Contraception: Perception of Pregnancy Risk by Women Undergoing Induced Abortions. *Contraception*, 71(3):202–207.

Moulton, B. R. (1986). Random Group Effects and the Precision of Regression Estimates. *Journal of Econometrics*, 32(3):385–397.

Moulton, B. R. (1990). An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Unit. *The Review of Economics and Statistics*, 72(2):334–38.

Mulligan, K. (2016). Access to Emergency Contraception and Its Impact on Fertility and Sexual Behavior. *Health Economics*, 25(4):455–469.

NHS Foundation Trust, Chelsea and Westminster Hospital (2018). HIV & Sexual Health Services: Morning After Pill. Retrieved from https://www.chelwest.nhs.uk/services/hiv-sexual-health/morning-after-pill.

Nuevo-Chiquero, A. and Pino, F. (2019). To Pill or not to Pill? Access to Emergency Contraception and Contraceptive Behaviour. IZA Discussion Paper No. 12076, Institute for the Study of Labor (IZA).

Peltzman, S. (1975). The Effects of Automobile Safety Regulation. *Journal of Political Economy*, 83(4):677–725.

Pfeifer, G., Reutter, M., and Strohmaier, K. (2018). Goodbye Smokers' Corner: Health Effects of School Smoking Bans. *Journal of Human Resources*, (n/a):1217–9246r3.

Philipson, T. J. and Posner, R. A. (1995). A Theoretical and Empirical Investigation of the Effects of Public Health Subsidies for STD Testing. *The Quarterly Journal of Economics*, 110(2):445–474.

pro familia Deutsche Gesellschaft für Familienplanung, Sexualpädagogik und Sexualberatung e. V. (2019). Rezeptfreie Pille danach in Europa. Retrieved from `https://www.profamilia.de//fileadmin/publikationen/7788.pdf`.

Raine, T. R., Harper, C. C., Rocca, C. H., Fischer, R., Padian, N., Klausner, J. D., and Darney, P. D. (2005). Direct Access to Emergency Contraception Through Pharmacies and Effect on Unintended Pregnancy and STIs: a Randomized Controlled Trial. *Journal of the American Medical Association*, 293(1):54–62.

Raymond, E. G., Spruyt, A., Bley, K., Colm, J., Gross, S., and Robbins, L. A. (2004). The North Carolina DIAL EC Project: Increasing Access to Emergency Contraceptive Pills by Telephone. *Contraception*, 69(5):367–372.

Raymond, E. G., Trussell, J., and Polis, C. B. (2007). Population Effect of Increased Access to Emergency Contraceptive Pills: a Systematic Review. *Obstetrics & Gynecology*, 109(1):181–188.

Sedgh, G., Singh, S., Shah, I. H., Åhman, E., Henshaw, S. K., and Bankole, A. (2012). Induced Abortion: Incidence and Trends Worldwide from 1995 to 2008. *The Lancet*, 379(9816):625–632.

Späth, A., Schneider, C., Stutz, L., Tschudin, S., and Zemp Stutz, E. (2017). Schweizerischer Verhütungsbericht (Obsan Dossier 59). Neuchatel: Schweizerisches Gesundheitsobservatorium.

Spinelli, A., Talamanca, I. F., and Lauria, L. (2000). Patterns of Contraceptive Use in 5 European Countries. European Study Group on Infertility and Subfecundity. *American Journal of Public Health*, 90(9):1403.

Statistisches Bundesamt (Destatis) (2018). GENESIS-Online Datenbank: Lebendgeborene, Schwangerschaftsabbrüche. Retrieved from `https://www-genesis.destatis.de/genesis/online/link/tabellen/12612*`.

U.S. Food & Drug Administration (2020). FDA's Decision Regarding Plan B: Questions and Answers. Retrieved from `https://www.fda.gov/drugs/postmarket-drug-safety-information-patients-and-providers/fdas-decision-regarding-plan-b-questions-and-answers`.

Wagner, G. G., Frick, J. R., Schupp, J., et al. (2007). The German Socio-Economic Panel Study (SOEP)–Scope, Evolution and Enhancements. *Schmollers Jahrbuch: Journal of Applied Social Science Studies/Zeitschrift für Wirtschafts-und Sozialwissenschaften*, 127(1):139–169.

Wilcox, A. J., Dunson, D. B., Weinberg, C. R., Trussell, J., and Baird, D. D. (2001). Likelihood of Conception with a Single Act of Intercourse: Providing Benchmark Rates for Assessment of Post-Coital Contraceptives. *Contraception*, 63(4):211–215.

World Bank (2018). DataBank: World Development Indicators. Retrieved from https://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.PCAP.KD&country.

World Health Organization (WHO) (2018). Centralized Information System for Infectious Diseases (CISID). Retrieved from http://data.euro.who.int/cisid/.

Young, A. (2018). Channeling Fisher: Randomization Tests and the Statistical Insignificance of Seemingly Significant Experimental Results. *The Quarterly Journal of Economics*, 134(2):557–598.

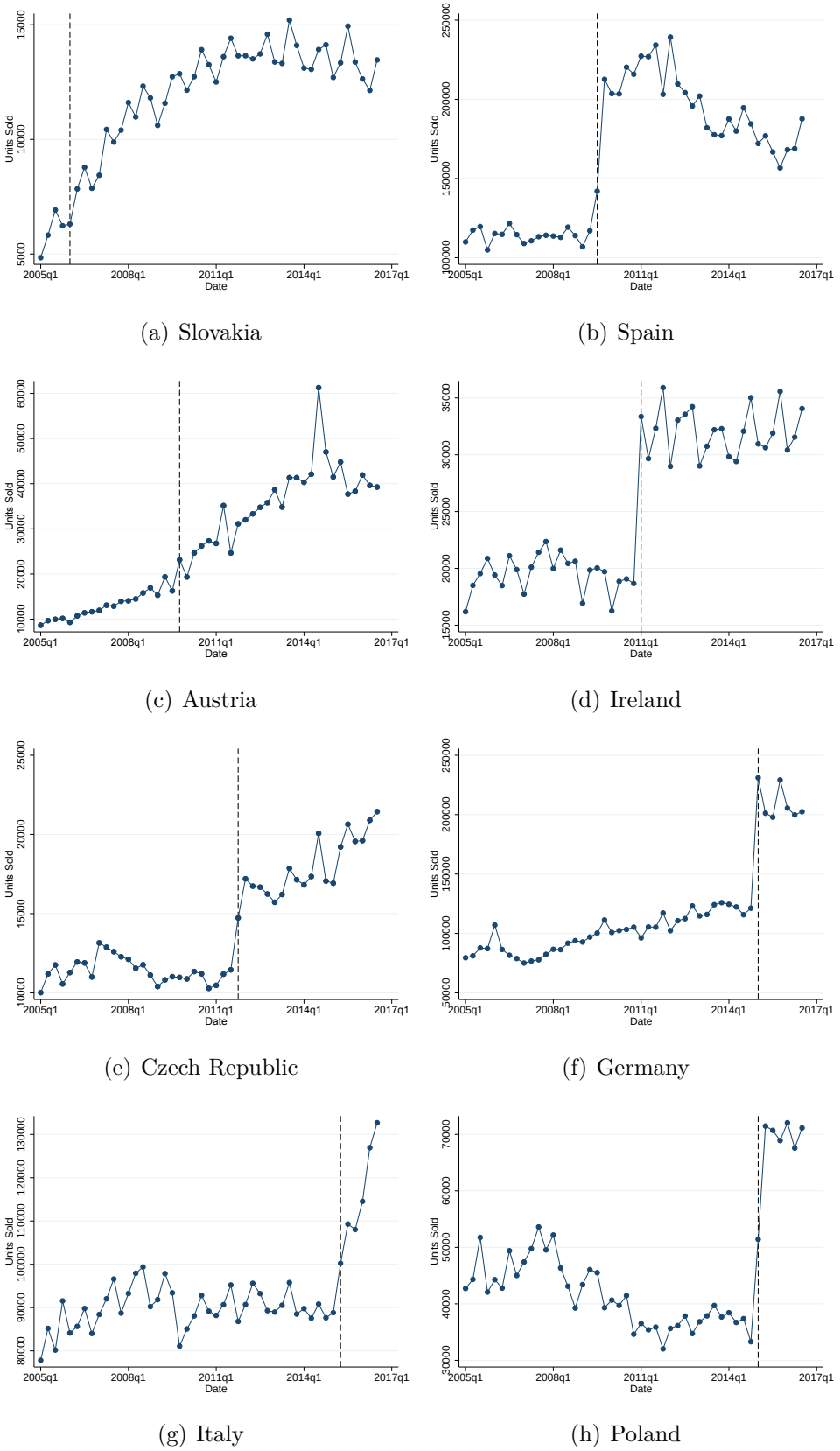
Zuppann, C. A. (2011). The Impact of Emergency Contraception on Dating and Marriage. *Unpublished Working Paper available at http://www.sole-jole.org/12450.pdf.*

Appendix

Table 9: Control Variables: Summary Statistics

	Mean	SD	Min	Max	N
GDP (per capita)	35,531.34	24,259.74	2,101.6	111,968.3	504
Unemployment Rate (% of total labor force)	9.42	5.58	1.8	31.1	504
Female Youth Rate (15–19 years, % of females)	6.00	1.05	3.8	10.3	504
Male Youth Rate (15–19 years, % of males)	6.60	1.11	4.4	10.3	504
Females (% of total population)	51.20	1.10	49.4	54.2	504
Population Density	126.05	105.93	2.8	505.1	504
Life Expectancy at Birth	78.18	3.16	69.7	83.2	504
Indicator for Legality of Abortions	0.88	0.32	0.0	1.0	504

Note: Means, standard deviations, minimum and maximum values, and the number of observations, N, for the control variables.



(a) Slovakia (b) Spain

(c) Austria (d) Ireland

(e) Czech Republic (f) Germany

(g) Italy (h) Poland

Figure 13: Units Sold of EC Pills in Europe by Countries

Note: Units sold of EC pills in Slovakia, Spain, Austria, Ireland, Czech Republic, Germany, Italy, and Poland in Panels (a) to (h), respectively. The dashed, vertical lines indicate the dates of the OTC introductions.

Table 10: OTC Effects on Abortion Rate by Age Groups

	(1) under 20	(2) 20–24	(3) 25–29	(4) 30–34	(5) 35–39	(6) 35 or older	(7) Sum
OTC	-0.1802	2.0644	0.4601	0.2418	0.4713	-0.1808	0.9289
	(0.5465)	(1.5983)	(0.9277)	(0.5302)	(0.4070)	(0.1893)	(2.5409)
%-Change	-1.87	11.87	2.82	1.63	4.14	-6.60	1.55
$Mean_0$	9.6200	17.3924	16.3168	14.7989	11.3818	2.7395	60.0156
N	359	294	287	293	285	359	286
R^2	0.988	0.920	0.993	0.988	0.981	0.989	0.995

Note: OTC effects on abortions per $1,000$ females in different age groups. Column (7) reports estimates for the sum of the age-group-specific rates. All specifications include state and year fixed effects, as well as GDP per capita, unemployment rate, male and female youth rate, share of females in the total population, population density, life expectancy, an indicator for the legalization of abortions, and country-specific linear time trends. $Mean_0$ shows the level of the respective outcome variables in not (yet) affected countries and %-Change the respective relative effect. Standard errors, clustered on country level, in parenthesis. Significance levels: $^*p < 0.10$,$^{**}p < 0.05$,$^{***}p < 0.01$.

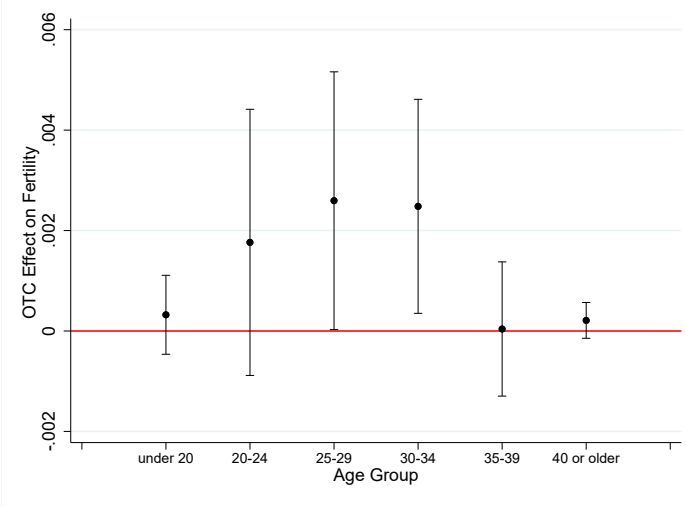


Figure 14: OTC Effects on Fertility by Age Group

Note: Lagged OTC effects on fertility and corresponding 95% confidence intervals over different age groups. The plotted estimates correspond to the values reported in Table 4. State and year fixed effects, as well as GDP per capita, unemployment rate, male and female youth rate, share of females in the total population, population density, life expectancy, an indicator for the legalization of abortions, and country-specific linear time trends are included.

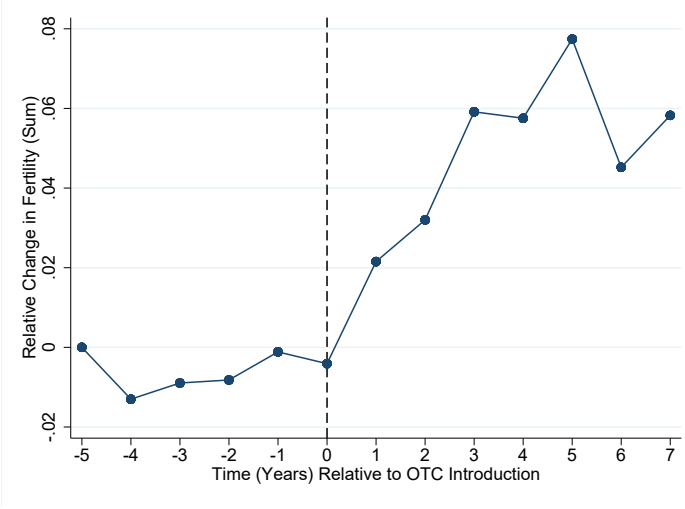


Figure 15: Fertility (Sum) in Europe Relative to OTC Access

Note: Mean changes in the sum of age-group-specific fertility over time relative to the introduction of OTC access to EC pills, relative to the fifth year prior to the switch. The dashed vertical line at zero indicates the start of the prescription-free access. The figure comprises twelve countries for the time span −5 to 3, eight countries for 4 to 6, and seven countries for 7.

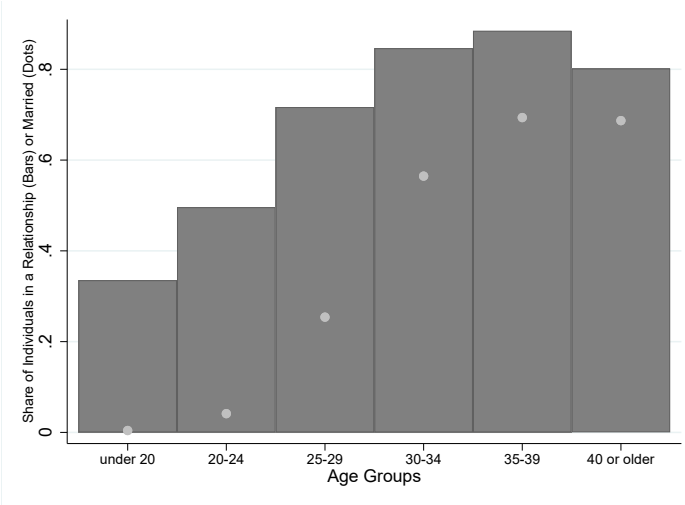


Figure 16: Individuals in a Relationship or Married by Age Groups

Note: Share of individuals who are in a stable relationship or married across six age groups from under 20 to 40 or older. The dark gray bars indicate the share of individuals who are currently in a stable relationship. The light gray dots indicate the share of individuals who are married. Data from the German Socio-Economic Panel, SOEP v34.

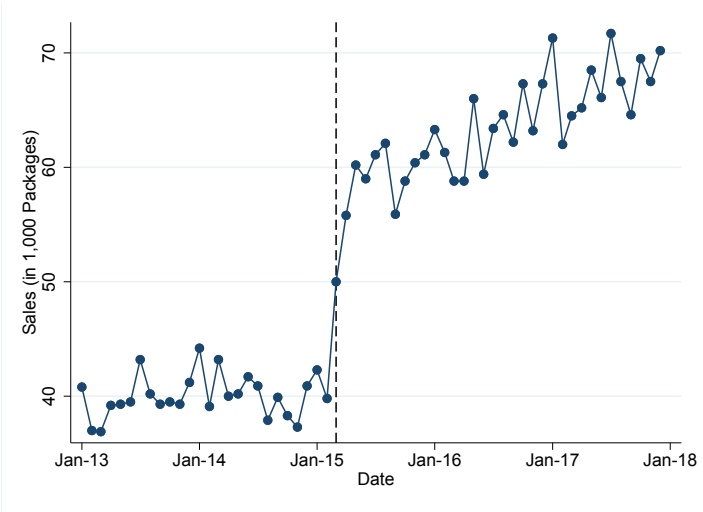
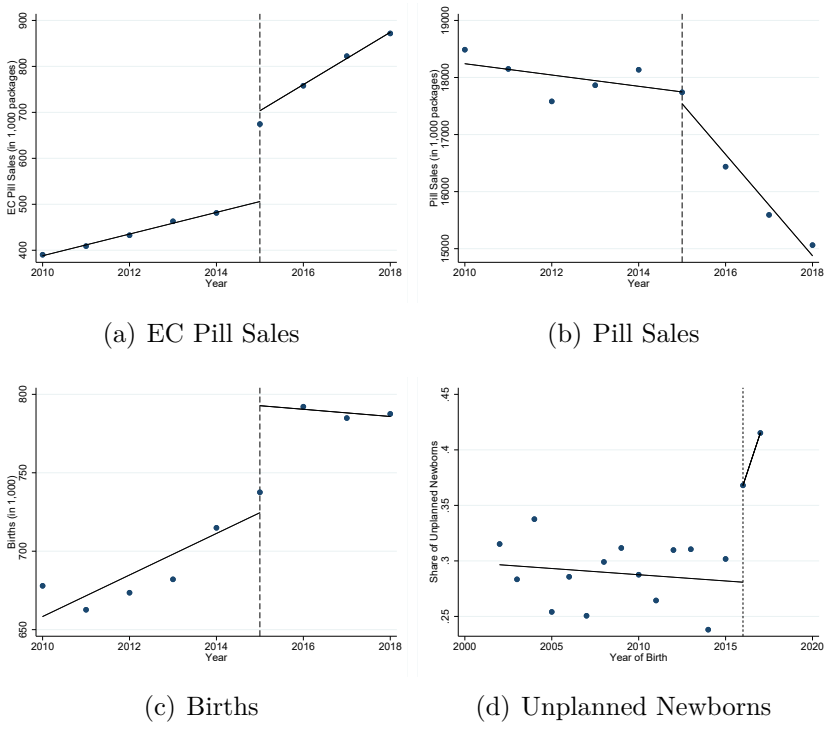


Figure 17: EC Pill Pharmacy Sales in Germany over Time

Note: Monthly sales of EC pills (in 1,000 packages) through pharmacies in Germany over time from January 2013 to January 2018. The introduction of prescription-free access, in March 15, 2015, is indicated by the vertical dashed line. Data source is Insight Health.



(a) EC Pill Sales

(b) Pill Sales

(c) Births

(d) Unplanned Newborns

Figure 18: EC Pill Sales, Pill Sales, Births, and Unplanned Newborns over Time: Annually

Note: Annual numbers for EC pill sales and other hormonal contraceptive sales (subfigure caption just states "Pill" for the sake of brevity and because this category is mostly comprised of birth control pills), as well as number of births and the share of unplanned newborns over time. Linear fits are provided for the pre- and post periods, respectively. The OTC introduction of EC pills in 2015 is indicated by the vertical, dashed line.

Data and Institutional Appendix

Variable Description

The first part of the analysis uses three main outcome variables, which are partly measured differently or segregated in more details (e.g., by age groups or marital status), as well as seven further control variables for up to 28 European countries. Two variables are aggregated on country-quarter level and available for the years 2005 to 2016. All other variables are aggregated on country-year level and available for the years 1999 to 2016. The second part of the analysis, which solely focuses on Germany, uses four outcome variables on a monthly (or quarterly) frequency for the years 2010 to 2018.

Dependent Variables

Units Sold: Units sold is the number of packages of emergency contraceptive pills sold per 1,000 females and refer to sales of manufacturers to wholesalers. Consequently, the data covers the pharmacy as well as the hospital market. The absolute number of sold units is divided by the number of females living in the respective country-year combination and multiplied by 1,000.

Manufacturers' Revenues: Manufacturers' revenue is local currency sales converted to Euro at constant exchange rates (adjusted for exchange rate fluctuations) per 1,000 females. The absolute value of sales is divided by the number of females living in the respective country-year combination and multiplied by 1,000.

Abortion Rate: Number of abortions per 1,000 females. The number of abortions is divided by the number of females living in the respective country-year combination and multiplied by 1,000.

Abortion Ratio: Number of abortions per live births. The number of abortions is divided by the number of live births in the respective country-year combination.

Birth Rate: Crude birth rate indicates the number of live births occurring during the year, per 1,000 population estimated at midyear. Subtracting the crude death rate from the crude birth rate provides the rate of natural increase, which is equal to the rate of population change in the absence of migration.

Fertility: Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year.

Abortion by Age Groups: Legally induced abortions, i.e., induced expulsion of the fetus during the first part of a pregnancy, permitted by law for health or other reasons, by mother's age.

Fertility by Age Groups: Fertility rates by mother's age (age specific fertility rate) is the ratio of the number of live births to mothers of age x to the average female population of age x.

Births within and outside of Marriage: Live births by mother's legal marital status.

Sexually Transmitted Infections (STIs): Syphilis, gonorrhea, chlamydia, herpes, and HIV, by number of cases per 1,000 people.

EC Pill Sales: Number of packages of emergency contraceptive pills sold per month; for Germany only.

Hormonal Contraceptive Sales: Number of packages of hormonal contraceptives (other than emergency contraceptive pills) sold per month; for Germany only. Predominantly consisting of birth control pills.

Births: Number of live births per month; for Germany only.

Unplanned Newborns: Share of newborns for which the mother indicates that the pregnancy was rather unplanned, per month of birth; for Germany only.

Treatment Indicator

OTC: Indicator on over-the-counter availability of EC pills in a respective country-time combination. It is not differentiated between agents or products from different manufacturers, neither whether the drug is available OTC or behind the counter (BTC), but only whether it is accessible with or without a doctor's prescription. BTC means that the drug is not placed on a shelf for self-service, but that a customer must demand it from the pharmacist. The construction of the OTC indicator is based on various sources. General information is listed in Table 11. More detailed, country-by-country information is provided in Table 12.

Control Variables

GDP per Capita: GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars.

Unemployment Rate: Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.

Youth Rate, Female and Male: Female (male) population between the ages 15 to 19 as a percentage of the total female (male) population.

Female Share of Population: Female population is the percentage of the population that is female. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.

Population Density: Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship—except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases, the definition of inland water bodies includes major rivers and lakes.

Life Expectancy: Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Indicator for Legality of Abortions: Indicator for legality of abortions is zero when the legal ground on which abortion is permitted does not include economic or social reasons as well as on request. Hence, abortion is permitted only in cases where the pregnant woman's life or health is at risk, when the pregnancy is a result of a criminal act or incest, or in cases of a fatal fetal abnormality.

Table 11: Data Sources

Variable	Time Period	Data Source
Units sold	2005q1-2016q3	IQVIA MIDAS (purchased 19.12.2016)
Manufacturer's revenue	2005q1-2016q3	IQVIA MIDAS (purchased 19.12.2016)
Abortion rate and ratio	1999-2015	The Global Life Campaign (GLC) and Eurostat https://www.glcpublications.com/ https://ec.europa.eu/eurostat/de/data/database (last accessed 19.10.2018)
Birth rate	1999-2016	World Bank Database https://data.worldbank.org/ (last accessed 08.05.2019)
Fertility	1999-2016	World Bank Database https://data.worldbank.org/ (last accessed 08.05.2019)
Abortion by age groups	1999-2017	Eurostat https://ec.europa.eu/eurostat/de/data/database (last accessed 27.03.2019)
Fertility by age groups	1999-2015	Eurostat https://ec.europa.eu/eurostat/de/data/database (last accessed 08.05.2019)
Births within and outside of marriage	1999-2016	Eurostat https://ec.europa.eu/eurostat/de/data/database (last accessed 26.03.2019)
STIs	1999-2016	WHO https://www.who.int/healthinfo/statistics/en/ (last accessed 28.03.2019)
OTC indicator	1999-2017	ECEC, profamilia, Italia and Brand (2016), country-specific news http://www.ec-ec.org/emergency-contraception-in-europe/ country-by-country-information-2/ https://www.profamilia.de//fileadmin/publikationen/7788.pdf (last accessed 14.06.2019)
EC pill sales	Jan2010-Dec2018	IQVIA, IMS PharmaScope National Sonderstudie (purchased 04.12.2018)
Hormonal contraceptive sales	Jan2010-Dec2018	IQVIA, IMS PharmaScope National Sonderstudie (purchased 04.12.2018)
Births	Jan2010-Nov2018	Statistisches Bundesamt (Destatis) https://www-genesis.destatis.de/genesis/online (last accessed 22.05.2019)
Unplanned newborns	Jan2002-Dec2017	German Socio-Economic Panel, Mother-Child-Questionnaire (Newborns) https://www.diw.de/en/diw_02.c.222729.en/questionnaires.html SOEP v34

Note: Variables, time periods, and data sources used in the analyses of the paper "The Morning After: Prescription-Free Access to Emergency Contraceptive Pills", dated June 2019.

Table 12: Institutional Background Information and Sources

Code	Country	Institutional Background Information
AL	Albania	**OTC access:** 2017 q2
		Cost: 4.50€(LNG), 15.60€(UPA)
		Source: ECEC Website
AT	Austria	**OTC access:** 2010 q1
		Cost: 13.50€(LNG), 31.90€(UPA)
		Source: ECEC Website, Italia and Brand (2016)
BE	Belgium	**OTC access:** 2001 q2
		Cost: 9.85€(LNG), 24.99€(UPA)
		Source: ECEC Website, https://www.lifesitenews.com/news/belgium-allows-non-prescription-morning-after-pill-sales
BA	Bosnia and Herzegovina	**OTC access:** prescription still required
		Cost: 14.50–22.50€(LNG), 25.30–30.00€(UPA)
		Source: ECEC Website, Italia and Brand (2016), https://www.cecinfo.org/country-by-country-information/status-availability-database/countries/bosnia-and-herzegovina/
HR	Croatia	**OTC access:** 2015 q2
		Cost: 21.40€(LNG), 25.60€(UPA)
		Source: ECEC Website, Italia and Brand (2016)
CZ	Czech Republic	**OTC access:** 2011 q4
		Cost: 21€(LNG), 24.50€(UPA)
		Source: ECEC Website, https://gogirlguides.com/health/how-to-get-the-morning-after-pill-in-europe/
DK	Denmark	**OTC access:** 2001 q2
		Cost: 12.45€(LNG), 23.36€(UPA)
		User: median age 24 (range 13–50 years), 73% first-time user
		Source: ECEC Website, Italia and Brand (2016), Hansen, C. C., Svare, E. I., Petersen, R. H., & Bock, J. E. (2002). Who are the users of emergency contraception? Ugeskrift for laeger, 164(43), 5003-5005.
EE	Estonia	**OTC access:** 2003 q3
		Cost: 15.79€(LNG), 18.73€(UPA)
		Source: ECEC Website, Italia and Brand (2016)
FI	Finland	**OTC access:** 2002 q2
		Cost: 18.87€(LNG), 33.60€(UPA)
		User: mean age 23.4 (range 19–45; students only), one-time user 97.7% in (1 year)
		Source: ECEC Website, Italia and Brand (2016), Virjo, I., & Virtala, A. (2003). Why do university students use hormonal emergency contraception? The European Journal of Contraception & Reproductive Health Care, 8(3), 139-144.

Note: Codes, countries, OTC access dates, institutional background information and relevant references of the paper "The Morning After: Prescription-Free Access to Emergency Contraceptive Pills", dated August 2019. Code stands for the two-letter country codes defined in ISO 3166-1. Approximate costs differentiated by the agents levonorgestrel (LNG) and ulipristal acetate (UPA). Website of the European Consortium for Emergency Contraception (ECEC): http://www.ec-ec.org/emergency-contraception-in-europe/country-by-country-information-2/ .

Table 12: Institutional Background Information and Sources (continued)

Code	Country	Institutional Background Information
FR	France	**OTC access:** 1999 q2
		Cost: 6.75€(LNG), 18.88€(UPA)
		User: mean age 26.7 (range 15–48 years), first-time user 63.6%
		Source: ECEC Website, Italia and Brand (2016), https://www.sciencedirect.com/science/article/pii/S0010782403001148, Moreau, C., Bouyer, J., Goulard, H., & Bajos, N. (2005). The remaining barriers to the use of emergency contraception: perception of pregnancy risk by women undergoing induced abortions. Contraception, 71(3), 202-207.
DE	Germany	**OTC access:** 2015 q1
		Cost: 16€(LNG), 30€(UPA)
		User: >66% >20 years (<1% <14, 33.3% 14–20, 54% 21–35, 12.5% >35), first-time user 98%
		Source: ECEC Website, Italia and Brand (2016), Kiechle, M., & Neuenfeldt, M. (2017). Experience with oral emergency contraception since the OTC switch in Germany. Archives of Gynecology and Obstetrics, 295(3), 651-660.
GR	Greece	**OTC access:** 2005 q2
		Cost: 5.40–8.96€(LNG), 25.77€(UPA)
		Source: ECEC Website
HU	Hungary	**OTC access:** prescription still required
		Cost: 19.30€(LNG), 22.60€(UPA)
		Source: ECEC Website, Italia and Brand (2016)
IS	Iceland	**OTC access:** 2001 q2
		Cost: 16€(LNG), N/A(UPA)
		Source: Italia and Brand (2016), https://gynopedia.org/Reykjavik#Emergency_Contraception_.28Morning_after_Pill.29, https://www.ncbi.nlm.nih.gov/pubmed/19420412
IE	Ireland	**OTC access:** 2011 q2
		Cost: 40.47€(LNG), 57.82€(UPA)
		User: mean age 24.4 (sd 6.7; range 14 to 51 years), first-time user 38.2%
		Source: ECEC Website, https://www.thejournal.ie/morning-after-pill-2-2077829-May2015/ Loughrey, F., Matthews, A., Bedford, D., & Howell, F. (2006). Characteristics of women seeking emergency contraception in general practice. Irish medical journal, 99(2), 50-52.
IT	Italy	**OTC access:** 2015 q2
		Cost: 13.10€(LNG), 26.90€(UPA)
		User: mean age 24.6; (3.95% <18, 63.4% 18–25, 23.7% 26–30, 8.9% >30 years), first-time user 62.3%
		Source: ECEC Website, https://gogirlguides.com/health/how-to-get-the-morning-after-pill-in-europe/, Bastianelli, C., Farris, M., & Benagiano, G. (2005). Reasons for requesting emergency contraception: A survey of 506 Italian women. The European Journal of Contraception & Reproductive Health Care, 10(3), 157-163.

Note: Codes, countries, OTC access dates, institutional background information and sources of the paper "The Morning After: Prescription-Free Access to Emergency Contraceptive Pills", dated August 2019. Code stands for the two-letter country codes defined in ISO 3166-1. Approximate costs differentiated by the agents levonorgestrel (LNG) and ulipristal acetate (UPA). Website of the European Consortium for Emergency Contraception (ECEC): http://www.ec-ec.org/emergency-contraception-in-europe/country-by-country-information-2/

Table 12: Institutional Background Information and Sources (continued)

Code	Country	Institutional Background Information
LV	Latvia	**OTC access:** 2003 q2
		Cost: 15.14€(LNG), 25.00€(UPA)
		Source: ECEC Website, Italia and Brand (2016)
LT	Lithuania	**OTC access:** 2005 q2
		Cost: 15.00€(LNG), 30.00€(UPA)
		Source: ECEC Website, https://gogirlguides.com/health/how-to-get-the-morning-after-pill-in-europe/
LU	Luxembourg	**OTC access:** 2005 q3
		Cost: 9.58€(LNG), 24.29€(UPA)
		Source: ECEC Website, https://gynopedia.org/Luxembourg_City#Sexually_Transmitted_Infections_28STIs.2FSTDs.29
NL	Netherlands	**OTC access:** 2004 q4
		Cost: 15.00€(LNG), 30.00€(UPA)
		Source: ECEC Website, https://gynopedia.org/Netherlands#What_to_Get_.26_Where_to_Get_It_2
NO	Norway	**OTC access:** 2000 q4
		Cost: 24.60€(LNG), 32.80€(UPA)
		Source: ECEC Website, https://www.sciencedirect.com/science/article/pii/S0010782403001148
PL	Poland	**OTC access:** 2015 q1
		Cost: 10.00€(LNG), 30.00€(UPA)
		User: mean age 22.4 (range 19–28; students only), mean use 1.5 times (range 1–8 times)
		Source: ECEC Website, Italia and Brand (2016), Olszewski, J., Olszewska, H., Abacjew, A., Chmylko, L., & Gaworska-Krzeminska, A. (2007). The use of emergency contraception in young Polish women. Acta obstetricia et gynecologica Scandinavica, 86(7), 861-869.
PT	Portugal	**OTC access:** 2000 q4
		Cost: 12.50€(LNG), 24.90€(UPA)
		User: mean age 26.7 (sd 7.9 years; 7.2% <18, 65.2% 18–30, 27.7% >30 years.), 62.6% first-time user
		Source: ECEC Website, https://www.sciencedirect.com/science/article/pii/S0010782403001148, Fontes, E., Guerreiro, J., Costa, T., & Miranda, A. (2010). Pattern of use of emergency oral contraception among Portuguese women. Pharmacy world & science, 32(4), 496-502.
SI	Slovakia	**OTC access:** 2006 q2
		Cost: 22.00€(LNG), 27.00€(UPA)
		Source: ECEC Website, https://gynopedia.org/Bratislava#What_to_Get_.26_Where_to_Get_It_2
ES	Spain	**OTC access:** 2009 q3
		Cost: 15.00€(LNG), 25.00€(UPA)
		User: mean age 25.4 (sd 7.1; 54.9% 14-24, 36.5% 25–35, 8.6% 36–50), first-time user 44.6%
		Source: ECEC Website, https://www.telegraph.co.uk/news/worldnews/europe/spain/06236955/Spain-to-allow-over-the-counter-morning-after-pill.html, Sevillano, L. G., Pellon, M., Lobato, C. T., Gil, M. S., & Valdivieso, I. S. (2014). Knowledge upon the emergency contraceptive pill in Spain. European journal of clinical pharmacy: atencion farmaceutica, 16(3), 224-228.

Note: Codes, countries, OTC access dates, institutional background information and sources of the paper "The Morning After: Prescription-Free Access to Emergency Contraceptive Pills", dated August 2019. Code stands for the two-letter country codes defined in ISO 3166-1. Approximate costs differentiated by the agents levonorgestrel (LNG) and ulipristal acetate (UPA). Website of the European Consortium for Emergency Contraception (ECEC): http://www.ec-ec.org/emergency-contraception-in-europe/country-by-country-information-2/

Table 12: Institutional Background Information and Sources (continued)

Code	Country	Institutional Background Information
SE	Sweden	**OTC access:** 2001 q2
		Cost: 17.00€(LNG), 25.00€(UPA)
		User: mean age 19.8 (15% $\leq$ 15, 43% 16–19, 28% 20–24, 14% $\geq$ 25 years), first-time user 75%
		Source: ECEC Website, https://www.sciencedirect.com/science/article/pii/S0010782403001148 Tyden, T., Wetterholm, M., & Odlind, V. (1998). Emergency contraception: the user profile. Advances in contraception, 14(4), 171-178.
CH	Switzerland	**OTC access:** 2002 q4
		Cost: 17.50€(LNG), 32.85€(UPA)
		User: mean age 24.9 (sd 6.9; range 15–49 years), first-time user 53.1%
		Source: ECEC Website, Italia and Brand (2016), Arnet, I., Frey Tirri, B., Zemp Stutz, E., Bitzer, J., & Hersberger, K. E. (2009). Emergency hormonal contraception in Switzerland: A comparison of the user profile before and three years after deregulation. The European journal of contraception & reproductive health care, 14(5), 349-356.
GB	United Kingdom	**OTC access:** 2001 q1
		Cost: 42.00€(LNG), 57.00€(UPA)
		User: mean age 20.2 (88% <20 years; age rage 14–37 years), first-time user 44%
		Source: ECEC Website, Italia and Brand (2016), Shawe, J., Ineichen, B., & Lawrenson, R. (2001). Emergency contraception: Who are the users? BMJ Sexual & Reproductive Health, 27(4), 209-212.

Note: Codes, countries, OTC access dates, institutional background information and sources of the paper "The Morning After: Prescription-Free Access to Emergency Contraceptive Pills", dated August 2019. Code stands for the two-letter country codes defined in ISO 3166-1. Approximate costs differentiated by the agents levonorgestrel (LNG) and ulipristal acetate (UPA). Website of the European Consortium for Emergency Contraception (ECEC): http://www.ec-ec.org/emergency-contraception-in-europe/country-by-country-information-2/

Randomization Inference Appendix

Monte Carlo Evidence on RI in Case of Few Clusters

Table 13 shows results of a monte carlo study that compares inference with conventional or cluster-robust standard errors to RI for a varying number of few clusters. In this context, the definition of "small" is widely discussed in the literature. Angrist and Pischke (2009) suggest a number of 42 clusters for reliable inference. Cameron and Miller (2015) propose a range from 20 to 50 clusters, depending on the setting like balanced or unbalanced clusters, or intra-cluster correlation. We decided on 30 and less balanced clusters, which reflects our setting at hand where we observe 22 to 28 clusters, depending on the outcome variable.

In each repeated sample, the number of observations within a cluster is set to 15, and the number of clusters is either 5, 10, 15, 20, 25, or 30. Further, the dependent variable y_{ig} of individual i belonging to group g is determined by the data generating process (DGP) $y_{ig} = \beta_0 + \beta_1 z_{ig} + \epsilon_{ig}$. The error term is $\epsilon_{ig} = \nu_g + \eta_{ig}$. It consists of a random component (ν_g), which is the same within each cluster, plus an individual level error component (η_{ig}), which is uncorrelated across individuals. Moreover, ν_g and η_{ig} are random draws from the standard normal, respectively. Thus, $\mathrm{E}(\epsilon_{ig} \cdot \epsilon_{jg}) \neq 0$ for $i \neq j$, so the error term has a cluster structure and is not independent and identically distributed (iid). Eventually, z_{ig} is a dummy variable that equals one for approximately half of the observations. This proportion is motivated by the share of treated units in our empirical analysis.[38] Moreover, β_0 is set to 1 and β_1 is set to 5.[39] In order to evaluate the size of the randomization test, the true null hypothesis $\mathrm{H}_0 : \beta_1 = 5$ is tested against its two-sided alternative $\mathrm{H}_1 : \beta_1 \neq 5$. Furthermore, the nominal size of the tests α is set to 0.05. Note that we interchange the values of the treatment variable z_{ig}, because this is the most intuitive way of conducting a randomization test. With regard to our empirical analysis, we chose the traditional t-statistic as test statistic. In case of multiple regressions and permutations of z_{ig}, this test statistic leads to the correct size of the randomization exercise (Kennedy and Cade, 1996). For our simulation, we decided on $1,000$ random permutations. However, we conduct $10,000$ permutations in the empirical analysis below.

Based on $S = 1,000$ simulations, Table 13 reports the estimated test sizes $\hat{\alpha}$ and respective 95% confidence intervals of two-sided t-tests conducted in three different ways. In the first row, we use OLS default standard errors assuming iid errors across observations. In the second row, the test is based on cluster-robust standard errors, which allow for correlations of the error terms within clusters, but are only valid asymptotically (Cameron and Miller, 2015). In the last row, the rejection rates are determined according to RI. Over all cluster sizes, our monte carlo evidence shows that default OLS standard errors produce a rejection rate considerably larger than the imposed nominal rejection rate of 5%. Thus, they highly over-reject the true null hypothesis irrespective of the number of clusters. As expected, over-rejection also occurs when cluster-robust standard errors are used. Before reaching 30 clusters, the nominal rejection rate never lies within the 95% confidence interval. Throughout all cluster sizes, however, the

[38] In another possible setting, the dummy variable is constant within clusters. Thus, either all individuals within a certain cluster are treated, or none at all (see Moulton, 1986, 1990; Barrios et al., 2012). Such a perfect intra-cluster correlation would lead to even more pronounced over-rejections of conventional or cluster-robust standard errors. However, in the setting analyzed in this paper, the variable of interest varies within clusters.

[39] β_1 is the coefficient of core interest; however, its value of 5 is chosen arbitrarily. Corresponding results hardly differ when other values are chosen.

Table 13: Estimated Type I Error for Different Number of Clusters

#Clusters	5	10	15	20	25	30
OLS	0.264	0.283	0.304	0.294	0.285	0.286
	[0.237; 0.291]	[0.255; 0.311]	[0.275; 0.333]	[0.266; 0.322]	[0.257; 0.313]	[0.258; 0.314]
Cluster-robust	0.129	0.097	0.069	0.077	0.069	0.056
	[0.108; 0.150]	[0.079; 0.115]	[0.053; 0.085]	[0.060; 0.094]	[0.053; 0.085]	[0.042; 0.070]
RI	0.051	0.047	0.047	0.056	0.055	0.047
	[0.037; 0.065]	[0.034; 0.060]	[0.034; 0.060]	[0.042; 0.070]	[0.041; 0.069]	[0.034; 0.060]

Note: Rejection rates for tests with nominal size $\alpha = 0.05$ from a monte carlo study with $S = 1,000$ simulations and $1,000$ permutations for the RI procedure. 95% confidence interval for the true test size, based on simulation standard errors, in brackets.

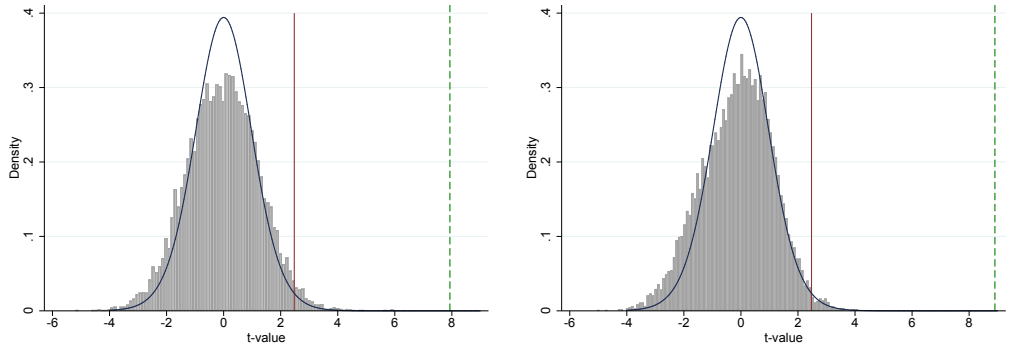
95% confidence intervals for the RI procedure always include the true (nominal) size of 0.05. Consequently, in cases with clustered data and only a limited number of clusters, as in our setting at hand, RI performs more reliably than traditional methods of inference.[40]

Graphical Depiction of RI Results

Figure 19 visualizes the results from Table 2 and Table 3, demonstrating the different inferential techniques and the need for RI. It shows the randomization (gray bars) and the original t-distributions (black line) for the OTC effect on sales figures, in Subfigures (a) and (b), and on direct health outcomes, in Subfigures (c) to (f). The green, dashed lines indicate the original t-values when conventional standard errors are used. The red, solid lines indicate the original t-values with cluster-robust standard errors. It becomes clearly visible that considering cluster-robust standard errors lowers the value of the test statistic in absolute terms, which makes it harder to reject the null hypothesis of no effect. Furthermore, with a clustered data structure and a small number of clusters, the test statistic is not t-distributed. Consequently, it would be misleading to compare the t-value with the t-distribution (black line), and one should employ the randomization distribution (gray bars) as a reference distribution. From all subfigures of Figure 19, it can be seen that some mass of the densities moves from the middle (around zero) toward the tails of the distributions. Thus, a greater number of extreme t-values will make it harder to reject the null hypothesis. Put differently, the significance of the effects would be overestimated when using conventional standard errors and/or the t-distribution as the reference distribution.[41]

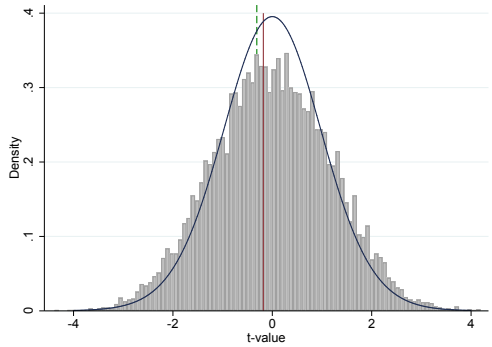
[40] The commonly used wild cluster bootstrap-t procedure does not perform superior to RI throughout our simulation setting. Results are available upon request.

[41] Wild cluster bootstrap-t p-values, as proposed by Cameron et al. (2008), Cameron and Miller (2015), and MacKinnon and Webb (2017), lead to slightly more significant effects. Thus, relying on our RI procedure yields more conservative estimates.

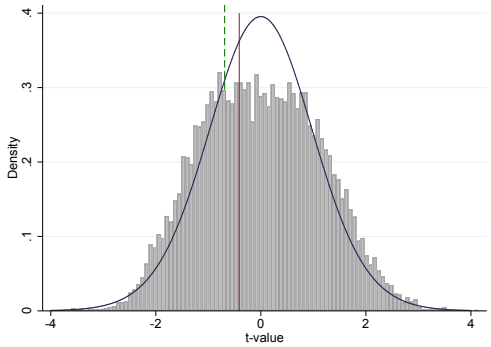


(a) Units Sold

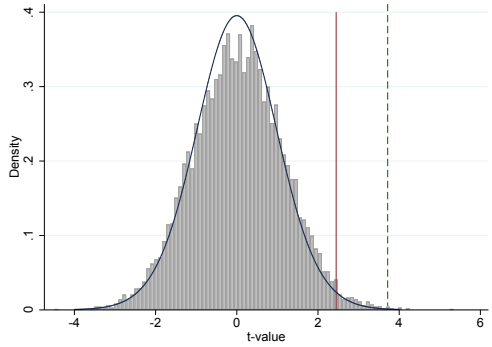
(b) Manufacturers' Revenue



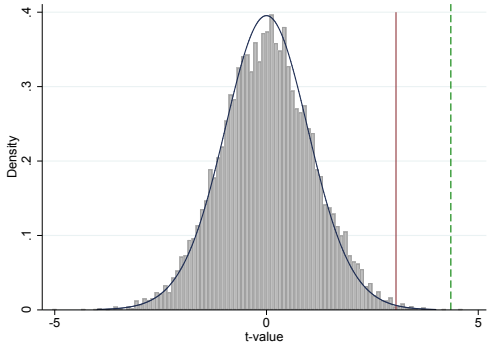
(c) Abortion Rate



(d) Abortion Ratio



(e) Birthrate



(f) Fertility

Figure 19: Randomization and t-Distribution: Effects on Main Outcomes

Note: Randomization (gray bars) and t-distributions (black lines) for the OTC effect on sales in Panels (a) and (b), abortions in Panels (c) and (d), and fertility in Panels (e) and (f). The green, dashed lines indicate the original t-values when conventional standard errors are used. The red, solid lines indicate the original t-values with cluster-robust standard errors.